

ROSSITE AND METAROSSITE; TWO NEW VANADATES FROM COLORADO

By WILLIAM F. FOSHAG

Assistant Curator, United States National Museum

AND

FRANK L. HESS

United States Bureau of Mines

OCCURRENCE

Contributed by Frank L. Hess

The mineral described in this paper was found in veinlets cutting McElmo sandstone in Bull Pen Canyon, San Miguel County, Colo., 5 miles southeast of Summit Point post office, Utah near the point where the 38th parallel cuts the boundary line between Colorado and Utah, and is on the western edge of the known carnotite-bearing sandstones of the area. The deposit from which it came is on a claim belonging to M. E. O'Neil, and to Mr. O'Neil I am indebted for his courtesy in allowing me to examine the deposit, to collect specimens, and for other specimens which he sent me later. At the left of the entrance to one of his prospect tunnels known as the Arrowhead was a considerable amount of soft, dull brownish-red sandstone which owed its color to a mixture which seems to be made up of hewettite, vanoxite, and roscoelite, though when mixed, as in this deposit, these minerals are very difficult to identify. Wherever I have seen sandstone with similar aggregates of minerals, it has been soft and friable, so that cracks in which minerals may form are easily developed. In certain parts of the sandstone are the usual carbonized plant remains that characterize the carnotite deposits in sandstones of McElmo age in the plateau region. Here and there were rich spots and streaks of carnotite. Veinlets of a pale yellow, flaky mineral ranging from the thickness of cardboard to one-half inch and several feet long cut the sandstone at various angles. Gypsum is so common in the sandstones that I at first supposed that it formed the veinlets, but closer examination showed that the mineral had only one prominent cleavage and so could not

be gypsum. Excellent material was available and was collected, but all was milky. Later I received from Mr. O'Neil further specimens which had glassy centers and milky rims which were apparently the effect of dehydration. The mineral was later than the carnotite and other uranium and vanadium minerals in the deposit.

Although fairly plentiful at the point of discovery, this is the only deposit in which I have found the mineral after an examination of hundreds of carnotite deposits. It is entirely possible, however, that some veinlets in other deposits thought at the time to be gypsum may be this mineral.

We have named the clear, glassy mineral *rossite* in honor of Dr. Clarence S. Ross, of the United States Geological Survey. Since it was found that the lighter yellow, flaky mineral differed from the clear material in degree of hydration as well as in its optical properties, it was deemed advisable to distinguish them in mineralogical nomenclature. We therefore propose to call the naturally dehydrated form *metarossite*, a name that refers to its relation to rossite as well as to its probable mode of genesis.

ROSSITE

INTRODUCTION

Rossite was found sparingly in the second lot of material obtained, only as small lumps in the flaky mineral. When either rossite or metarossite is dissolved in hot water and allowed to crystallize the crystals have a composition corresponding to the natural rossite. A chemical analysis was made on the natural mineral as well as one on the recrystallized product. Inasmuch as no natural crystals of rossite were found the crystallography is based entirely upon the recrystallized compound. The optical properties were also determined upon the recrystallized mineral.

CHEMICAL PROPERTIES

Contributed by William F. Foshag

PYROGNOSTICS

Rossite when heated before the blowpipe fuses easily to a black bead without imparting any color to the flame. Heated in a closed tube it fuses easily and gives off water. The mineral is slowly but completely soluble in water from which it can be recrystallized. Moistened with concentrated hydrochloric acid the mineral turns mahogany red (vanadic acid). When an acid solution of the mineral is reduced with hydrogen sulphide or sulphur dioxide it becomes blue in color.

ANALYSES

Sufficient material in the form of hard, glassy cores of rossite could be selected from the more flaky mineral and cleaned by rubbing the soft metarossite off. The rossite could not be completely purified by this means, but the sample analyzed carried only a small percentage of the metarossite and a few per cents of sand grains from the inclosing sandstone. For a second analysis a quantity of the metarossite was recrystallized and the clear, glassy crystals so obtained used.

