Vanadium Deposits in the Caballo Mountains, New Mexico

By Carl A. Allen

Among practical mining men and many mining engineers there was long an inclination to consider vanadium and uranium as rare metals, whose consideration and study should be left to the research chemist and rare-metal enthusiast. This was also true of tungsten, but as the deposits of wolframite, in Boulder county, Colorado, and elsewhere, have now for some time been engaging the activities of metal miners, vanadium is also beginning to be regarded as a metal to be sought and its deposits studied like those of gold, silver, or copper.

The principal use of vanadium is in the manufacture of steel. It gives to steel toughness and the ability to withstand repeated shocks. The parts of automobiles that must stand the severest strains, especially jarring strains, are made from vanadium steel, as is drill steel for rock-drills.

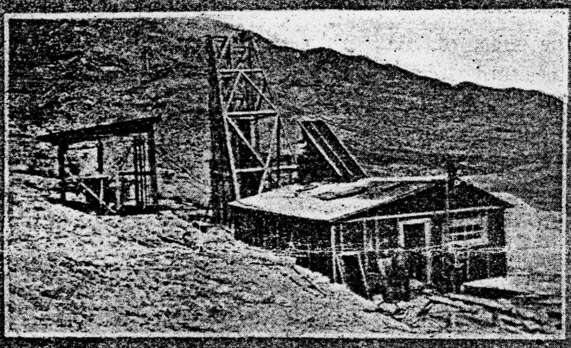
So far as I am aware, only two States can boast of workable deposits of vanadium; Colorado and New Mexico. In Colorado the ore is principally carnotite and is found in stratified rocks in the region from Placerville west to the Utah line. In New Mexico the deposits of vanadinite or vanadate of lead, which this article describes, were really discovered in 1909, although the veins had been worked for lead for a number of years. The Caballos mountains, in which they are found, are about half way between Albuquerque and El Paso, in Sierra county. They run parallel to and are about six miles east of the Rio Grande river. Their length is about thirty miles, and near the northern end is the site of Elephant Butte dam, the largest project of the United States Reclamation Service. The highest elevation is about 10,000 ft., or from 5000 to 6000 ft. above the bed of the river. Near the mines, Palomas pass divides the range into North and South Caballos. The nearest station is Cutter twelve miles nearly due east on the Atchison, Topeka & Santa Fé railroad.

Geologically, the region is old, and, to the casual observer, unattractive. Leaving the railroad for the mountains, the first six or eight miles of the country is flat and barren, the road now and then passing over nearly obliterated sheets of black lava. Then low, rough foothills are reached that have been formed by the tilting of sedimentary beds of limestone, shale, and quartzite. These continue to the foot of the main range, and were, no doubt, tilted when the range was formed. The range itself is more like a long, rough hogback, and is composed of sedimentary beds of limestone lying on its eastern slope, and on the western side granite, gneisses, and schists. F. C. Schrader[1] calls the age of the limestone Carboniferous and makes note of a large bed of Cambrian quartzite below it, and also of a large fault scarp on the western side. The beds are, no doubt, of Paleozoic age, as fossils of that age are abundant. Beds of gray limestone are interspersed with thin strata of shale and calcareous slate. These beds I would class as Silurian, while the red strata geologically next above, and which form a line of hills just east of the veins, are, no doubt, the Carboniferous 'Red Beds' mentioned by Schrader.

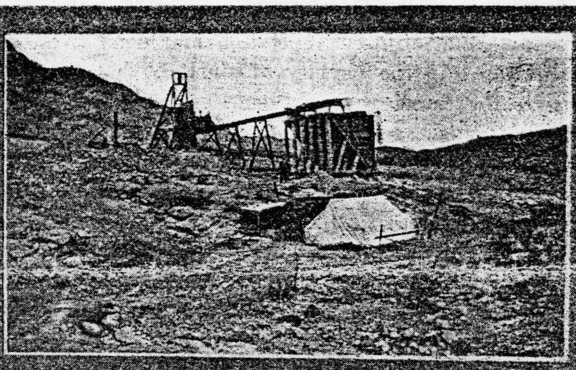
For at least six miles, parallel fissures that cut these sedimentaries can be found, and a number of them have been prospected for lead. While the fissures are strong and well defined, the lead in the form of galena is of low grade and in scattered places in the veins, perhaps being confined to a contact between a bed of limestone and shale.

