CORVUSITE AND RILANDITE, NEW MINERALS FROM THE UTAH-COLORADO CARNOTITE REGION

EDWARD P. HENDERSON AND FRANK L. HESS,*
U. S. National Museum.

INTRODUCTION

In the carnotite-bearing deposits of Colorado and Utah the sandstone and accompanying clays are impregnated with many dark brown and black mineral masses, which show no crystal form to the unaided eye and few other definite characteristics. The most common of the dark colored minerals are listed below.

Roscoelite	vanadium mica
Rauvite	$CaO \cdot 2UO_3 \cdot 6V_2O_5 \cdot 20H_2O$
Vanoxite	$2V_2O_4 \cdot V_2O_5(8\pm)H_2O$
Corvusite	$V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$
Rilandite	hydrous chromium aluminum silicate
Lignite	
Tar (?)	
Asphaltite	
Psilomelane	
Iron-copper-cobalt oxide.	

Two of the names, corvusite and rilandite, are new and are proposed in this paper. The authors hesitated to give names to such compounds as those to which they are applied because no entirely satisfactory formula can be offered for either, but since the substance called corvusite is common in the carnotite region a verbal handle seems necessary. Rilandite, although at present known from only one locality, was obtained in rather large quantity and its association is such that it seems likely that it will be obtained from other places in the carnotite region. If at some future date further study shows these names unnecessary they can easily be relegated to oblivion.

GENERAL RELATIONSHIPS

Roscoelite or a similar dark mineral is provisionally identifiable by the microscope from many places in this region. Roscoelite is well known, rauvite and vanoxite[1] and the asphaltite[2] have been

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[1] Hess, Frank L., New and known minerals from the Utah-Colorado carnotite region: *U. S. Geol. Surv. Bull.* **750**, pp. 63–78, 1924.

[2] Hess, Frank L., Uranium-bearing asphaltite sediments of Utah: *Eng. and Min. Jour. Press,* vol. **114**, No. 7, pp. 272–276, 1922.

described previously, and the other dark minerals are described in this article.

In the specimens from which vanoxite was described, spaces between part of the sand grains were filled solidly with a black, or deep brown, mineral which exhibited shrinkage cracks that were inconsistent with a crystalline mineral. At that time it was not shown that this material was another mineral. When some of these specimens were viewed at certain angles the material had a purplish or bluish luster.

Some years ago one of us (F.L.H.) visited the Jack Claim, at that time owned by R. G. Hart and A. L. Tomlinson, on the east side of La Sal Mountains, Grand County, Utah, and about 10 miles west of Gateway, Colo., in which Mr. Hart had found peculiarly beautiful segregations of a mineral with a bluish luster much more pronounced than that of the previous material, and in masses evidently nearly pure. The best specimen, about 2½ inches square by 2 inches thick, was kindly presented to Mr. Hess and is now in the United States National Museum (No. 96806).

The material was found in sandstone of Morrison age (formerly called McElmo by the United States Geological Survey) beside a petrified log which was considerably decayed before petrifaction.

Carnotite and related minerals of the "carnotite region" of southwestern Colorado and southeastern Utah are found only with organic material, and in order to show the relations of the black minerals some discussion of the occurrence of both organic and dark vanadium minerals is necessary.

The vegetal remains take three ordinary forms: (1) macerated leaves and stems; (2) bundles or rolls of plants, like the twisted rolls of sea-weeds found on some present day beaches; and (3) wood ranging from twigs to logs 100 feet long and 6 feet or more thick at the butt. Besides these there are saurian bones and occasional bits of lignite which, however, have had little influence on the uranium and vanadium minerals. The first two forms of vegetal material are carbonized. The wood is petrified, and only where it was considerably decayed before petrifaction has there been any considerable deposition of uranium and vanadium minerals.

Black or dark roscoelite (or a closely related mineral) forms in halos and in thin zonal bands around the vegetal matter, including the wood, and is the commonest of the black minerals. In places it forms layers in the outer zonal bands so dense that the sandstone breaks away from them as if from distinct bedding planes and leaves rounded surfaces which are locally known as "rolls." The sandstones are cross-bedded and "rolls" cut through the cross-bedding planes at all angles. (Fig. 1.) In other words the halos or "rolls" are reversed concretions—they have moved outward from a center instead of toward it.

FIG. 1. A "roll" in sandstone formed by black roscoelite, in Morrison sandstone, Maverick Camp, 10 miles southeast of Gateway, Colo.

Roscoelite does not always form definite bands but it is sometimes found diffused through the sandstone in such a way as to give it a gray color, and even when spreading from a piece of fossilized wood it may diffuse gradually and have no definite boundary. (See Fig. 2.) In the densest bands and in some other places it is so black that it is difficult to distinguish from other black minerals except by means of the microscope.