Water was determined as loss on heating. Since the mineral fused easily, a low temperature was sufficient to accomplish the complete expulsion of the water. Actually most of the water was driven off at a temperature of 120° C. As the dehydrated mineral is very slowly soluble in water, another portion was taken for the other constituents. The mineral was dissolved in hot water, the insoluble matter filtered off, and the vanadium precipitated as mercuric vanadate and ignited to the oxide. Lime and magnesia were determined in the usual manner. Constituents precipitated by hydrogen sulphide in acid solution (Pb, Cu, Mo, etc.) were found to be absent. Iron and phosphorus could not be detected. The results follow:

TABLE 1.—*Analysis of rossite*

Constituent	Natural glassy	Recrystallized	Ratios		Theoretical CaO.V ₂ O ₅ . 4H ₂ O
Water (H ₂ O)-----	22.90	22.59	1,255 330	4×0.963	23.22
Lime (CaO)-----	18.00	18.48		1×1.012	18.07
Magnesia (MgO)-----	0.14	-----			
Vanadic oxide (V ₂ O ₅)-----	58.00	58.92	323	1×0.990	58.71
Insoluble-----	1.60	-----			
	100.64	99.99			

Rossite is therefore a simple hydrous calcium vanadate. Its composition is expressed by the formula CaO.V₂O₅.4H₂O. In the last column of Table 1 the theoretical composition for this compound is given.

CRYSTALLOGRAPHY

Contributed by William F. Foshag

GENERAL

None of the specimens of rossite show any crystallographic forms. The mineral, however, is soluble in water, and material suitable for goniometric measurements can easily be obtained by recrystallization. The habits of crystals obtained in this manner were all very similar, and repeated recrystallizations under various conditions failed to

vary the habit greatly. The crystals best suited for measurement were about a millimeter or less in length; the faces of the larger crystals were too curved while the largest were an aggregate of a number of individuals apparently complexly twinned. Except for one lot that was tabular in habit all crystals obtained were prismatic. More than 50 crystals were mounted on the goniometer and provisionally examined, but only 15 were found to be entirely suitable and completely measured. The measurements showed rossite to be triclinic with the forms c (001), b (010), a (100), m (110), and y (101). Because of the absence of pyramids on all of the crystals the axial ratios and the numerical value of q were not calculated. The polar elements were determined to be as follows: $\alpha_0 = .4969$, $\gamma_0 = .1624$, $p_0 = .8295$, $\lambda = 80^\circ 39'$, $\mu = 59^\circ 31'$, $\nu = 85^\circ 38'$. The axial angles are $\alpha = 98^\circ 18'$, $\beta = 97^\circ 24'$, $\gamma = 89^\circ 34'$.

CALCULATION OF THE ELEMENTS

The crystals were measured on the two-circle goniometer, the prismatic habit rendering it easy to adjust them in polar position. The prominence of the brachypinacoid and the good brachypinacoidal cleavage gave satisfactory results for v . The forms whose measurements could be used in the calculation of the elements were the following: a (100), m (110), b (010), and c (001). No pyramids could be found on any of the crystals, and repeated recrystallizations under various conditions failed to produce any habit with the slightest pyramidal development. The axial ratios and the numerical value for q were therefore not determined. All measurements were made upon the artificially recrystallized mineral. The suitable measurements of the four forms upon which the elements are based are given below:

TABLE 2.—Measurement of a (100) rossite

Crystal No.	Reflection	Size of face	β	
			$^\circ$	'
2	Excellent	Medium	86	22
3	do	do	86	49
3	Good	do	87	8
4	do	Narrow	86	10
4	do	do	87	4
5	Excellent	Medium	84	33
6	Good	do	86	53
6	do	do	86	58
8	do	Broad	85	40
8	do	Medium	86	15
10	do	do	85	46
10	do	do	85	49
12	do	do	85	10
13	Excellent	do	83	3
Average			85	38

TABLE 3.—Measurement of m (110) rossite

Crystal No.	Reflection	Size of face	ϕ	
2	Excellent	Broad	54	47
3	do	do	53	55
3	do	do	53	31
4	Good	do	53	28
4	do	Medium	53	3
6	do	do	53	5
8	do	Broad	52	45
10	Excellent	do	54	43
10	Good	Medium	52	57
12	Excellent	Broad	52	2
	do	do	52	27
Average			53	48

TABLE 4.—Measurement of c (001), rossite

Crystal No.	Reflection	Size of face	ϕ		ρ	
			°	'	°	'
2	Excellent	Large	73	39	31	34
3	do	do			31	24
4	do	do	73	11	31	27
7	do	do	72	29	31	26
11	do	do	72	18	31	43
Average			72	54	31	31

