The Rare Metals—Vanadium and Uranium

THE value of vanadium and uranium for commercial uses is stimulating search for compounds of these rare elements. Vanadium, which is used chiefly for hardening steel (it is claimed to be twelve times more effective than tungsten), is scarce; and this utility and scarcity tend to create an increasing demand. Uranium, which is valued commercially for use in the manufacture of porcelain and glass, and scientifically for its radio-active properties, is also scarce and is in growing demand.

The known deposits of uranium and vanadium minerals in Utah, says Prof. J. M. Boutwell of the U. S. geological survey, occur in the eastern and southeastern portion of the state in the margins of the basins of the Green, Grand and Colorado rivers. The area is a geographic and geologic unit. The gentle southerly dip of the Uintah range gradually gives way to a flat dip, thus in the Book Cliffs and the region immediately south to a slight northerly dip, and thus forms the great Green River basin. On its margins the underlying beds are turned up by the laccolithic instrusives of the La Sal group on the east, the Abajo cluster on the southeast, the Henry mountains on the southwest and the San Rafael swell on the west. The rare minerals appear to be restricted to Mesozoic sediments in or adjacent to these instrusive centers.

The Utah deposits occur in the same geographic province as the deposits of western Colorado, and probably in an equivalent series of rock formations, but they differ in important mineralogical characteristics and in certain features of geological occurrence.

The principal Utah deposits, which are at Richardson, Grand county, on Grand river, are predominantly high-grade vanadium ores, with some carnotite. At other localities low grade carnotite ores are found. The carnotite and certain of the vanadiferous minerals associated with the Richardson deposits occur in particular beds of sandstone adjacent to a strong fracture, and are in general like replacement deposits of metallic ores in limestone beds. The San Rafal deposits, near San Rafael river, are disseminations of carnotite apparently restricted to those sandstones and conglomerate beds in which plant remains occur.

As regards their quantity and grade, the deposits of carnotite which have been discovered thus far in Utah are poorer than those on La Sal and Rock creeks in Colorado, and, so far as known, no vanadiferous sandstone equal in commercial value to the Placerville deposits has been found in Utah. The vanadiferous minerals of Richardson, Utah, which are the most valuable deposits of this class yet discovered in the state, have a high commercial value, and have not, so far as known, been found in Colorado. Carnotite deposits northeast of San Rafael Swell have not proved of sufficiently high grade to be of commercial value. The possibilities of a carbonaceous sandstone, which is said to occur in large quantities southeast of San Rafael Swell and to contain some vanadium, remain to be determined.

Richardson Deposits.

The Richardson deposits occur in southeastern Utah, in the canyon of the Grand river, near Richardson postoffice. This locality may be most conveniently reached from Cisco, on the Rio Grande Western railway, by regular stage down the canyon, a distance of 27 miles. The deposit may be reached also, though more indirectly, by taking stage at Thompsons, on the Rio Grande Western, for Moab, 35 miles southwest, and driving thence up the canyon, about 12 miles, to Richardson. Trails also lead into Richardson from various eastern points, including several mining camps in the La Sal mountains.

At its junction several strong streams from the northwest slopes of the La Sal Mountains the canyon of the Grand river opens out into an extensive amphitheater. Its flat bottom extends along Grand river and eastward from the stream for several miles, and is inclosed by precipitous cliffs carved into massive erosion forms, mammoth tables, lofty columns, and graceful spires. About two miles east of the little settlement of Richardson, on the east bank of the Grand, the desert plain is broken by low hogbacks. Along the crest of one of these the deposits under discussion are found.

General Geology.

The geology of this region has never been studied in detail, and is known only broadly by correlation with that of regions which have been studied to the north and in western Colorado. Such hasty observations as the writer was able to make en route, supplemented by suggestions of geologists who have worked in neighboring areas, serve to establish the general geologic position of the formations in this region.

The route from Cisco to Richardson passes down from younger to older geologic formations, as the general dip is gently northward from the intrusive core of the La Sal Mountains and beneath the Green River basin. Leaving the Cretaceous shales, which form the main surface of the high-lying Green River basin, one descends southward through variegated bedded Cretaceous sandstones, including Dakota Cretaceous, into a thick formation of red beds, mainly sandstones. These comprise, both topographically and lithologically, three parts—(1) cliff-making, well-bedded, brownish-red sandstone, approximately 1,000 feet thick, with persistent cross-bedded members, underlain by (2) bench-making, shaly, dark-brown sandstone, several hundred feet thick, with alternately more and less massive resistant members, and at the bottom (3) cliff-making, thin-bedded, brownish-red sandstone, with well-defined persistent stratification. A cliff-making, light pinkish-purple, shaly sandstone, which includes coarse cross-bedded sandstones and conglomerates, with well-rounded granitic and porphyritic pebbles, underlies this series, with unproved stratigraphic relationship, and outcrops on the banks of the river and adjoining plains on the east. This formation appeared roughly conformable with the overlying sandstones, but this point was not specially studied and observations were insufficient to warrant any positive statement in regard to it.