In the exploration of these fissures for lead, the Southwestern Lead & Coal Co. has been active. Many feet of work was done on the Napoleon and Rosa Lee veins, and considerable low-grade galena found on the latter. The company built a small concentrator for its treatment, and to add to its holdings purchased the Swan and Dewey veins. As these two are now the ones being actively worked for vanadium, their history may be interesting. The Dewey was located by R. Widner and his father. The White Swan was located by non-resident prospectors, and when they allowed their rights to lapse, Widner located the claims early the morning of April 1, 1906, only to find that R. T. Ward had been there at midnight and located ahead of him, giving it the name White Swan. Ward, however, agreed to allow Widner a half interest for doing the location work, and later traded to him his remaining interest for a Jersey cow. In the fall of 1907 Widner sold both claims to the Southwestern Lead & Coal Co. for $3000. They were considered valuable at that time only as lead prospects. The Dewey had practically no work on it, the Swan a short adit and a shallow shaft. In the adit was a streak of galena and a 6-in. streak of pure vanadinite. This was called lead carbonate, although the elder Widner was not satisfied about it and spent much time studying the long, brown, hexagonal crystals which separated so beautifully in his pan. The transfer to the lead company was made shortly before that company ceased operations, and very little more work was done. The two veins lie parallel, about 700 ft. apart, and are one and one-half miles north of the old lead mine, where the concentrator is situated. After the discovery of the value of the vanadium content of the veins, A. B. Bement, of Terre Haute, Indiana, one of the stockholders of the lead company, organized the Vanadium Mines Co. This company took over all the property of the lead company and has been actively at work developing these two claims and working out the treatment of the ore.

The third and only other vein of importance so far opened up is the Red Top, one end of which is owned by R. Widner and the other end by J. H. Hardin. It was quite extensively prospected for lead, and has one shaft



NEW SWAN HEAD-FRAME.



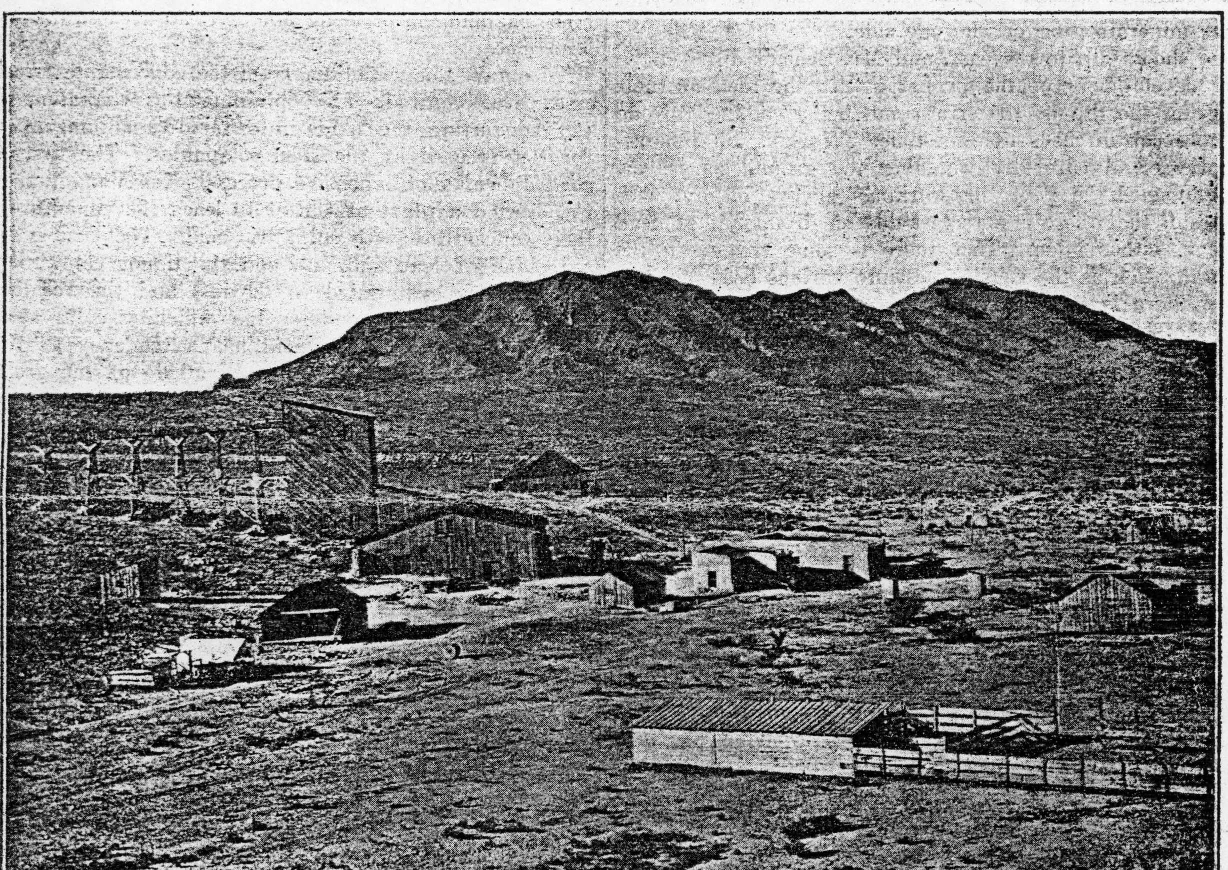
DEWEY HEAD-FRAME AND ORE-BINS.