Another black vanadium mineral forms massive aggregates which usually lie near the site of the minerals originally formed in the sediments, but its relationships are not always clear as it may travel a considerable distance from the nucleus. Except for roscoelite, it is found in greater quantity than any other of the dark minerals of the carnotite region. A black tarry substance exudes from some of these samples. The material studied from the Jack Claim and described farther on is believed to be of this type, but it contained no organic matter.

In places patches of sandstone are irregularly blotched and spotted by black minerals and sometimes impregnated with carno-

FIG. 2. Black roscoelite halo around a piece of fossil wood (now removed) in Morrison sandstone. East side of Carrizo Mountains, New Mexico.

tite and allied minerals. Thin sections made from the black spots show vanoxite which is recognized by its crystal habit. Other black or nearly black minerals are also found which are, at present, assumed to be uranium minerals, but these have not been found in sufficiently pure segregations to be profitably studied.

Small pieces of lignite are enclosed in the sandstone and Kithil[3] has described one which contained uranium. Samples of the type lignite have been reexamined and it was found that the lignite itself is not radioactive. The specimens were in contact with the sensitive

[3] Kithil, Karl L., On the occurrence of a probable new mineral: *Science*, vol. **38**, pp. 624–25, 1913.

side of a photographic plate for four days and where free from visible carnotite did not affect the plate.

Rilandite, a peculiar black chromium compound, described in this article, is also found in the Morrison sandstone. Manganese dioxide discolors the sandstone in many places and in Sinbad Valley black spots which are composed of a mixture of iron, cobalt and copper oxides are found; at Temple Rock, shiny asphaltite carrying uranium, vanadium and other elements occurs. These last two occurrences are not in the Morrison formation, but are in lower rocks.

Corvusite

The name corvusite is derived from the latin word for raven (corvus), since this mineral has a purplish bluish-black color similar to that of a raven.

It is strange that although the mineral here described as corvusite is one of the commonest of the black minerals in the carnotite region, yet specimens suitable for analysis are very rare. The best material (Museum No. 96806) was that already referred to as collected from the Jack Claim located about 10 miles west of Gateway, Colo. Samples which are dark brown, instead of black, were collected from the Ponto No. 3 claim of the former W. L. Cummings Chemical Co., on the north wall of Gypsum Valley, San Miguel Co., Colo., at least 40 miles south and slightly east of the Jack Claim.

The best specimen has a purplish blue-black color and is massive, but due to the slickensides, shown on the material studied, it somewhat suggests a fibrous material. In its luster and slickensiding it is reminiscent of rauvite. There are numerous shrinkage cracks in the samples, some filled with gypsum and fervanite, and others open. The hardness is between 2.5 and 3, the fracture is conchoidal, and the specific gravity, determined by heavy solutions, is 2.82. The difference in color between the blue-black and brown specimens is explained by the higher iron content of the brown material (about 10 per cent Fe_2O_3). The streak of the two varieties is the same as the color of the specimens. The chemical compositions of the two types are so nearly alike that there is little doubt but that they are practically the same material.

Both types are soluble in mineral acids, but before complete decomposition is effected the color of the purplish blue material changes to a distinct brown, and is then more slowly soluble. At room temperatures, probably between 20° and 30°C, distilled water dissolved 8.10 per cent vanadic oxide, V_2O_5. Tests were made for the lower oxide of vanadium, V_2O_4, but none was found to be present.

The mineral being practically opaque under the microscope, the material analyzed was obtained by hand picking the coarsely crushed powder, selecting only the pieces which had the purplish blue or brown color, and, to the eye, were free from impurities.

ANALYSIS OF THE PURPLISH BLUE-BLACK CORVUSITE
E. P. Henderson, analyst

Oxide	Per cent	Recalculated	Molecular values
Insol.	1.08		
Sol. SiO_2	0.30		
Na_2O	1.44	1.46	.0235
K_2O	1.06	1.08	.0115
CaO	1.98	2.01	.0359
MgO	0.27	0.27	.0068
Fe_2O_3	5.82	5.93	.0371
V_2O_4	9.67	9.82	.0614
UO_3	1.71	1.74	.0064
V_2O_5	64.89	65.86	.3617
H_2O	11.68	11.87	.6585
	99.90	100.04	

The molecular ratios have been combined in many different ways yet no entirely satisfactory formula was obtained which included all the various elements found, therefore only the tentative formula, $V_2O_4 \cdot 6V_2O_5 \cdot X\ H_2O$, is proposed.

