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NEW AND KNOWN MINERALS FROM THE UTAH–COLORADO CARNOTITE REGION

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By Frank L. Hess.

VANOXITE, A NEW VANADIUM MINERAL.

With few exceptions, the carnotite deposits in the plateau region from Meeker, in northern Colorado, to Carrizo Mountain, on the line between New Mexico and Arizona, are in sandstone of McElmo (Lower Cretaceous or Upper Jurassic) age. Around the carnotite is usually an irregular envelope of dark vanadium-bearing sandstone, ranging from gray to black. The sandstone owes its color to vanadium minerals, but although many have searched for them no crystals of dark vanadium minerals visible to the unaided eye have yet been found. Like the carnotite, the other vanadium minerals so far found in the carnotite-bearing areas are secondary, and in many places they have traveled from a fraction of an inch to 6 feet or even farther through the sandstone from the nuclei where decaying plant remains precipitated both vanadium and uranium minerals in the accumulating sands. In some places the migrating solutions were intercepted by cracks, but even there they did not form easily visible crystals of the dark minerals, though here and there they deposited well-crystallized hewettite, meta-hewettite, volborthite, and calciovolborthite. However, in a single specimen from the Red Jacket claim of the W. L. Cummings Chemical Co., in Gypsum Valley, San Miguel County, Colo. (latitude 38° 3′ N., longitude 108° 42′ W.), the walls of narrow cracks are covered with minute acicular crystals about 0.03 millimeter (0.0012 inch) long and one-fifth as thick, making a coating that looks like dark-brown velvet with a very short pile. This mineral I hope to describe at a later date.

In some places small masses of sandstone, in part concretionary, are tarry black; in others almost equally black sandstone forms peculiar thin curved layers 2 or 3 millimeters (one-eighth inch) or less thick, from which the light-colored sandstone cleaves cleanly with little regard for bedding.

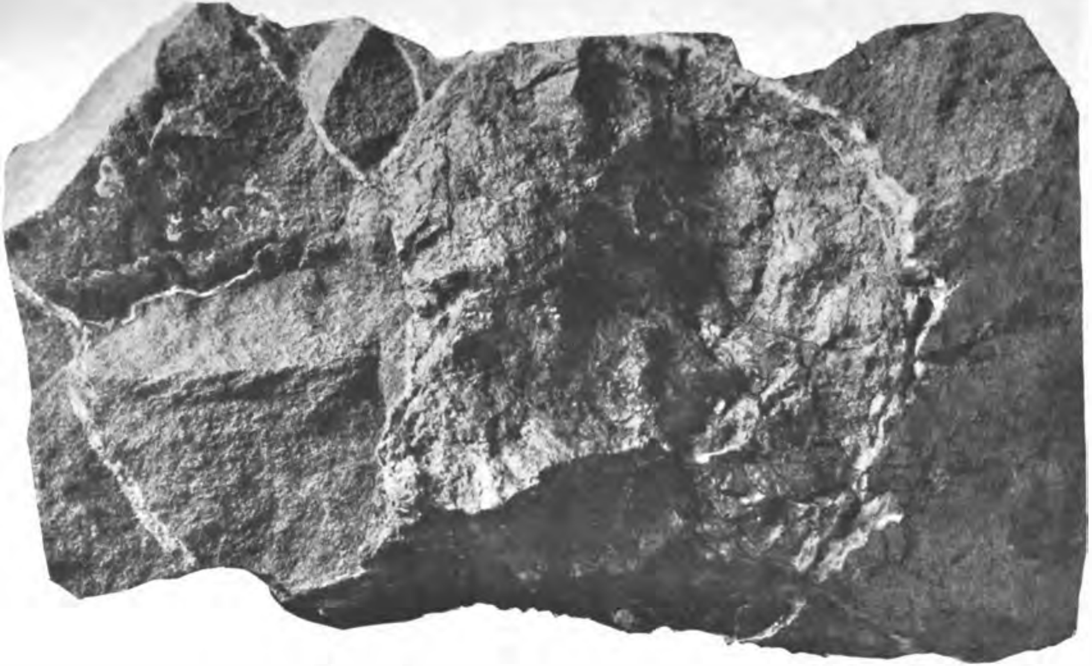
The first specimen of the black vanadium-bearing sandstone seen at the United States Geological Survey was brought to the office in 1910 by Mr. R. H. McMillan, who had found it during an examination of the Jo Dandy claim, on the southwest wall of Paradox Valley, Montrose County, Colo. (sec. 21, T. 46 N., R. 17 W., latitude 38° 14′ N., longitude 108° 46′ W.). The material collected by Mr. McMillan was not suitable for analysis, for besides the sand grains, pyrite, carnotite, and gypsum could be recognized, and the specimen gave a radiograph even where no carnotite could be recognized. Mr. McMillan gave to the material the name "kentsmithite," and this name has become current among miners and prospectors of the region for any of the black or very dark vanadium-bearing sandstones.