[1] 'Ore Deposits of New Mexico,' U. S. Geol. Surv. Prof. Paper 68, p. 284.

over a hundred feet deep. The vein lies south of the Swan and Dewey veins, about ¾ of a mile, being about half way between them and the lead mine.

As before mentioned, these three veins belong to a large number of parallel fissures in massive limestones and slates. The three have galena in common with the others, but also have vanadinite, or vanadate of lead, which the others do not have. The ore occurs in shoots from 2 to 20 ft. wide, and of undetermined length. In the Dewey vein the vanadinite occurs in coarse crystals, sometimes almost black. The hanging wall is well defined and is usually followed by a streak of almost pure crystals in solid radiating masses or disintegrated as crystalline sand, the color being dark brown to black. Away from this streak the ore occurs as fine crystals in a fine black dust, probably pure manganese oxide in a very porous gangue. This gangue varies from barite and calcite to a slightly altered limestone. In the latter case the black oxide of manganese fills the seams and cracks of the broken rock nearly uniform in grade. The other ore is both a molybdate and vanadate of lead, impregnating the altered and silicified lime. This ore is non-crystalline, and although containing many vugs and cavities, is hard and much more difficult to break than the other ore. The manganese dust that is found in the Dewey vein is found in many places in the Swan vein. Also at nearly every place in the Swan vein can be found a streak, 12 to 18 inches in width, having galena and small amounts of copper carbonates. This streak may be in the vein or lying on either wall. Often there will be a gradual change from the soft porous gangue containing the vanadinite to the firm silicified limestone bearing the coarse cubes of galena.

The genesis of the deposits presents an interesting field for study. The scarcity of the mineral in workable deposits and its occurrence here in only three of a large number of parallel fissures is sufficient to arouse the curiosity of the economic geologist. From the data that can



CONCENTRATOR, WITH CABALLOS MOUNTAINS IN BACKGROUND.

and when panned yields beautiful yellow-brown crystals of vanadinite. In the main working shaft at 75 ft. a natural cave was found, 3 ft. wide, 30 ft. long, and 12 ft. high. There is very little galena in this vein.

