

# TINTICITE, A NEW MINERAL FROM UTAH\*

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## ABSTRACT

A creamy white clay-like substance with unusual optical and chemical properties was found as a wall coating in a limestone cave near the Tintic Standard Mine in the Tintic Mining District, Utah. The chemical analysis and *x*-ray comparative data shows the mineral to be new and is here named tenticite. Its composition is  $2\text{FePO}_4 \cdot \text{Fe}(\text{OH})_3 \cdot 3\frac{1}{2}\text{H}_2\text{O}$ , with an index between 1.74 and 1.75; hardness 2.5, and specific gravity 2.82. Stereo electron-micrographs show the crystals to average about one micron in greatest dimension and that they perhaps crystallize in the orthorhombic system. The limestone surrounding the cave carries pyrite, which accounts for the iron, while the phosphate is derived from bat guano on high ledges of the cave.

## INTRODUCTION

In 1944 while studying the alteration associated with hidden ore bodies in the Tintic Mining District, Utah, Dr. T. S. Lovering of the U. S. Geological Survey, collected a substance which possessed physical properties much like clay. Examination of the material by the writer revealed unusual optical properties for clay. From a chemical analysis made by Dr. Randall E. Hamm, University of Utah, it was found that  $\text{Fe}_2\text{O}_3$ ,  $\text{P}_2\text{O}_5$ , and  $\text{H}_2\text{O}$  were present in proportions unlike any known mineral. A check analysis consequently was made with results very similar to the first. Powder patterns of the Tintic mineral and beraunite, which is of similar composition, were found to be different by the Bureau of Mines, Salt Lake City, and by Mr. J. M. Axelrod of the Geological Survey. It seems justifiable therefore to conclude that the substance is a new mineral. The name tenticite, after the locality where it is found, is proposed for this new phosphate.

## PHYSICAL PROPERTIES

It will be shown later that crystals of tenticite vary in size from .3 mc. to 1.67 mc. in greatest dimension, consequently no megascopic crystals are observable. The material appears to be a dense, earthy, compact, porcelain-like mass filled with innumerable veinlets of greenish-brown jarosite. The pure tenticite has a creamy white color with a slight tinge of yellowish green. Since the material is composed of submicroscopic crystals the true hardness could not be determined, but the compact aggregates can be easily scratched with the fingernail, although there is no soapy feel to the powder. When chewed it is not gritty, but neither is it smooth like the clay minerals. A hardness of 2.5 therefore seems most descriptive. The specific gravity was determined by the pycnometer

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method and was found to be 2.82. It is insoluble in  $H_2O$ ,  $H_2SO_4$ , and  $HNO_3$ , but slowly soluble in  $HCl$ . In  $H_2O$  however, there is a rapid dissociation of the crystals which, when agitated, form a near colloid. It readily yields water in the closed and open tubes and before the blow pipe fuses quickly to a black slag.

#### OPTICAL PROPERTIES

In a thin section of tenticite no structure whatsoever is discernible. Small thin fragments in index oils are colorless, but the larger, thicker fragments show a faint yellowish green. With crossed nicols there appears a confused aggregate polarization of low birefringence. Even under very high magnification individual crystals, of course, cannot be resolved, but thin edges of fragments show low gray interference colors. The mean index is near 1.745, and the birefringence is estimated to be about 0.005 to 0.007. This latter value is based partly on the fact that all indices seem to be below 1.75 and above 1.74.

#### CRYSTALLOGRAPHY

An electron micrograph of tenticite made by the American Cyanamid Company showed such well formed crystals that it was thought there might be a possibility of determining the crystal forms if a stereo electron micrograph were available. Professor L. Marton of Stanford University graciously supplied a stereo pair which shows the third dimension rather well. † This stereo pair (Fig. 1) is herein reproduced intact so that anyone might view them with a simple parlor stereoscope.

X-ray studies of the mineral definitely rule out the possibility of the crystals being isometric, tetragonal, or hexagonal, and after studying the stereo pictures, it appears that of the other three systems, the crystals seem to best fit the requirements of the orthorhombic system. In all, five different electron micrographs were taken of the mineral. The crystals appear to be oblong and tabular, the largest of which was 1.67 microns in greatest dimension, while the smallest was 0.3 micron, with the general average being around one micron. The thickness measured on the stereo picture is about  $0.1 \pm$  micron. No angles, of course, could be accurately measured, but those crystals which appear to lie flat have approximately  $90^\circ$  corners, while those lying at angles seem to show a side pinacoid and a front dome, in addition to the flat tabular faces.