Other specimens of the black vanadium-bearing sandstone from the Jo Dandy claim were furnished to the United States Geological Survey by Mr. A. O. Egbert, among which were the specimens on which the analyses quoted herein were made. Specimens from other claims were furnished by Messrs. Beattie & Beattie, Mr. O. Barlow Wilmarth, and others. Later still, specimens of dense black mineral almost free from sand, rich in vanadium but also rich in uranium, were furnished by Mr. Warren Bleecker and Mr. Karl Kithil, from Calamity Creek, Mesa County, Colo.; by Mr. H. K. Thurber, from Mr. A. O. Balsley's claims on Dry Wash, 16 miles southeast of Moab, Utah; and by Messrs. John I. Mullen and O. O. Gaw, from Dolores Camp, in sec. 19, T. 48 N., R. 18 W., Montrose County, Colo. In November, 1921, I visited the field, studied the occurrences of the black or dark vanadium minerals where exposures permitted, and collected specimens.

It seemed probable from field examinations that the several dark or black vanadium-bearing sandstones were colored by the same mineral, but microscopic and chemical work has shown that there are at least three minerals, besides the nearly sand-free black uraniferous mineral. In this paper only the black mineral first mentioned, from the Jo Dandy mine, is described.

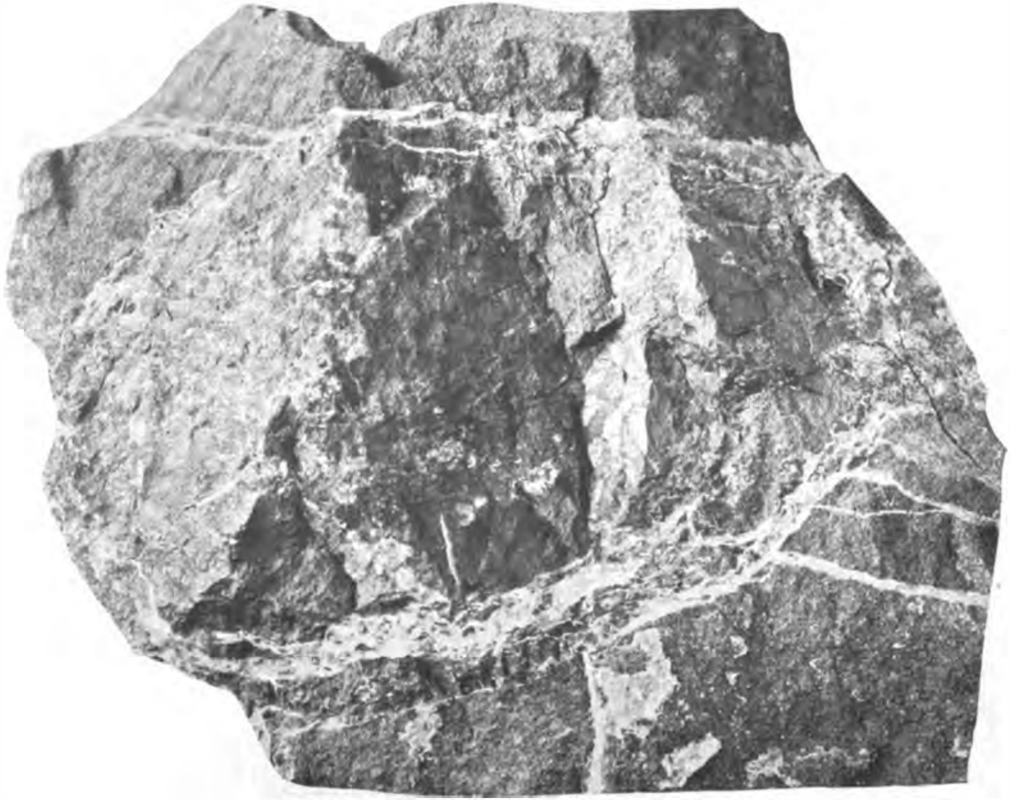
The Jo Dandy mine is high on the southwest side of Paradox Valley, in a sandstone of the McElmo formation, here dipping gently southward, away from the valley. The mine was worked in 1910 and 1911 for vanadium ore, which was shipped to England. Since then it has produced considerable carnotite ore.