The White Swan vein is the most developed and presents the most interesting study. It has a main shaft with drifts on the vein at 80 and 140 ft. From the first level a winze has been sunk toward the second, and a raise brought to the surface. Considerable stoping has been done. The vein is from 2 to 20 ft. wide, and the vein filling is a porous, friable calcite or altered limestone, with varying amounts of barite and fluorspar. The porosity ranges from vug-holes the size of a marble to caves 5 and 10 ft. long. The ore is of two classes; the most common is vanadinite in minute hair-like crystals, much finer than those in the Dewey, and usually as little rosettes lining the cavities in the vein filling. The crystals, although perfect in form, are exceedingly delicate and slender. They are of a yellowish brown color, and with a white background or base of calcite form specimens of exquisite beauty. Where these crystals occur, the solid portion of the gangue is impregnated with the same material, making the fine and coarse be gathered at this stage of the development of the mines, it appears that there have been two distinct earth movements at widely separated periods of time. The first was, no doubt, when the Caballos mountains were formed and caused the large fault on the western face and the original fissuring on the eastern slope. The second disturbance was apparently productive of very little structural change, but from the cooling magma of the intruding rock hot solutions emanated and, following the line of least resistance, circulated in the old fissures, and by processes of replacement and fresh deposition, took away part of the galena ores and left vanadinite. That there has been replacement there is no doubt, little cavities showing perfectly by their shape that they once held crystals of galena, are now lined with crystals of vanadinite. Also the gentle gradation from vanadinite in its soft porous gangue to galena in a harder, less altered gangue is further evidence of replacement. That this replacement was effected by circulating meteoric or surface waters is improbable. First, because the magnitude of the deposits is great and the process of deposition has been carried far into the walls beyond where any signs of former galena deposits can be noted. Second, because surface waters frequently contain hydrochloric or sulphuric acid, both of which are solvents for lead vanadate. Third, the veins at the present time are entirely without water, and its presence at any time in any quantity, such as to cause a secondary enrichment, would have left appreciable amounts of the green oxide of vanadium, of which there is practically none.

East of the shaft on the 80-ft. level of the Swan mine, occurs a very sharply defined fault plane, cutting the vein at nearly right angles and dipping to the east 45°. To the west of the fault the ore-shoot is 15 ft. in width and shows extensive mineralization. On passing through it, a larger part of this is cut squarely off and the minerals appear as seams of very rich ore along a relatively narrow body of average grade ore and in little cracks often running far into the lime. These conditions indicate the existence of this fault plane when the waters that formed the vanadium shoots were circulating. Its slickensides of clay formed a barrier to the solutions, with the resulting larger mineralization on the one side.

The shoots dip to the east, and Mr. Bement directed the early development of the property with the idea of their following the dip of the strata and being confined to one or more certain beds of limestone. Working on this assumption, and carefully watching the ground as it was being opened, he kept the workings always in ore, with the result that there is a remarkably small amount of dead work in either mine. That there is some change in the mineralization as the vein passes into various beds of limestone, there is no doubt, but personally I do not believe that the shoot will be found to have the same dip as the strata. It seems to be more nearly vertical and approaching the dip of the fault plane. Mr. Bement located this fault plane on the surface of the Swan claim, and I noted several evidently of the same series between the Swan and Dewey claims. If these faults continue with depth, they will probably influence the outline, if not actually determine the dip of the shoots.

The Red Top vein shows the same features as the Dewey and Swan. At either end of the vein the combination of molybdate and vanadate is seen to be the dominating type of ore. This vein can be traced for a greater distance than the others, and the shear-planes parallel to the main fissure indicate considerable fracturing. No compact orebodies of magnitude, like those of the Swan and Dewey, have as yet been found. In the main shaft driving has been done on irregular bunches of yellow massive ore, while to the side of it is seen manganese oxide containing vanadinite. In this is a cave some 10 ft. wide, 10 ft. deep, and 30 ft. long.

What igneous rocks are associated with the different earth movements can only be determined by careful field study and petrographic examination. North of the mines, there are extensive flows of lava. East of the concentrator can be seen the remnants of a flow lying on the 'Red Beds,' and east in the vicinity of Ward's ranch there are numerous dikes cutting through the Cretaceous strata, some of which can be traced for long distances.

