

# CARNOTITE NEAR MAUCH CHUNK, PENNSYLVANIA.

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## INTRODUCTION.

The occurrence of carnotite near Mauch Chunk, Carbon County, Pa., was noted by the writer in 1908<sup>1</sup> and was fully described by him four years later.<sup>2</sup> The recent increase of interest in carnotite as a source of radium has made it seem worth while to prepare this additional note, placing on record the results of further chemical examination of the mineral and discussing the possible commercial value of the deposit, a point which was not touched on in the previous articles.

## LOCATION.

The exact locality is the eastern termination of Mount Pisgah, about three-quarters of a mile north of the town of Mauch Chunk. The Central Railroad of New Jersey swings around the end of this ridge near the river level. About 100 feet higher up the slope is the highway from Mauch Chunk to Nesquehoning, Lansford, and Tamaqua. Just inside of this is an electric railroad line, to make place for which it has been necessary to cut a shelf about 2,000 feet long into the mountain side, the cut forming a rock wall that is 30 feet high at the east end and that gradually decreases in height toward the west. It is on this rock wall that the carnotite appears as an irregularly distributed but prominent yellow stain.

## HISTORY.

The presence of a uranium mineral at this locality was noted as early as 1874,<sup>3</sup> but it was identified as autunite, the absence of phosphorus and the presence of vanadium escaping notice. Mr. John Eyerman, of Easton, Pa., informs the writer that the *New York World* in September, 1886, contained an article on the discovery of "metallic uranium" at Mauch Chunk, and that specimens obtained by him at that time showed a yellow coating, but that the specimens were not examined chemically. Thus twice was the opportunity lost

<sup>1</sup> *Science*, new ser., vol. 29, p. 751, 1909.

<sup>2</sup> *Am. Jour. Sci.*, 4th ser., vol. 33, pp. 574-580, 1912.

<sup>3</sup> Genth, F. A., *Second Pennsylvania Geol. Survey*, Rept. B, p. 144, 1874.

to discover the mineral which in 1899, after an examination of specimens from Colorado, was described as carnotite.<sup>1</sup> The true nature of the Mauch Chunk material was discovered by the writer in 1908, when it was regarded as of no more than scientific interest, but inasmuch as material containing as little as 1 per cent of uranium oxide now finds a ready market for the preparation of radium salts, this deposit may prove to be worth prospecting, for it certainly contains some material of this grade, although the quantity apparently is small.

### GEOLOGY.

The carnotite occurs in a 40-foot layer of coarse-grained conglomerate lying near the base of the Pottsville formation (Pennsylvanian) and just above the red Mauch Chunk shale (Mississippian). The strata dip 30°–60° S., into the mountain, and as the road follows the strike, the same bed is exposed throughout the cut. The rock consists of a rudely stratified mass of well-rounded pebbles, chiefly of white quartz, but in part of gneiss, crystalline limestone, and serpentine, averaging about 1 inch in diameter, though a few attain 6 inches. There are also lenses of dark-gray shale which show, under the microscope, in the midst of kaolin and quartz fragments; scattered grains of dark silicates and iron oxides.<sup>2</sup> These shale lenses are irregular in size and distribution, but one 4 feet long and 8 inches thick was noted. The cement of the conglomerate is in most places silica, the rock being a very hard quartzite, but here and there calcite takes the place of quartz. In the uptilting of the strata there has been considerable slipping of the beds on one another, as shown by slickensides on many of the surfaces.

The carnotite is thoroughly but unevenly distributed throughout the conglomerate. In the harder quartzitic variety it fills the few openings there may be, especially cracks in the pebbles themselves, and spreads over some of the slickensided surfaces; but by far the greater part of it appears as a replacement of the calcareous cement of certain portions of the conglomerate. These bodies formed by replacement are extremely irregular in size and shape, but most of them are only a few inches in diameter, although one near the east end of the cut is more than 10 feet wide. How far into the mountain these pockets extend it is impossible to say, but as the carnotite has evidently been deposited by the circulating surface waters—in fact, it can be seen in course of deposition where streams trickle out of cracks at the present time—it probably does not extend below the ground-water level and may be restricted to a very shallow zone.

<sup>1</sup> Friedel, C., and Cumenge, E., *Compt. Rend.*, vol. 128, p. 532, 1899.

<sup>2</sup> An unintentional misstatement in the writer's previous paper (p. 578) may be corrected here. It was stated that the shales "do not owe their color to carbon \* \* \* but \* \* \* chiefly to the presence of hornblende," etc. This should read: "They do not owe their color entirely to carbon," for an actual test shows the presence of considerable carbonaceous matter.

## COMPOSITION OF THE CARNOTITE.

In the previous description of the material only an incomplete chemical analysis was given, for its impurity was so evident that it seemed a waste of time to do more than establish its general nature. After the appearance of the article, however, Dr. W. F. Hillebrand, of the Bureau of Standards, informed the writer that he had discovered a nearly pure calcio-carnotite<sup>1</sup> among specimens from Colorado, and suggested that if possible a redetermination of the potassium and calcium be made in the Pennsylvania material, so as to fix more certainly its position in the series.