TABLE 5.—Measurement of y (101) rossite

Crystal No.	Reflection	Size of face	ϕ		ρ	
			°	'	°	'
	Good	Medium	44	20	—87	22
	do	do	44	30	86	27
15	do	do	43	47	86	5
1	Twin, excellent	do	44	6	--	--
1	do	do	44	24	--	--
Average			44	13	—86	38

In this compilation the angles are listed as "excellent" when the readings between two faces were designated "excellent" during measurement; and listed as "good" when the readings for the faces were between "excellent" and "good" or between "good" and "good." It will be noted that even in the cases where the faces are all designated as "excellent" the measurements range from $83^{\circ} 38'$ to $84^{\circ} 49'$, a difference of over 3° for ϕ for (100); and from $52^{\circ} 2'$ to $54^{\circ} 47'$, a difference of almost 3° for ϕ for (001). This variation is large for crystals so

well suited for crystallographic measurement and the cause is not entirely clear. The average values for ϕ and ρ of the forms of rossite are given in the following table:

TABLE 6.—Averages of measured angles of rossite

Form	Number of measurements	ϕ		ρ	
		°	'	°	'
<i>a</i> (100)-----	14	85	38	90	0
<i>m</i> (110)-----	11	53	48	90	0
<i>c</i> (001)-----	5	72	54	31	31
<i>y</i> (101)-----	5	-86	38	44	13

The value of the elements based on these measurements are as follows:

TABLE 7.—Axial elements of rossite

Projection elements	Polar elements	Linear elements
$x_0' = 0.5829$	$x_0 = 0.4969$	
$y_0' = .1906$	$y_0 = .1624$	
$p_0' = .9730$	$p_0 = .8295$	
$q_0' = \quad \quad$	$q_0 = \quad \quad$	
$v = 85 \quad 38$	$r = 1 \quad \quad$	
$h = \quad \quad$	$\lambda = 80 \quad 39$	$\alpha = 98 \quad 18$
	$\mu = 59 \quad 31$	$\beta = 97 \quad 24$
	$\nu = 85 \quad 38$	$\gamma = 89 \quad 34$

FORMS AND ANGLES

Except for the forms *b* (010), *a* (100), *m* (110), *c* (001), and *y* (101) no others were found except a few doubtful ones. These doubtful forms were observed only once each and may represent, in part at least, nothing more than the smooth surfaces by which the crystals were attached to the walls of the crystallizing dish. All the forms noted with the average angle of each are given in the table below:

TABLE 8.—Measured forms of rossite

Number	Letter	Number of crystals	Number of measurements	Symbol	ϕ		ρ	
					°	'	°	'
1-----	<i>c</i> -----	15	15	001	72	54	31	31
2-----	<i>b</i> -----	15	30	010	0	00	90	00
3-----	<i>a</i> -----	15	30	100	85	38	90	00
4-----	<i>m</i> -----	15	30	110	53	48	90	00
5-----	<i>y</i> -----	5	5	101	-86	38	44	13
6-----	-----	1	-----	-----	96	21	64	00
7-----	-----	1	-----	-----	61	10	44	00
8-----	-----	1	-----	-----	35	24	88	23

c (001). The basal pinacoid was found on all of the crystals measured and is usually the only terminal face present. Very often it is smoothly curved.

b (010). The brachypinacoid is always the most prominent face in the prism zone and is always bright and smooth.

a (100). The macropinacoid is always present, but is variable in size, ranging from broad to narrow. Its relative size is dependent upon the size of the unit prism.

m (110). The unit prism is usually present as a medium to broad face, but may be absent. Next to the clinopinacoid it is the most prominent face on the crystals.