When I visited the claim I was so fortunate as to be in the company of Mr. John I. Mullen, field superintendent of the Standard Chemical Co., to which the claim belongs. I was also peculiarly fortunate in the time of visit, because at that time the black vanadium-bearing sandstone was well exposed in the side of a drift in a somewhat eye-shaped section which followed the dip 7 or 8 feet and was between 2 and 3 feet thick. In the center was a dense black round spot 4 inches in diameter from which the mineral had evidently spread into the surrounding sandstone. Veinlets of gypsum cut the sandstone, and the black spot was both cut and outlined by them.



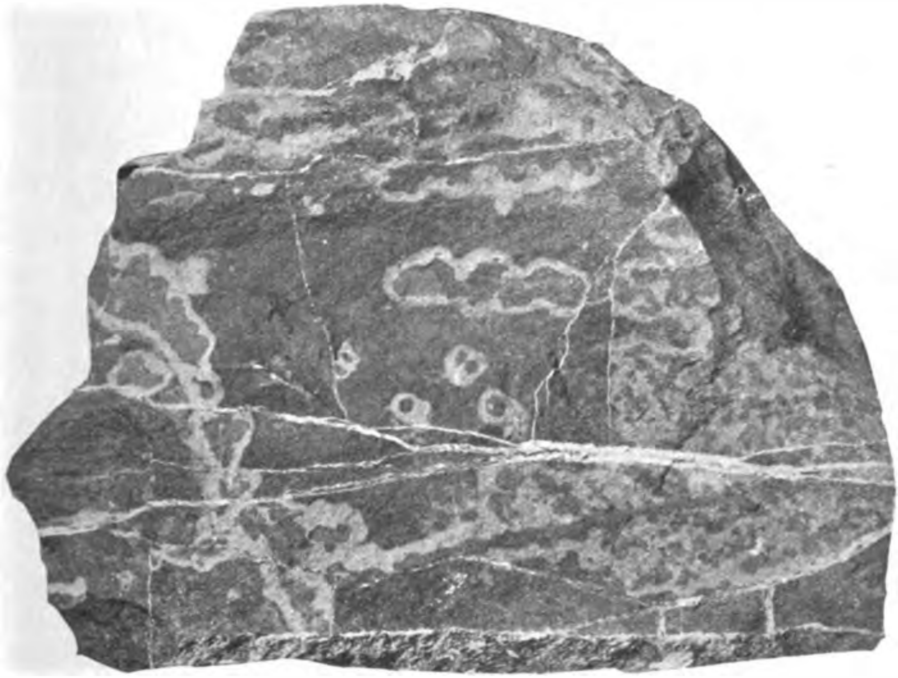
CROSS SECTION OF REPLACED WOOD IN SANDSTONE, JO DANDY MINE, PARADOX VALLEY, COLO.

The wood has been replaced by vanoxite, pyrite, and smaller quantities of other minerals. The white veins are gypsum, and gypsum outlines the replaced wood. The inclosing sandstone is impregnated with vanoxite and smaller quantities of other minerals. Three-fourths natural size.



