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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STRATEGIC MINERALS INVESTIGATIONS
PRELIMINARY MAP

GEOLOGIC MAP OF THE GATEWAY AREA, MESA COUNTY, COLORADO, AND THE ADJOINING PART OF GRAND COUNTY, UTAH

Base from aerial photographs, land survey divisions from General Land Office plats adjusted to observed land corners as plotted on photographic base.

1 0 1 5 Miles

Geology by W. L. Stokes, R. T. Russell, R. P. Fischer, and A. P. Butler, Jr.
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EXPLANATION

- Kd — Dakota(?) sandstone (Cretaceous)
- Jm — Morrison formation (Jurassic)
- pJm — Pre-Morrison formations (Jurassic and older)
- Morrison contacts, dotted where inferred
- Base of main ore-bearing sandstone; dotted where inferred
- Fault showing downthrown side; dashed where not accurately located
- Strike and dip of beds
- Horizontal beds
- Vanadium-uranium mine or prospect
- Located land corner
- BM 4563.9 — U.S. Coast and Geodetic Bench mark with elevation

FIGURE 2- MAP SHOWING VANADIUM DEPOSITS AND MINE WORKINGS ON PART OF CALAMITY GROUP OF CLAIMS
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FIGURE 1- MAP SHOWING AXIS OF SYNCLINE AND BELT OF CLOSELY SPACED VANADIUM DEPOSITS

VANADIUM DEPOSITS IN THE GATEWAY AREA, MESA COUNTY, COLORADO, AND THE ADJOINING PART OF GRAND COUNTY, UTAH

By W. L. Stokes and R. P. Fischer

In the course of investigation of the domestic vanadium resources by the Geological Survey, United States Department of the Interior, the vanadium ("carnotite") deposits in the Gateway area, Mesa County, Colo., and in the adjoining part of Grand County, Utah, were examined and mapped during parts of 1942, 1943, and 1944. The work in 1943 was in cooperation with the Bureau of Mines, as part of a Federal prospecting project for vanadium. In addition to the writers, A. P. Butler, Jr., and R. T. Russell participated part-time in the field work, which was under the direct supervision of R. P. Fischer. Thanks are due to Mr. W. S. Burbank for helpful suggestions concerning the map and text. The accompanying map shows the distribution of the known vanadium deposits and the outcrop of the ore-bearing Morrison formation. The map base was compiled from aerial mosaics, which were prepared by the Soil Conservation Service.

The area is part of a ruggedly dissected plateau. Most of the canyons are steep-walled, and in many places vertical cliffs a hundred or more feet high extend continuously for several miles. Altitudes range from about 4,500 feet along the Dolores River to about 8,000 feet on the plateau surface a few miles away.

Mining in the area began as early as 1914, but all individual deposits have been worked in a desultory manner, and in some years in the late twenties and early thirties no production is recorded for the entire area. Before 1924 the ore was mined principally as a source of radium, and since then principally for vanadium. A small mill at Gateway has operated intermittently since it was built in 1936, but except for the ore treated there, all of the ore mined has been shipped from the area for treatment. The ore production data summarized below was compiled from the files of the Bureau of Mines, individual operators, and Metals Reserve Co., and it is believed to be nearly complete.

Production of "carnotite" ore in the Gateway area, Mesa County, Colo., and the adjoining part of Grand County, Utah

Period	Short tons (rounded figures)	Approximate average grade (percent V_2O_5)
1914-23	3,500	?
1924-39	3,500	4
1940-44	30,000	4
		2-2½

Geology.—The rock formations in the area consist mainly of continental sediments of late Paleozoic and Mesozoic age. A broad northeast-trending syncline, into which the rocks dip at low angles from the Uncompahgre Plateau uplift on the northeast and from the Sinbad Valley anticline and the La Sal Mountains on the southwest, extends through the central part of the area (see fig. 1).

The Morrison formation of Jurassic age, which contains all the known vanadium deposits in the area, is 600 to 700 feet thick, and it consists of two easily distinguished parts. The lower and upper parts of the formation are 260 and 410 feet thick, respectively, at the Calamity group of claims on Calamity Creek in the east-central part of the area, and at the Corvusite mine on Beaver Mesa 12 to 14 miles to the west they are 220 and 280 feet thick, respectively. The lower part is composed of lenticular beds of gray, medium-grained, current-bedded sandstone, alternating with and replacing red and sandy clay and mudstone; these beds are regarded as channel, mud-flat, and flood-plain deposits of fluvial origin. A zone of widespread, bench-forming sandstone beds at the top of the lower part contains most of the important vanadium deposits, but sandstone beds as much as 50 feet above and 50 feet below this zone also contain deposits in places. The upper part of the Morrison is composed of light-colored, soft, bentonitic clay and mudstone with a few sandstone lenses.

The Dakota (?) sandstone of Cretaceous age overlies the Morrison formation, and it consists of 100 feet or more of sandstone, shale, and conglomerate, all dominantly gray or brown. It is cliff-forming and caps the high mesas. The Entrada sandstone of Jurassic age crops out in a light-colored, smooth-weathering cliff, called the "slick rim" by the miners, and is a distinctive datum about a hundred feet below the Morrison formation. The formations below the Entrada are dominantly reddish and consist of sandstone and shale.