Peale observed that on Dome Plateau (which overlooks the Richardson amphitheater from the west) the lower portion of the Jurassic formation covers a considerable area south of the hogback that borders the Grand River valley at this place. He further notes, and shows in a section, that in the vicinity of the junction of Grand and Dolores rivers the Triassic forms the greater part of the surface, but that the Grand cuts through both Jurassic and Triassic and exposes the Carboniferous in the canyon bottoms. The general map of this region (Sheet XIV, by Holmes, in the Hayden Atlas) gives the area included in the Richardson amphitheater as upper Carboniferous, inclosed by and dotted with inliers of red beds of "Jura-Trias" age.

The stratigraphic relation between the sandstone series and the underlying conglomeratic formation is significant. If no unconformity exists at this horizon it is possible that the conglomeratic formation is equivalent to Triassic conglomerates of the Dolores formation in western Colorado. On the other hand, if an unconformity does exist here, the conglomerates may be correlated with Carboniferous conglomerates of Colorado. The final solution of this important stratigraphic problem must await detailed comparative study, preferably by geologists familiar with the Colorado section.

The structure of this series partakes of the general north-northwest monoclinal dip of the region. This is interrupted, however, by a zone of deformation which enters the Richardson amphitheater at the northeast, near the mouth of Fisher creek, crosses in a southwesterly course, indicated by breccias and steeply upturned beds, and passes out on the southwest along a zone marked by intense crumpling and probable faulting. Crumpling, fissuring, and faulting on a small scale are common throughout this zone. No igneous rocks were found in place, although some are reported by prospectors to occur about 10 miles south, on Grand river, and about 15 miles southeast, in the foothills of the La Sal mountains.

Character of the Ores.

The deposits are chiefly compounds of vanadium, including vanadio-arsenates of copper, barium, and calcium. These and perhaps additional compounds of vanadium occur, in all instances observed, in aggregates of small, brittle, green, greenish-yellow, and yellowish-green crystals. Individual crystals are about one-sixteenth of an inch in diameter, and have the forms of thin, imperfectly terminated foils or plates. They are grouped parallel or radiate in sheaves or wreaths. The light-olive or yellowish-green varieties are distributed irregularly, while the darker green, roughly circular crystals are usually in rosettes or wreaths. The olive and yellowish crystals have a characteristically pearly luster, and the deep green ones usually show a dull, waxy luster. Small oval masses of amorphos carnotite and also small yellow crystals, slightly darker than this carnotite, are intimately associated with the green crystals. From his preliminary analyses, Doctor Hillebrand has decided that one of the minerals is a new variety of calcio-volborthite, highly arsenical, and another is a new, hydrous, copper vanadate, distinct from volborthite and calcio-volborthite.

Occurrence of the Ores.

Both the vanadium crystals and the associated amorphous carnotite occur along the previously mentioned strong northeast-southwest fracture zone, coating walls of cracks and within certain beds of sandstone. The fracture zone, 5 to 25 feet in width, is the main line of deformation in the region. It traverses the country in a N. 60 degrees E. direction, and dips to the southeast at an angle of 70 degrees.

The rocks which it cuts are well bedded, brownish-red, gray, and white sandstone, with a little olive shale. They dip generally to the northwest at angles ranging from 35 to 40 degrees. In the immediate vicinity of the fracture they are shattered, fissured, and faulted. Faulting on the main fissure has brought green shale in the foot wall against gray sandstone in the hanging wall. The sandstone dips normally to the northwest, but the beds in the foot wall have been intensely crushed and sheared and now stand at high angles for a distance of at least 20 feet west of the fault. The amount of dislocation is not apparent on this property, but the direction may have been downward on the west or foot-wall side. Stratigraphically these beds probably lie at about the base of the main red sandstone series and thus a short distance above the conglomeratic series.