DIAGONAL SECTION OF REPLACED WOOD SHOWN IN PLATE IV.

Three-fourths natural size.



SANDSTONE IMPREGNATED WITH VANOXITE SHOWING PECULIAR BLOTCHING DUE TO SEGREGATION OF THE VANOXITE, JO DANDY MINE, PARADOX VALLEY, COLO.

One-third natural size.

VANOXITE CRYSTALS EXTENDING INTO A GYPSUM VEINLET, JO DANDY MINE, PARADOX VALLEY, COLO.

Photographed through crossed nicols. Enlarged 125 diameters.

Mr. Mullen had a piece of rock containing the spot worked out for me, and it proved to be a replacement of wood. (See Pls. IV and V.)

In the mine the sandstone surrounding the fossil wood was damp and gave the impression of being entirely black, but after it was dried and placed in the light a peculiar blotching became apparent. Queer irregular black spots of sandstone are bordered by light-colored sandstone 2 to 6 millimeters (one-eighth to one-fourth inch) thick. (See Pl. VI.) The vanadium mineral has segregated into the blotches, and the light-colored sandstone, now almost or quite free from vanadium, is largely cemented by gypsum and faintly stained by iron. Some faces along cracks are coated thinly with the dark vanadium mineral and are blue-black. A somewhat brownish-yellow stain from uranium minerals appears as some of the specimens dry. It resembles uvanite (hydrous uranium vanadate, $2UO_3.3V_2O_5.15H_2O$) in color, but it is probably tyuyamunite, the lime carnotite. A mineral that is probably pintadoite (the green hydrous calcium vanadate, $2CaO.V_2O_5.9H_2O$) colors the sides of one crack, and a considerable number of rocks on the dump were stained by it. At other places in the mine hewettite (the red hydrous calcium vanadate, $CaO.3V_2O_5.9H_2O$) is found, and in places the rock is spotted with dots 12 to 13 millimeters (one-half inch) in diameter of a dark vanadium mineral. Part of the dots have an aureole of carnotite. The mineral in the dots was naturally supposed to be the same as that described in this paper, but microscopic examination shows it to be entirely different. I hope to describe it in another paper. The mass replacing wood is opaque in thin section except where cut by veinlets of gypsum. It polishes easily and appears jet-black with spots of pyrite, but the microscope shows it to be generally impregnated with pyrite. Although no cellular structure could be made out, on heating it gives off odors familiar in distilling coal. It contains no sand, and the uranium, vanadium, and iron minerals are replacements of the wood and not mere fillings of a cavity left by its decay.

Black crystals, the largest of which is about 0.25 millimeter (0.01 inch) long and about one-eighth as thick, extend into the gypsum veinlets. (See Pl. VII.) The thinnest parts of the crystals show no translucency. These are the largest crystals found. In the interstices of the sandstone similar crystals, which are also embedded in gypsum, reach a maximum length of about 0.04 millimeter (0.0016 inch). The thickness varies a good deal and ranges from possibly one twenty-fifth to one-fifth of the length. A few of the thinnest crystals show a brownish color. Owing to the extreme minuteness of the crystals it has been impossible to determine their optical properties. Some crystals have rhomboid sections. (See Pl. IX, *B*.)

In some of the sandstone the mineral has filled solidly the interstices between the sand grains, as shown in some places in Plate IX, *B*, although this is one of the most vuggy parts of the mass.

Analyses of two specimens of the best material sent by Mr. Egbert were made in the chemical laboratory of the United States Geological Survey by W. T. Schaller. One specimen (No. 1), besides the unknown mineral and quartz sand, contained gypsum, tyuyamunite, limonite, pyrite, and possibly other minerals. The other specimen (No. 2) was somewhat purer. The analyses of the two specimens and the calculated mineral contents are as follows:

Analyses of black sandstone from Jo Dandy mine, Paradox Valley, Colo.

[W. T. Schaller, analyst.]

No. 1.