A sample was accordingly separated from the gangue as carefully as possible and these elements determined, potassium by the chloroplatinate method and calcium as the oxalate. At the time it seemed worth while to check the values for uranium and vanadium, and since these had previously been determined volumetrically they were this time separated by the nitric acid evaporation method and weighed as oxides. As before, Mr. J. S. Long, of the department of chemistry of Lehigh University, assisted in the work, and thanks are here extended to him. The results of the analyses follow:

*Analyses of carnotite from Mauch Chunk, Pa.*

	1	2	3	4	5	Mol. No.
V <sub>2</sub> O <sub>5</sub> .....	7.2	21.1	9.80	21.73	21.34	1
UO <sub>3</sub> .....	23.8	69.8	31.11	68.99	67.64	2
K <sub>2</sub> O.....	(1.6)	4.7	3.55	7.86	11.02	1
CaO.....	1.5	4.4	.64	1.42	.....	.....
H <sub>2</sub> O.....	10.5	.....	7.13	.....	.....	.....
Fe <sub>2</sub> O <sub>3</sub> .....	6.1	.....	17.68	.....	.....	.....
Insoluble.....	49.3	.....	29.62	.....	.....	.....
	100.0	100.0	99.53	100.00	100.00	.....

1. Previous analysis; K<sub>2</sub>O by difference.
2. Same, recalculated after deducting insoluble matter, water, and Fe<sub>2</sub>O<sub>3</sub>.
3. New analysis.
4. Same, recalculated as above.
5. Theoretic composition of potassio-carnotite on water-free basis.

Although here, as before, the admixture of silica, limonite, etc., in the material analyzed renders its exact nature somewhat doubtful, the uranium and vanadium oxides approach the 2:1 ratio characteristic of the autunite group. The relative amounts of potassium and calcium evidently vary from one specimen to another at this locality, but the presence of a carnotite high in potassium is now established.

<sup>1</sup> In explanation of the nomenclature here used it may be pointed out that calcio-carnotite has now received a separate name, after the locality in Turkestan, Russia, where it occurs; this name is tjuyamunit in German, or, as it should be transliterated into English (rules of the Royal Society, the American Chemical Society, etc.), tyuyamunit. It is questionable, however, whether the introduction of such unnecessary new names into mineralogy is desirable. The writer favors applying the term carnotite to the isomorphous series as a whole and using potassio-carnotite and calcio-carnotite to describe the end members.

**ORIGIN OF THE DEPOSIT.**

The question how the mineral was formed can be readily answered. It evidently is simply a precipitate from the ground water and can be seen in the process of formation where water trickles out through cracks in the rocks. The real problem concerns the source of the uranium and vanadium dissolved in the water, for the region is notably free from all phenomena of igneous activity and deep-seated veins. The problem, moreover, is not merely of local significance nor limited to these metals; it is a part of the greater problem of the origin of the whole group of syngenetic sedimentary deposits, of copper shales, bedded iron and manganese ores, and other metalliferous strata, and the results obtained in the study of one phase of the problem may apply more or less to many others.

If carnotite had been known when all strata were thought to be of marine origin, it would no doubt have been assumed that uranium and vanadium have been precipitated from the sea water, in which, like gold, they are of course present in extreme dilution; but now that the importance of continental deposition is recognized the matter becomes simpler. It is no longer necessary to assume concentration from almost infinitely dilute solutions. If these metals occur in the earlier rocks surrounding a given basin of continental deposition, they may become concentrated in the sediments in two ways: If the climate is such that decomposition exceeds disintegration, they may be dissolved by the rain water, carried down by the rivers, and, if these flow into lakes without outlet, become concentrated to such an extent as to be precipitated. If, on the other hand, the climate is so dry that disintegration is in excess of decomposition, mechanical transportation of the various minerals will take place, and those containing the heavy metals will be concentrated more or less completely into "black sand" lenses, because of their high specific gravities compared with that of quartz, which, as a rule, will make up the bulk of the sediment.

Mr. Frank L. Hess, in a recent paper on the origin of the western carnotite deposits, read before the Geological Society of Washington, has applied the first of these explanations to those deposits; but, as pointed out in the writer's previous paper, the second is the only one which seems applicable to the Mauch Chunk occurrence. Uranium-bearing minerals are common in pegmatites and vanadium-bearing dark silicates in gneisses throughout the pre-Cambrian and early Paleozoic crystalline rocks surrounding this region, and the climate of late Mississippian time is believed to have been decidedly dry, so that everything would seem to favor the operation of the process suggested by the second explanation.

**COMMERCIAL VALUE OF THE DEPOSIT.**

Present knowledge of the deposit is insufficient to warrant any statement as to its workability. The total area covered by the carnotite-bearing lenses is more than 50 square feet. As the rock weighs about 160 pounds to the cubic foot, every foot of its extent back from the rock wall would represent 4 tons. Analysis of a small specimen gave 4.4 per cent of uranium oxide, but this was a rich sample and it is doubtful whether much of the material runs over 1 per cent. However, as the cost of shipping the ore to consumers would be far less than that for the Colorado deposits, a profit of \$25 a ton could be expected even on 1 per cent ore, and conservative prospecting of the deposit is to be recommended.