THE DULL BROWN CORVUSITE. The physical properties of this variety (Museum No. 96807) agree in general with those of the purplish material, but the streak is yellowish brown. Suggestions of a purplish color are also visible in the brown material.

Several years ago W. T. Schaller analyzed some dark colored vanadium compounds (collected by F.L.H.) from the same claim. His analyses have not been previously published and by his courtesy they are given in a following table for comparison.

The most striking similarity between these analyses is in the constant ratios between the two vanadium oxides V_2O_4 and V_2O_5. The average ratio of these four analyses is almost exactly 1 V_2O_4 to

Analysis of the Dull Brown Corvusite
E. P. Henderson, analyst

Chem. symbol	Per cent	Recalculated for insoluble	Ratios
Insol.	21.52		
Sol. SiO_2	3.30	4.21	.0694
MoO_3	0.22	0.28	
CaO	0.32	0.40	.0071
MgO	1.63	2.07	.0513
Na_2O	0.98	1.24	.0200
K_2O	1.69	2.15	.0228
V_2O_4	5.99	7.62	.0458
V_2O_5	39.78	50.68	.2785
Fe_2O_3	9.58	12.20	.0764
UO_3	2.31	2.94	.0102
H_2O	12.32	15.83	.8785
	99.64	99.58	

Analyses of Corvusite from the Carnotite Region

	E. P. Henderson, analyst		W. T. Schaller, analyst	
	Purple	Brown	Dark purple-black	Dull brownish black
	1	2	3	4
Insol.	1.08	21.52	0.16	0.17
Sol. SiO_2	0.30	3.30	0.63	2.19
CaO	1.98	0.32	1.85	1.70
MgO	0.27	1.63	Not det.	Not det.
V_2O_4	9.67	5.99	10.26	10.13
K_2O	1.06	1.69	Not det.	Not det.
Na_2O	1.44	0.98	Not det.	Not det.
V_2O_5	64.89	39.78	69.00	65.24
Fe_2O_3	5.82	9.58	1.69	0.99
UO_3	1.71	2.31	1.16	3.12
H_2O	11.68	12.32	13.52	14.09
MoO_3	Not det.	.22	.16	.18
	99.90	99.64	98.43	97.81

Comparison of Ratios between V_2O_4 and V_2O_5

V_2O_4	.0582	.0360	.0618	.0610
V_2O_5	.3566	.2186	.3792	.3586
V_2O_4	1	1	1	1
V_2O_5	6.01	6.07	6.02	5.87

$6(5.99)V_2O_5$. The samples were collected from different areas in the field and the material was independently prepared and analyzed by two analysts, and it is difficult to see how this constant ratio would result unless there is a compound formed between the two vanadium oxides. The name corvusite is proposed for the compound $V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$. All of the analyses have a rather similar water content yet it is impossible to determine how much of the water belongs with corvusite and how much is combined with the extraneous matter present.

Vanoxite has a black color and even if the general appearance of corvusite were mistaken for vanoxite the two compounds are so different chemically that it is easy to distinguish between the two.

Vanoxite $2V_2O_4 \cdot V_2O_5 \cdot 8H_2O$
Corvusite $V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$

Rilandite, a New Chromium Mineral

The black material described here is from a claim located for carnotite by Mr. J. L. Riland, the veteran newspaper publisher of Meeker, Colorado, and was sent some years ago to one of us (F.L.H.) after a visit to the claim. It seemed incredible that a black material of the weathered zone could contain such high percentages of chromium. Recently E. P. Henderson visited the claims and Mr. Riland reported finding the mineral in a number of petrified logs. He also presented the U. S. National Museum with additional specimens (No. 96808). Mr. Riland's carnotite claims are a little more than 13 miles east and somewhat north of Meeker and are in sandstone which is apparently in the lower part of the Morrison formation, and therefore of the same age as the carnotite deposits in the better known area in southwestern Colorado and southeastern Utah. The sandstone was at first erroneously identified as Dakota (Cretaceous) by Gale,[4] but in a later paper[5] they were referred to the Jurassic.

[4] Gale, H. S., Carnotite in Rio Blanco County, Colo.: *U. S. Geol. Surv. Bull.* **315**, pp. 110–117, 1907.

[5] Gale, H. S., Carnotite and associated minerals in western Routt County, Colo.: *U. S. Geol. Surv. Bull.* **340**, pp. 258–259, 1908.

The material under consideration was found with a fossil log, but in no great quantity. It is not known to have been found elsewhere, although other chromium minerals have been found in the sandstones of the carnotite region. Gale[6] says that at the carnotite deposits in Routt County some of the sandstone is stained by a chromium mineral and Ransome collected, near Sinbad Valley, sandstones probably of La Plata age that were stained green by a chromium mineral.[7] At Placerville a chromium mineral, probably mariposite,[8] is found both with a vein in a Dolores (?) limestone, and with vanadium deposits in the overlying La Plata sandstone. On the southwest side of the La Sal Mountains, Utah, small quantities of a chromium bearing chloritic mineral were found (by F.L.H.) filling tiny cracks in Morrison sandstones.