Substance.	Per cent.	Tyuyamunite.	Gypsum.	Pyrite.	Remainder.	Recalculated to 100 per cent.	Molecular weight.	Molecular ratios.	
Vanadyl (V_2O_4)	11.93				11.93	53.1	166	0.320	2.2
Vanadium pentoxide (V_2O_5)	6.25	0.49			5.76	25.7	182	.141 }	1
Uranium trioxide (UO_3)	1.55	1.55			.11	.5	142	.004 }	
Phosphorus pentoxide (P_2O_5)	.11								
Ferric oxide (Fe_2O_3)	.94			0.94					
Water (H_2O)	[7.37]	.39	2.33		4.65	20.7	18	1.150	7.9
Lime (CaO)	3.78	.15	3.63						
Molybdenum trioxide (MoO_3)	0.11								
Sulphur trioxide (SO_3)	6.26		5.20	1.05					
Selenium (Se)	Trace.								
Silica (SiO_2):									
Insoluble	61.51								
Soluble	.19								
	100.00	2.58	11.16	1.99	22.45	100.0			

No. 2.

Substance.	Per cent.	Tyuyamunite.	Gypsum.	Limonite.	Remainder.	Recalculated to 100 per cent.	Molecular weight.	Molecular ratios.	
Vanadyl (V_2O_4)	22.56				22.56	50.9	166	0.307	1.9
Vanadium pentoxide (V_2O_5)	13.59	0.49			13.10	29.5	182	.162 }	1
Uranium trioxide (UO_3)	} [a] 2.58	{ 1.55			.11	.2	142	.001 }	
Phosphorus pentoxide (P_2O_5)									
Ferric oxide (Fe_2O_3)				0.94					
Water (H_2O):									
−110° C	3.13	.39	0.11	[b] .17					
+110° C	6.15				8.61	19.4	18	1.078	6.7
Lime (CaO)	.40	.15	.17		(.08)				
Sulphur trioxide (SO_3)	.24		.24						
Selenium (Se)	Trace.								
Silica (SiO_2)	51.35								
	100.00	2.58	0.52	1.11	44.38	100.00			

[a] The proportions of the three substances are treated as if the same as in analysis No. 1.
[b] Estimated as 15 per cent of the limonite.

The ratios for No. 1 give approximately the formula $2V_2O_4.V_2O_5.5H_2O$; for No. 2, $2V_2O_4.V_2O_5.7H_2O$. If the two sets of ratios are averaged they give 2.1, 1, and 7.5 respectively, or very close to $2V_2O_4$-

A.

B.

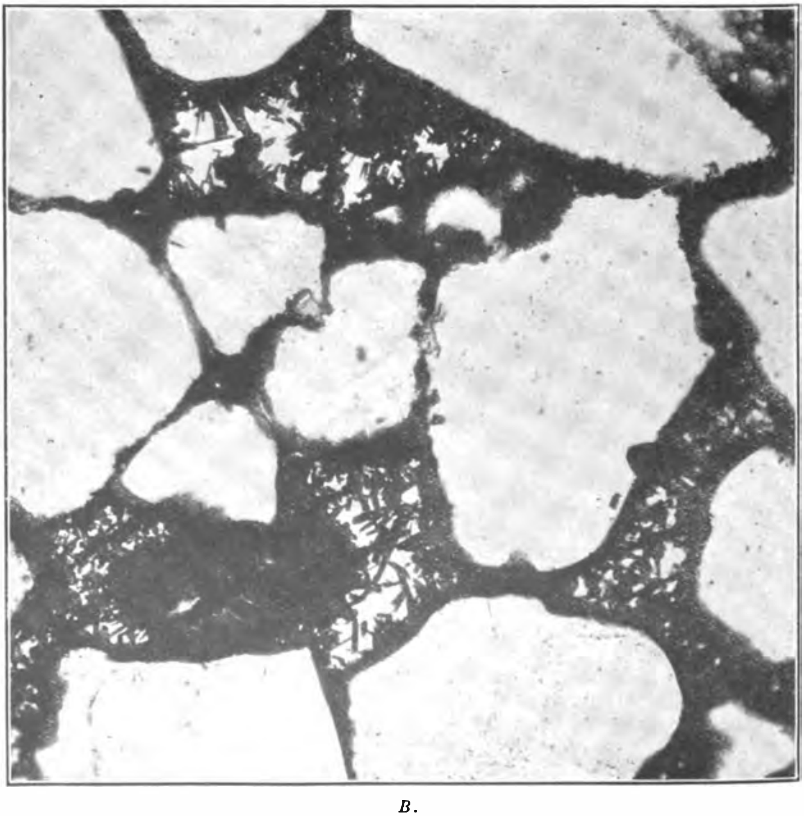
CONCRETION OF VANOXITE IN SANDSTONE, FROM BEATTIE & BEATTIE'S BILL BRYAN CLAIM, IN WILD STEER CANYON, ON THE SOUTH SIDE OF PARADOX VALLEY, COLO.