The vanadium crystals are characteristically found in thin patches, 1 to 10 inches in diameter, upon the walls of sandstone blocks in the shattered zone. They are most abundant next to the main fissure. Yellow crystalline material, ranging in color from orange to canary yellow, also occurs in this manner, and some amorphous carnotite is occasionally found there. The more usual mode of occurrence of the carnotite, however, is in small oval masses, one-sixteenth of 1 inch in diameter, along certain beds of gray sandstone in the hanging wall. These bodies are also most abundant adjacent to the fissure, but are found as far away as development has proceeded, about four feet. As regards their origin, it is sufficient for present purposes to state that the mineral now appears from general aspect to have been formed by replacement of the sandstone, as a complete and gradual transition series may be traced from unaltered gray sandstone to pure amorphous carnotite. On the walls of the oval cavities in which this carnotite is found small clusters, rosettes, and wreaths of the dark-green variety of vanadium crystals frequently occur. This is the most intimate relationship between the vanadiferous and uraniferous minerals observed, and appears to indicate an earlier date of deposition for the vanadiferous compounds. On some of the specimens of yellowish-green crystals minute pieces of a robin's-egg blue mineral appear, which resemble bits of silk thread in luster, structure, and general apeparance. The composition of this mineral has not been determined.

These minerals show along croppings for about 1,000 feet along the fracture zone and have been found to a depth of 32 feet below the surface.

History and Development.

These deposits have been extensively prospected and opened along two claims, each 1,500 by 600 feet, owned by the Welsh-Lofttus Uranium and Rare Metals company, and slightly on adjoining claims to the north and south. They are stated to have been discovered in March, 1898, by a man named Welsh, and prospected the same year by James H. Lofttus. After doing some prospecting and making various small shipments for testing, in June, 1902, Mr. Lofttus sent about 500 pounds to Buffalo for analysis and experiments in reduction. In September, 1903, the material was discovered to be radioactive, and some was sent to Curie, at Paris, who failed to affirm the presence of radium. In May, 1903, the company was incorporated, under the laws of New York, to work these deposits on two claims, known as the Jesse D No. 1 and Jesse D No. 2, and to reduce the ores at the company's experimental plant at Buffalo, N. Y.

The fracture zone along which the property extends, and in which the vaniferous and uraniferous minerals lie, has been opened at about 20 places by prospect pits, short tunnels, and shafts. The principal development has been at the southwest end of the property, where a shaft has been sunk in the fracture to a depth of 32 feet, and levels have been driven northeastward along the main mineralized zone, at depths of 18 and 32 feet, for distances of 18 and 40 feet, respectively.

In the course of this development work numerous shipments of cabinet specimens and small amounts, aggregating about 2,000 pounds, were made, and in 1904 somewhat more than half a carload was shipped to Buffalo for experimental purposes. The ores yield concentrates of uranium oxide and a high grade mixture of crystals of the various vanandium minerals.

The property has never been systematically operated, but the work done shows the walls of the openings in the fracture zone to be extensively coated and blotched with the vanadiferous minerals and that certain beds carry small masses of carnotite. The presence and grade of the desirable minerals have been proved, but further development is required to demonstrate that the available amount of this rare product is sufficient to make this property a regular shipper.

Traces of these minerals in this same general fracture zone are reported to have been followed from this locality to deposits in Colorado, and also southwest from Richardson for several miles.

San Rafael Deposits.

About 15 miles southwest of Green River station (Rio Grande Western railway) deposits of carnotite have been found in several places. These deposits lie on the western margin of the Green River basin in a series of eastward-dipping cuestas (hogbacks) which rise gradually to San Rafael Reef. West of this series of ridges is a race course, or wide, open valley, analogous in form and probably in origin to the race courses around the Black Hills and the Bighorns. Rising steeply from this is a high, precipitous rock wall, over the notched crest of which the flat-topped central plateau of San Rafael Swell appears. The sandstone which floors the central area, and also apparently that which makes the encircling reef, was considered by Dutton to be triassic. Thus the soft beds forming the low, concentric valley, over 1,000 feet in thickness, with the gypsum beds intercalated in their upper portion, are also doubtless, triassic. The overlying coarse sandstones and fine conglomerate forming the crest of the cuesta which incloses this inner valley may thus be jurassic; next above are slightly less resistant, olive, maroon, and gray carbonaceous shales, with interberred sandstones, which underlie and probably pass into a sandstone that may be Dakota cretaceous. The Green River cretaceous, which then comes in underlies the main Green River basin, and apparently passes upward into the heavy series which forms the Book Cliffs.

The deposits are found about a mile east of the gorge cut by San Rafael river at two or possibly three horizons that embrace a thickness of about 100 feet, and extend along their strike for about two miles. The particular series in which these ore-bearing members lie are coarse sandstones and fine conglomerate, which dip eastward at angles ranging from 10 to 30 degrees below the variegated shales and about 200 to 250 feet above the main red shale formation. They may thus be tentatively considered to be of Jurassic age.