Statements as to the average grade of the ore might at this time be misleading, due to the relatively limited amount of development. The Vanadium Mines Co. has expected the mines to average 1% ore. Pure vanadinite contains 10.8% metallic vanadium, and it follows that the grade of the ore can be regulated a great deal in the mining or by sorting. Of the massive ore free from crystals, the combination of vanadate and molybdate runs from ¾ to 2%, which is better than where the molybdate is absent. When ready for steel, as ferro-vanadium, the metallic vanadium is worth at the present time $4 or $5 per pound. At this price ¼% ore has a gross value of $20 to $25 per ton, and with a modern mill and proper treatment of concentrate should yield a good profit. There is very little difference in assays from the three veins, and all have large quantities of ¼ to ½% material, and although an attempt may be made to keep the grade up to 1% at first, the lower-grade material will, no doubt, be eventually treated.

The treatment of the ore is first by concentration. The old lead concentrator is used for concentrating the ore in a small way and as a testing plant to determine the most efficient equipment for a modern mill nearer the mines. The mill is inadequate for permanent duty, principally because of the lack of fall in the original site. The ore must be ground to at least 20 mesh, to liberate the minerals, and this means the slender friable crystals are reduced to fine. This and the presence of the barite are the most difficult features in the concentration; a modern mill, however, should effect a good saving. The pure mineral contains 65% lead. Its specific gravity is the same as galena, but, unlike that mineral, there is no tendency for the fine ore to float.

Water is a very serious question in this part of New Mexico, and the present supply for this mill is obtained from drilled wells at the power-plant, four miles east. The water is pumped this distance through a 4-in. spiral-riveted pipe, and although the profile of the line is rough (the maximum head being 350 ft.), no great difficulty has been met.

To obtain the vanadium from the concentrate two processes are required; (1) obtaining the vanadium oxide, (2) converting the oxide into ferro-vanadium, in which form it is used by the steel companies. The first is the most difficult and expensive process. The Vanadium Mines Co. erected a plant at Cutter to leach the vanadium from their concentrate with sulphuric acid. The lead is left as a residue of lead sulphate and the liquor containing the vanadium is evaporated to dryness and the residue calcined to vanadium oxide. One difficulty is to secure a thorough leaching. The acid has a tendency to form a coating of lead sulphate on the outside of the grains of mineral, which protects the inside from further action. Experiments have been conducted along the line of smelting with an acid flux, the vanadium to be then leached from the slag with water. This has been done in Germany and may be found to be more efficient than the acid treatment.

This company is the pioneer with this class of ore, and, like all pioneers, must by experience and increasing knowledge of the peculiar conditions, work out the method that, from a commercial standpoint, will be the most profitable. Others that come after will profit by its experience.

ALABAMA's gold production in 1910 was 1622.16 fine ounces, valued at $33,533, and that of silver 268 fine ounces valued at $145, according to H. D. McCaskey of the U. S. Geological Survey. These figures show an increase in value of gold output for Alabama of $4294 and an increase in silver output of $35 in value. The silver production is entirely from recovery of this metal in refining the gold. The production of gold and silver in Alabama in 1910 was reported from three deep mines and three gold placers. The total placer gold was valued at $357 in 1910, as against $69 in 1909. The deep mine production was from 9763 short tons of ore with an average recoverable value per ton in gold and silver of $3.41. In 1909 the ore production was 9886 short tons, but the recoverable value per ton was only $2.96.

THE SLOPE of the surface at any point is one factor determining the amount of water absorbed by the ground. The direction and amount of slope also determine the form of the water table; that is, of the upper limit of saturation. Except where the surface is flat, the water table is generally not parallel with the surface; it is almost invariably farthest from the surface on the summits of hills and mountains and nearest to it in valleys and along the coast, reaching the surface in swamps and along rivers, lakes, and beaches. The surface of the water table is always in motion, its higher portions flowing toward the lowest outlets along rivers or the sea. This direction of flow explains why fresh water is usually found when a well is dug in a sandy beach.—'Water-Supply Paper 223,' U. S. Geological Survey.