A and *B* are taken from opposite sides. The lighter spots in the prominent knob in *A* are carnotite with fossil plant remains. Similar material formed the core of the main part of the concretion. Natural size.

A.

UNDER SIDE OF THE CONCRETION OF VANOXITE SHOWN IN PLATE VIII.

The cracks shown in all three views (Pls. VIII and IX, A) are from the dehydration of the vanoxite.



B.

CRYSTALS OF VANOXITE IN INTERSTICES OF SANDSTONE, JO DANDY MINE, PARADOX VALLEY, COLO.

Enlarged 190 diameters.

$V_2O_5.8H_2O$. It is probable, as will come out in the discussion of this and other minerals, that the water content may be higher than is indicated by the formula.

I propose for this mineral the name vanoxite (van-ox'ite).

Vanoxite-bearing sandstone is also found in the Henry Clay claim of the Radium Co. of Colorado, at Long Park, on the northeast side of Paradox Valley, 5 miles north of the Jo Dandy claim. At this place some masses of sandstone are heavily impregnated with the mineral, so that thin sections show no trace of crystals, but only sand grains wholly embedded in the vanoxite, with a little pyrite. Where the mined rock was under cover so that the salt did not wash off during rains, the beautiful pascoite (an orange-colored soluble hydrous calcium vanadate, $2CaO.3V_2O_5.11H_2O$) was found on the surfaces.

Beattie & Beattie, of Naturita, Colo., sent to the United States Geological Survey a fine concretion of sandstone cemented by vanoxite from the Bill Bryan claim, in Wild Steer Canyon. (See Pls. VIII and IX, *A*.) A comparison of the views of this concretion with the forms shown in section in Plate VI indicates that they are very similar. In the Beattie & Beattie specimen two linear nuclei, along which the vanoxite formed, are crossed. The ends of the shorter nucleus are shown in Plate VIII. Here, as everywhere else in the carnotite deposits of the plateau region, there is fossil plant material, which is accompanied by some carnotite. When received at the Geological Survey this specimen was without crack. The shrinkage due to dehydration during the eight years that the specimen has been in the Survey is well shown in the views. Part of the specimen fell off and had to be glued back in place.

Other specimens, according to their richness and the degree to which vanoxite forms the cement for the sand grains, act similarly. When dried specimens are wetted they usually fall apart, apparently because the partly dehydrated vanoxite again takes up water and sets up new strains sufficient to break the rocks. The fine specimen shown in Plates VIII and IX, *A*, was almost destroyed by the wetting necessary to permit sawing off an end. Tiny shrinkage cracks may be seen between the sand grains in some thin sections. Such a specimen received from Mr. George Kunkle, from his claims 6 miles west of Gateway, Colo., is shown in Plate X, *C*.

The easy dehydration of the mineral, in which it resembles most of the other uranium and vanadium minerals of the region, makes it seem probable that the analyses must show very much less than the maximum quantity of water held. That the specimens were considerably dehydrated before analysis was begun was shown by shrinkage cracks, and grinding must have driven off more water, so the formula should probably be written $2V_2O_4.V_2O_5.(8+)H_2O$.