Figure 2 is an attempt to show the interpreted form of a typical crystal and is here offered for what it might be worth. One crystal appears to be

† For a description of the method employed in taking this stereo electron micrograph see Marton L., Stereoscopes with the electron microscope, *Jour. Applied Physics*, 15, No. 10, 726-727 (1944).

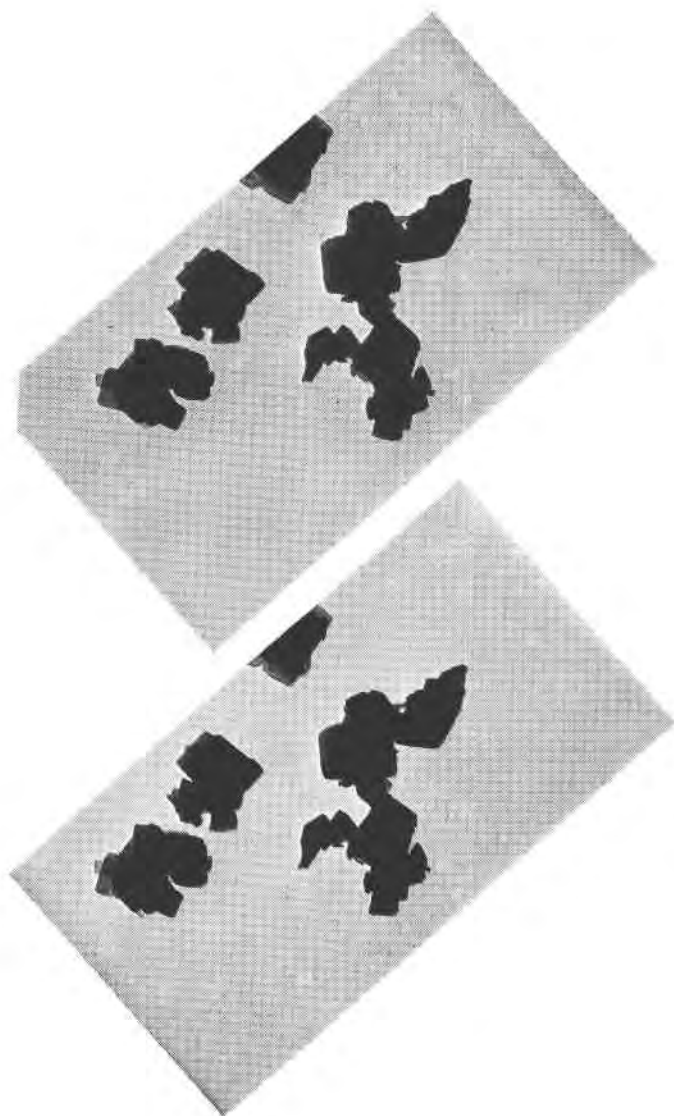


FIG. 1. Electron micrograph stereo pair of tincticite.  $\times 9200$ .

warped but yet not fractured. This was probably done while the microscopic mount was being prepared and suggests that the crystals can be rather easily deformed.

#### COMPOSITION

In selecting the material for analysis it was necessary to exercise great care in order to exclude the jarosite veinlets. Fortunately the veinlets are all large enough to be ordinarily visible, but any finely disseminated

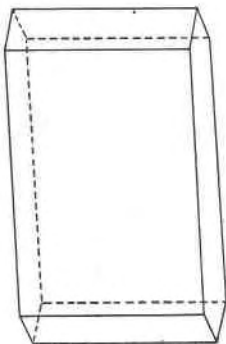


FIG. 2. Crystal of tinticite. Interpretation from electron micrograph stereo pictures.

jarosite could not be separated. The analyses therefore show small amounts of  $\text{SO}_3$ ,  $\text{Na}_2\text{O}$ , and  $\text{K}_2\text{O}$ , all of which can be accounted for by the presence of small amounts of jarosite and natro-jarosite. On some fragments, when treated with  $\text{HCl}$ , a very slight effervescence is observed, thus accounting for the  $\text{CaO}$ . The impurities responsible for  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{FeO}$  were not detected, but the amounts of these are so small that they can be disregarded in calculating a formula.