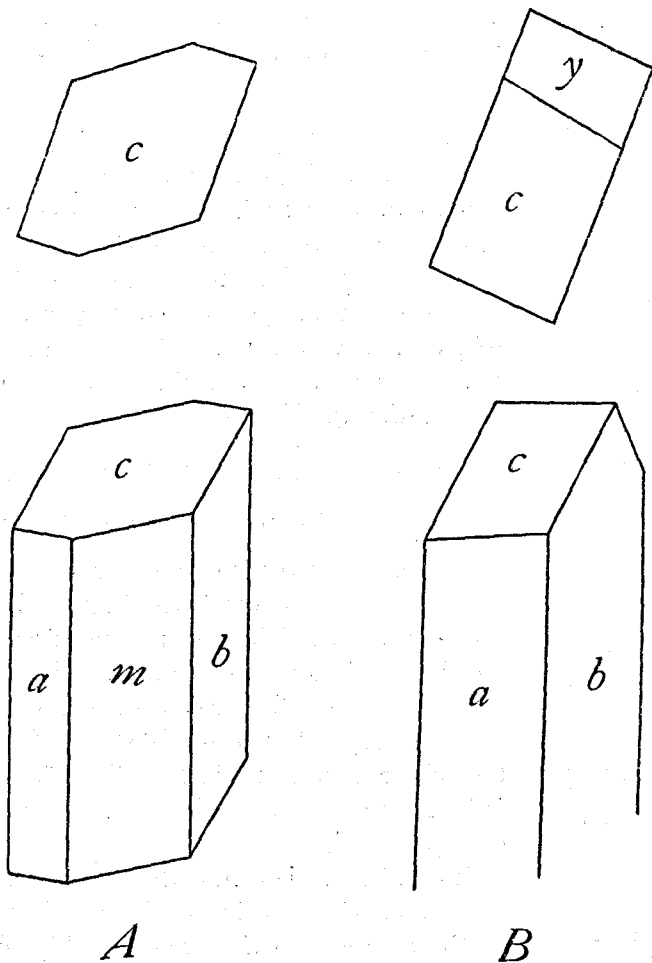


FIG. 1.—A AND B, CRYSTAL HABIT OF ROSSITE

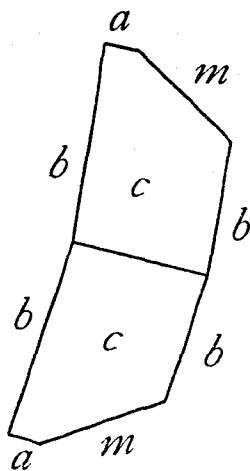
There are no other faces present in the prism zone. Those present are always sharp, without striations, but some are slightly curved.

y ($\bar{1}01$). The face of the macrodome is present on some crystals but is usually smoothly curved so that accurate measurement was impossible. It is often present as a small triangular terminal face, but sometimes becomes as prominent as the base.

HABITS

The crystals of rossite are commonly of a prismatic habit (fig. 1), but a habit tabular to the base was found in one lot of crystals. The

prismatic habit varies somewhat, due to the relative size of the macropinacoid and the unit prism. When the orthopinacoid is large the crystals have an almost equal horizontal thickness. When the prism is prominent and the macropinacoid small or lacking the crystals are almost lathlike. The length of the crystals also varies. Many crystals showing a combination of the three pinacoids are stumpy and even almost equidimensional; in the latter case they appear as rhombs. The crystals rarely are long needlelike blades.



TWINNING

Among the larger crystals twins are the rule but are so intricately intergrown that it is difficult to know just what relations the individuals have to each other. Among the smaller crystals twins are rare. In one lot, however, twins having the general appearance of the butterfly twins of gypsum were found. In these the twinning plane is the macropinacoid (100). These twins are similar to Figure 2.

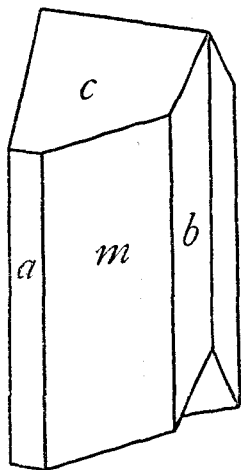


FIG. 2.—TWIN CRYSTAL OF ROSSITE

PHYSICAL AND OPTICAL PROPERTIES

Contributed by William F. Foshag

The color of rossite varies from Martius yellow in the small crystals to pinard yellow in the larger crystals. The luster varies from vitreous pearly to glassy. The hardness lies between 2 and 3. The specific gravity, determined by floating clear crystals in a suitable bromoform-carbon tetrachloride mixture is 2.45. The fresh mineral is brittle and has a good cleavage parallel to the clinopinacoid.