The values lie in a light-yellow mineral, which in certain cases seems to be carnotite. Part of this material is chrystaline, part is granular, and part forms a thin coating of faint yellow, greenish-yellow, and light-green color. The pay is much disseminated and very lean; no massive pieces of amorphous carnotite comparable to the Colorado ores have been found.

Ore has been taken from eight separate spots which are located in three general groups. In these groups there are certain common and certain distinguishing features. Thus in all of them the pay occurs in sandstone or conglomerate and in intimate association with plant remains. In the northern group it is in the form of massive carnotite, cementing quartz grains in a certain cross-bedded sandstone, or as a faint stain upon petrified wood. In the southern group massive carnotite occurs in an 18-inch bed of conglomerate, either as cement or merely coating pebbles of chert, jasper, quartz, and possibly petrified wood, or within gray clay nodules. None was seen in the overlying cross-bedded sandstones, though a little appeared in the underlying white sandstone. At the third locality the pay is found in a bed of gray, blackened, slightly carbonaceous sandstone, in two layers, either upon or immediately adjacent to plant remains. It forms a thin, glistening coating upon fossil bark, wood, and cellular tissue, and in some instances has entirely replaced cell walls. A query as to the derivation of the carnotite from the organic remains is naturaly suggested, but it seems more propable that they acted only as a chemical precipitant, by reason of their carbonaceous content. No fissures were observed during the hasty examination, but deliberate search would probably have revealed sufficient partings along which solutions rich in uranium might have passed until they met the carbonaceous precipitant.

History and Development.

All deposits in this locality are embraced in a single property comprising eight claims, which extend along the strike of the country rock in a north-south direction for a distance of about two miles. The deposits are stated to have been discovered by sheep herders and to have been subsequently prospected by parties residing in Green River. The croppings have been pretty thoroughly worked, and a shipment of 30,000 pounds was sent to Germany. The workings are all surface prospects and test cuts, of which the most extensive are an open cut 7 to 18 feet wide by 40 feet long and five feed deep, on the carnotite-bearing conglomerate, and a trench about five feet wide and 100 feet long, two to three feet deep, to open a bed of plant remains, stained with the yellow mineral regarded as carnotite. The lean character of the remainder of the ore, added to the report that no response has been received from the shipments, leads to the conclusion that the ore is of too low grade to pay, under the most favorable conditions, and doubly so under the high expense of working and shipping under existing conditions.

Southeast of the San Rafael Swell, in Wildhorse canyon, and eight to ten miles north of Hanksville, Wayne county, considerable deposits of a black, vanadiferous sandstone and some carnotite in float are reported to occur. The material is a dense, black, carbonaceous sandstone, which contains combustible matter and after burning yields a residue that includes some vanadium (Hillebrand). Small blotches of carnotite appear on the surface of the rock. Various analyses given out through the press have shown good percentages of both uranium and vanadium. In the sample tested in the laboratory of this survey, however, no uranium was detected.

These deposits were discovered in the fall of 1903 by sheep herders, and prospected in 1904 by Messrs. Browning and Beebe. The black vanadiferous sandstone is reported to be present in large quantity in the Cretaceous formation. Owing to its distant location the writer was unable in the limited time available to visit this property. The owners are said to be actively developing their property, and future work may reveal pay ore in sufficient quantity to make this deposit commercially profitable.

Miscellaneous Prospects.

In more inaccessible regions adjoining those in which the above described deposits are found prospectors, herders, and explorers have from time to time reported the occurrence of these rare minerals. Our increasing knowledge of the subject not only tends to make these reports seem plausible, but to lead one to regard it as possible that valuable deposits, perhaps more valuable than any yet discovered in the state, may exist at some of these localities.

On the east, deposits of carnotite are reported to have been traced from Colorado southeastward into the region of the Abajo mountains, in southeast Utah. The rocks in which carnotite occurs, in the Colorado localities, on the east side of the La Sal mountains, are known to extend southwestward in that direction. Accordingly it would not be surprising if valuable deposits, comparable with the rich Colorado ores, should occur in them, especially in the vicinity of the Abajo eruptive center.

Carnotite is also reported to occur west of the La Sal mountains, at Mill creek, on Grand river, north of Moab and south of the Richardson locality.

North of Richardson and about 10 miles south of Thompson's Springs, bedded deposits of uranium are said to have been found. They are reported to have been opened to a depth of four feet and proved to exist in considerable quantity and to be of good quality.

On Cold creek, 20 miles north of Price, a sandstone is said to bear blotches of carnotite, together with green and yellow stains, possibly of copper, and fossil plant remains.

Southward, between Price and the Henry mountains, small amounts of carnotite are reported to occur at three different places.

Vague reports of occurrences at four or five other points have come to the writer, but they are too uncertain to be worthy of publication.