#### ANALYSIS OF TINTICITE

	R. E. HAMM, <i>analyst</i> Univ. of Utah	LEE C. PECK, <i>analyst</i> Univ. of Minn.
$\text{SiO}_2$	—	.19
$\text{Al}_2\text{O}_3$	—	.18
$\text{Fe}_2\text{O}_3$	49.28	48.84
$\text{FeO}$	—	.00
$\text{MgO}$	—	.24
$\text{CaO}$	—	.36
$\text{Na}_2\text{O}$	—	.45
$\text{K}_2\text{O}$	—	.32
$\text{H}_2\text{O}+$	17.21	18.42
$\text{H}_2\text{O}-$	1.72	1.32
$\text{TiO}_2$	—	.04
$\text{P}_2\text{O}_5$	30.21	28.40
$\text{SO}_3$	.71	1.07
	<hr/> 99.13	<hr/> 99.83

Recalculating the  $\text{Fe}_2\text{O}_3$ ,  $\text{P}_2\text{O}_5$ , and  $\text{H}_2\text{O}+$  to 100% the following values are found:

	HAMM	<i>mol.</i>	PECK	<i>mol.</i>
$\text{Fe}_2\text{O}_3$	50.96%	.319	51.05%	.319
$\text{P}_2\text{O}_5$	31.24%	.220	29.69%	.209
$\text{H}_2\text{O}$	17.80%	.989	19.26%	1.070
	100.00%		100.00%	

The formula is then  $3\text{Fe}_2\text{O}_3 \cdot 2\text{P}_2\text{O}_5 \cdot 10\text{H}_2\text{O}$ , which when simplified is  $2\text{FePO}_4 \cdot \text{Fe}(\text{OH})_3 \cdot 3\frac{1}{2}\text{H}_2\text{O}$ .

#### X-RAY DATA

Through the courtesy of the U. S. Bureau of Mines, Salt Lake City, and the kind cooperation of Dr. E. Vernon Potter and Mr. Ralph W. Huber of that institution, an  $x$ -ray photograph of tincticite was made and the following data are the result of their work. The picture was taken using the powder method, on a General Electric machine generating 40 KVP and 9 milliamps.  $\text{Fe-K}_\alpha$  radiation was employed with exposure of  $1\frac{1}{2}$  hours. The darkest lines of the estimated intensities are 6 and the weakest less than 1. A definite number was not assigned to any line having an intensity below 1. Density values were made of the darkest lines on a Leeds and Northrup microphotometer.

#### TINCTICITE, $2\text{FePO}_4 \cdot \text{Fe}(\text{OH})_3 \cdot 3\frac{1}{2}\text{H}_2\text{O}$ FROM TINTIC, UTAH

<i>D</i>	<i>Est. Int.</i>	<i>Density</i>	<i>D</i>	<i>Est. Int.</i>	<i>Density</i>
6.70	4	.13	2.12	<1	
6.07	5	.14	2.09	<1	
5.67	5	.18	1.974	<1	
4.56	4	.14	1.941	<1	
4.38	2	.09	1.911	<1	
3.91	6	.23	1.873	<1	
3.28	6	.22	1.824	<1	
3.16	1	.07	1.710	<1	
3.01	6	.19	1.649	<1	
2.96	3	.11	1.586	<1	
2.59	<1	—	1.551	<1	
2.51	<1		1.517	<1	
2.44	<1		1.504	<1	
2.39	<1		1.475	<1	
2.35	<1		1.434	<1	
2.25	<1		1.409	<1	

#### OCCURRENCE AND ORIGIN

Not far from the Tintic Standard Mine is a shallow cave in limestone. The rocks surrounding the cave are heavily stained with limonite and

manganese oxide, indicating that the ground has been mineralized to some extent. The tenticite occurs associated with jarosite and limonite on the lower walls and floor of the cave as a plaster varying in thickness from a few inches to a foot or more.

When it was discovered that the tenticite was a phosphate the problem arose as to the source of this material. The cave is in Cambrian limestone which contains no known phosphatic beds. In studying the mineralization of Tintic no other phosphatic minerals had been found. The iron and sulphate of the jarosite were easily accounted for by the former presence of pyrite. The phosphate problem was solved however when careful search of the upper walls of the cave revealed considerable quantities of guano. Therefore the mineral was likely formed by meteoric waters seeping down over the walls of the cave, picking up phosphate from the guano and iron from the pyrite and precipitating the tenticite in the lower parts of the cave. The jarosite found with the tenticite invariably shows evidence of having formed late. This is expectable since where both sulfate and phosphate are available to combine with iron, the phosphate always forms first, and no iron sulfate will be precipitated until all of the phosphate is used up.

#### ACKNOWLEDGMENTS

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