Rossite is a biaxial with a large axial angle. The plane of the optic axes is essentially parallel to the axis c with $Z=c$ and roughly bisects the angle between a (100) and b (010). The base and the brachypinacoid show the emergence of an optic axis near the edge of the field. The extinction direction measured on the basal plane and from the edge 001-010 was found to be $16^\circ \pm 3$. The indices of refraction measured on the recrystallized mineral by the immersion method are as follows:

$$\alpha=1.710, \beta=1.770, \gamma=1.840$$

The dispersion is very strong; the emergence of an optic axis appears as a broad band of colors. The high dispersion manifests itself in bright-colored flashes when the crystal is mounted and revolved on the goniometer.

METAROSSITE

GENERAL

The mineral that occurred most abundantly in the material received is what we here call metarossite. It forms small yellow veins in a light gray and friable sandstone, is coarse, platy in habit, but is soft and friable. Occasionally within the center of masses of metarossite one can find small glassy kernels of rossite. The relation of the metarossite to the rossite suggests that it is a dehydration product of that mineral. As will be evident from the analyses given further on, the mineral is a distant hydrate and not a partially altered rossite. Two analyses made on different lots agree very well with each other and with the theoretical values for the formula assigned to it: $\text{CaO.V}_2\text{O}_5.2\text{H}_2\text{O}$. We feel justified, therefore, in assigning a distinct name to this compound.

CHEMICAL PROPERTIES

Contributed by William F. Foshag

PYROGNOSTICS

The behavior of metarossite before the blowpipe is entirely similar to the rossite. It is, however, somewhat more slowly soluble in water. Its chemical reactions are identical with those of rossite.

ANALYSIS

Abundant material was available for analysis. (No. 95331, U. S. N. M.) Two different samples were submitted to chemical analysis, one from the first lot received and another from the second lot. The samples were carefully chosen, only the larger and purer cleavage fragments being selected. Upon examination under the petrographic microscope the large majority of the flakes were clear and transparent, but the very large grains had a somewhat muddied appearance, due to included air. There were occasional grains of sand from the inclosing sandstone, estimated to amount to about 2 per cent. The analysis was carried out according to the scheme outlined under rossite, with the following results:

TABLE 9.—*Analysis of metarossite*

	Natural	Pearly	Ratios		Theoretical CaO.V ₂ O ₅ . 2H ₂ O
Water (H ₂ O)-----	13. 56	14. 08	786	2×1. 088	13. 14
Lime (CaO)-----	20. 04	19. 60	362	1×1. 003	20. 44
Magnesia (MgO)---	0. 10	0. 13			
Vanadic oxide (V ₂ O ₅)-	64. 08	64. 20	360	1×0. 997	66. 42
Insoluble-----	2. 72	2. 48			
	100. 50	100. 49			

Metarossite is a hydrous calcium vanadate of the formula $\text{CaO.V}_2\text{O}_5.2\text{H}_2\text{O}$. It differs from rossite in its lesser hydration, that mineral being the similar compound with four molecules of water. If rossite is left exposed to the air it gradually becomes lighter in color, loses its vitreous luster, and passes over into metarossite, still, however, retaining its platy structure. If metarossite is dissolved in water and allowed to crystallize, rossite separates out, but the glassy crystals so obtained gradually pass over into the metarossite again. It was at first thought that this change of the higher hydrate to the lower one was continuous, similar to the changes in hydration in other platy minerals, notably carnotite, autunite, etc. There are several facts, however, that point to the existence of two distinct hydrates. First, there is the occurrence of rossite as sharp residual kernels in the metarossite without any suggestion of gradation; and, secondly, the two analyses made upon separate lots of material agree satisfactorily with each other and very well with the theoretical values for the dehydrate.

CRYSTALLOGRAPHY

Contributed by William F. Foshag

No measurable crystals of metarossite were found, although on one specimen a crust of the vanadate showed projections resembling crystals. They were too imperfect, however, to be measured or to even suggest the symmetry of the crystals.

PHYSICAL AND OPTICAL PROPERTIES

Contributed by William F. Foshag

Metarossite is light yellow in color (Martius yellow, Ridgway) and has a dull pearly luster. It is soft and friable and can be easily crushed between the fingers. Due to its decided platy cleavage

(probably inherited from the rossite) it breaks easily into flat, flaky grains. These under the microscope are clear and homogeneous. This platy cleavage makes it difficult to obtain good quantitative measurements of its optical properties. Like the rossite the cleavage flakes show the emergence of an optic axis with a very high dispersion. The indices of refraction are considerably higher than those of rossite. Only α was within the range of the oils available and was found to be 1.840, β and γ were both somewhat higher than 1.85 but could not be measured directly because the ease with which the mineral dehydrated and melted prevented the use of piperine-iodide melts. The birefringence is high and so far as could be determined the minerals showed no pleochroism.