Ore deposits.—The vanadium ("carnotite") deposits in the area shown on the map are similar in mineralogy and occurrence to those in the neighboring parts of Colorado and Utah. The ore consists principally of a fine-grained, gray, micaceous mineral that coats the sand grains and partly or entirely fills the pore spaces of the sandstone, but generally some bright-yellow carnotite is mixed with this mineral. In a few places the ore minerals are chiefly dark-colored vanadium oxides. Run-of-mine ore of these types contains from 1 to about 5 percent V_2O_5. Fossil plant remains—logs and branches—are relatively abundant in the ore-bearing sandstone, and they show various states of preservation or alteration to coaly matter. Some of this plant material is richly mineralized, mainly with carnotite, which either replaces the wood or remains or partly fills cavities left by the decay of the wood. Commonly the sandstone surrounding the plant remains is well mineralized. Fossil logs in the Gateway area have yielded valuable amounts of high-grade carnotite ore. Clay pebbles and sandy shale beds within and underlying mineralized sandstone commonly contain some vanadium.

The ore bodies range from small masses only a few feet across and irregular in shape, containing only a few tons of ore each, to large tabular bodies of irregular outline and a couple hundred feet across, containing several thousand tons of ore. Deposits of average size in the area contain perhaps 100 tons each. The tabular bodies consist of one or more layers of ore that lie essentially parallel to the enclosing beds but do not follow the beds in detail. These layers are too thin to mine in parts of many deposits, but they may connect ore masses of minable thickness, and thus are followed as leads in prospecting and mining. Many masses of minable ore, including some of those in the tabular bodies as well as some that individually make small ore bodies, crudely resemble cylinders. They are elongate essentially parallel to the sandstone bedding, wherever the lateral boundaries are well defined, the edge of the ore crosses the bedding planes in a smooth curve. These cylindrical ore masses are called "rolls" by the miners.

As has been observed in other carnotite-producing areas,[1] neighboring rolls generally are oriented in about the same direction, and this direction corresponds closely to the common orientation of fossil logs in the ore-bearing sandstone, whether or not the rolls actually enclose the fossil logs. Most of the fossil logs and rolls in the Gateway area trend northeasterly, and the average direction is about N. 40° E.

Most of the fossil logs are thought to have drifted into place, and their orientation probably was controlled by stream conditions at the time the enclosing sands were deposited. The localization and trend of the ore rolls, on the other hand, must have been influenced in some manner by structural conditions of sedimentary origin that controlled the flow of solutions through the sandstone beds, for the ore minerals in their present form were deposited from solutions after the sands were deposited. In places, as in part of the Calamity group of claims (see fig. 2), the clusters of fossil logs and rolls in the ore deposits show a curving arrangement, suggestive of a meandering stream, even though the channels of sedimentation are not clearly defined.

The general distribution of the ore deposits in the eastern part of the area suggests a belt of relatively closely spaced deposits extending from the north end of the Blue Mesa northwestward to Calamity Mesa, and perhaps from there westward to Beaver Mesa (see fig. 1). Continued prospecting may show a less well defined extension of this belt westward to Polar Mesa. This belt is flanked by areas in which few deposits are exposed. It seems unlikely that the evident concentration of deposits along this belt is an accident of exposure. On the other hand, the trend of the belt is not obviously related to any known stage in the physiographic development of the area; it does not correspond with the general northeast orientation of the ore rolls or fossil logs; and in part at least it is divergent from the axis of the syncline (see fig. 1) and from the regional fractures, which mostly strike about parallel to the synclinal axis. Hence the localization of the belt seemingly cannot be rationalized by a simple explanation.

Suggestions for prospecting.—The genesis of the deposits and the controls that localized the ore are not definitely determined, and all of the evidence concerning them cannot be presented in a brief statement. Nevertheless, certain observed facts regarding the distribution and character of the deposits may be useful as guides in prospecting. Most of the deposits are in a zone of bench-forming sandstone beds near the middle of the Morrison formation, and prospecting should be largely restricted to this zone. A belt, in which the known deposits are relatively closely spaced at the outcrop, trends northwestward through the middle of the area. In many places the ore rolls and fossil logs have a common orientation locally, and they show trends useful in prospecting for extensions of known deposits as well as for new deposits. Within reasonable limits, exposures at the outcrop are considered to be representative samples of what may be expected in adjacent concealed parts of a bed, so that covered areas near closely spaced deposits at the outcrop are considered most favorable for subsurface prospecting. Considering all known factors, the ground between the Maverick and Calamity groups of claims seems to be relatively favorable for the discovery of deposits by subsurface prospecting, and the ore-bearing sandstone is no more than 50 to 100 feet beneath the surface in much of this area. Likewise the ground between the Outlaw and Blue Ribbon groups might be favorable, although the ore-bearing sandstone is mostly under thicker cover and the larger deposits may average lower in grade.

Although most discoveries in the future will probably be made by subsurface prospecting, surface prospecting along the rims and on the benches will probably still yield some results. A few parts of the area, notably east and north of Cone Mountain, have been relatively inaccessible and probably not thoroughly prospected.

1/ Fischer, R. P., Vanadium deposits of Colorado and Utah: U. S. Geol. Survey Bull. 936-P, pl. 57, 1942.