Description of the Material. Mr. Riland's material in some ways resembles dull pitch. It is massive, compact, with a dark brownish black color and breaks with a flat conchoidal fracture into granules some of which show a rather brilliant surface. When a quantity is spread out for study it is noticed that in general it has an angular platy habit.

It is very brittle, the hardness is between 2 and 3, and the streak is grayish brown.

In a few places there are films of a greenish alteration product, but other than this slight film there is nothing about the specimen suggesting a compound that is nearly half chromic oxide.

The chromium bearing material is confined to the outer surfaces of the petrified wood although it fills shallow recesses. The addition of the compound to the wood took place after the wood had been petrified as there is no evidence of any dark pigment in the inner portions of the specimen, and no woody structure is noticeable in the chromium material, but when pieces are broken off from the outside, the imprint of the wood is rather conspicuous.

The fossil wood was referred to Mr. C. B. Read of the United States Geological Survey who reports:

"This specimen shows the typical early cupressinoid type of wood structure. It compares in some respects with *Cupressinoxylon*

[6] *Op. cit.*, p. 261.

[7] Hillebrand, W. F., and Ransome, F. L., On carnotite and associated vanadiferous minerals in western Colorado: *U. S. Geol. Surv. Bull.* **262**, p. 14, 1905.

[8] Hess, Frank L., Notes on the vanadium deposits near Placerville, Colorado: *U. S. Geol. Surv. Bull.* **530**, pp. 148 and 151, et. al., 1917.

macrocarpoides, Penh. from the Cretaceous of Canada, but the indifferent preservation will not allow a critical study."

The sample was prepared for chemical analysis by selecting a number of pieces and brushing each piece with a stiff brush to remove the adhering brownish film of dust. It was hand-picked a second time and only those pieces which had a brilliant black surface were selected. The only assurance that the selection was uniform was the appearance under the binocular because the compound is almost opaque under the microscope.

Analysis of Rilandite

E. P. Henderson, analyst

		Ratios		
SiO_2	9.98	.1646	.1646	1
Cr_2O_3	47.59	.3093	.4911	3
Al_2O_3	18.58	.1818		
Fe_2O_3	4.38	.0274*		
CaO	1.32	.0235		
MgO	1.18	.0293		
H_2O	16.64	.8824*	.8750	5.3
	99.67			

* Fe_2O_3 4.38 corresponds to 5.12% limonite.
5.12% limonite requires 0.74% minus correction on H_2O.

This analysis is not reducible to simple molecular ratios. The iron is possibly present as limonite and if so taken the ratio be-

Wolchonskoite from Okhansk, Siberia

	1	Ratios	2	Ratios
SiO_2	37.01	.6138	36.84	.6109
Al_2O_3	6.47	.0633	3.50	.0342
Cr_2O_3	17.93	.1183	18.85	.1244
Fe_2O_3	10.43	.0653	17.85	.1118
Mn_2O_3	1.66			
MgO	1.91	.0474		
H_2O	21.84	1.2121	22.46	1.2465
PbO	1.01			
K_2O	trace		CaO 1.39	.0248
			100.89	

tween SiO_2 and R_2O_3 is 1:3; however, this is purely an arbitrary assumption. No suggestions can be made concerning the manner in which calcium and magnesium are combined. If the molecular ratio for H_2O is corrected for the theoretical quantity of water which must combine with iron to form limonite, a ratio of 5.3 for H_2O remains. We propose for the material the name rilandite. Wolchonskoite is chemically more nearly related to this material than any other compound described in the literature. The following analyses are taken from Dana.[9]

Since this is the only occurrence of this compound so far known, all that can be done at this time is to state the analysis and the ratios obtained. No definite formula is proposed.

It can readily be seen that there is a great difference between rilandite and wolchonskoite. In the National Museum's collections are specimens of wolchonskoite, from Okhansk, Siberia, which have a pronounced olive green color, and occur as a green clay-like mass in a brown sandstone.

A sample of analyzed rilandite from Routt County was given to Dr. E. Posnjak for *x*-ray study. He reports that the material, at least a large portion of it, is not amorphous. The diffraction lines are broad and the primary particles may be very small. Some of the lines correspond closely with the beidellite type of clay, although there are several strong lines that are different.

[9] Dana, J. D.; Dana, E. S., *A System of Mineralogy*, 6th ed. p. 696, **1892.**