RELATION OF ROSSITE AND METAROSSITE TO OTHER MINERALS

There are no known vanadates having the composition of these two minerals nor any arsenates or phosphates similar to them. They are, however, members of a series with the other known calcium vanadates found in nature, hewettite, and pascoite. Tripling the formulæ of rossite and metarossite brings out the following interesting relation:

Hewettite.....	1 CaO. 3 V ₂ O ₅ . 9 H ₂ O.
Pascoite.....	2 CaO. 3 V ₂ O ₅ . 11 H ₂ O.
Rossite.....	3 CaO. 3 V ₂ O ₅ . 12 H ₂ O.
Metarossite.....	3 CaO. 3 V ₂ O ₅ . 6 H ₂ O.

The relation of metarossite to rossite is not entirely clear. It is possible that in common with many other minerals with a decided platy cleavage the water content is variable and that the compound can lose water without any great change in its molecular structure. The ratios for the two hydrates show, upon analysis, such good agreement with the theoretically required amounts without any evidence for any intermediate steps that it seems possible that we are dealing here with two distinct hydrates and not with a continuous series. Even were this not the case it is deemed advisable to separate the two compounds in mineral nomenclature in order to avoid confusion, the properties of the two substances being so greatly different.

SYNTHESIS

Both pascoite and rossite have been synthesized by Waldemar T. Schaller¹ by heating hewettite suspended in water with precipitated calcium carbonate on the steam bath and allowing the clear solution

¹ Unpublished data.

to crystallize at room temperature. Rossite was formed when the calcium carbonate was present in excess. The crystals formed in this way are similar in every respect with those obtained by recrystallizing the natural rossite or metarossite. If the synthetic mineral is left exposed to the air it eventually loses water and passes over into metarossite.

SUMMARY

ROSSITE

Name.—In honor of Dr. C. S. Ross, of the United States Geological Survey.

Chemical properties.—A hydrous calcium vanadate, $\text{CaO} \cdot \text{V}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$. Analysis: CaO 18, MgO 0.14, V_2O_5 58, H_2O 22.90. Sum 100.64. Soluble in water.

Crystallographical properties.—Triclinic. $x_0=0.4969$, $y_0=0.1624$, $p_0=0.8295$, $\lambda=80^\circ 39'$, $\mu=59^\circ 31'$, $\nu=85^\circ 38'$, $\alpha=98^\circ 18'$, $\beta=97^\circ 24'$, $\gamma=89^\circ 34'$. Habit prismatic. Forms: c (001), b (010), a (100), m (110), y ($\bar{1}01$).

Physical and optical properties.—Color yellow. Luster pearly to vitreous. Biaxial. $2V$ large. Plane of the optic axes parallel to the axis c with $Z=c$.

$\alpha=1.710$, $\beta=1.770$, $\gamma=1.840$. Dispersion strong. Hardness: 2-3; specific gravity 2.45.

Occurrence.—Found as small glassy kernels embedded in flaky metarossite at Bull Pen Canyon, San Miguel County, Colo.

METAROSSITE

Name.—In allusion to its relation to rossite, a partially dehydrated rossite.

Chemical properties.—A hydrous calcium vanadate, $\text{CaO} \cdot \text{V}_2\text{O}_5 \cdot 2\text{H}_2\text{O}$. Analyses CaO 20.04; 19.60, MgO 0.10; 0.13, V_2O_5 64.08; 64.20, H_2O 13.56; 14.08, Insoluble 2.72; 2.48. Sums 100.50; 100.49. Soluble in water.

Physical and optical properties.—Color yellow. Luster pearly to dull. Biaxial. $2V$ large. Dispersion strong.

$\alpha=1.840$, β and γ higher than 1.85. Soft and friable.

Occurrence.—Found as small veinlets in sandstone at Bull Pen Canyon, San Miguel Canyon, Colo., as a dehydration product of rossite.

