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The Yellow Pine District, Nev.

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SYNOPSIS—The mining district about Goodsprings, Nev., was discovered in 1860 and produced lead ore. Gold and copper were found also. Zinc ore, the camp's mainstay now, was not recognized until 1906. The camp is gradually increasing in importance, and production is growing. Its features are discussed.

Toward the close of 1914 the Yellow Pine mining district, in the vicinity of Goodsprings, Nev., was working about 40 men, and its future appeared decidedly uncertain. Due to the extraordinary rise in the prices of lead and zinc, the principal products of the camp, 1916 opened with about 20 mines in operation and 400 men employed, with a monthly payroll of $45,000 and a monthly output approximating $400,000.

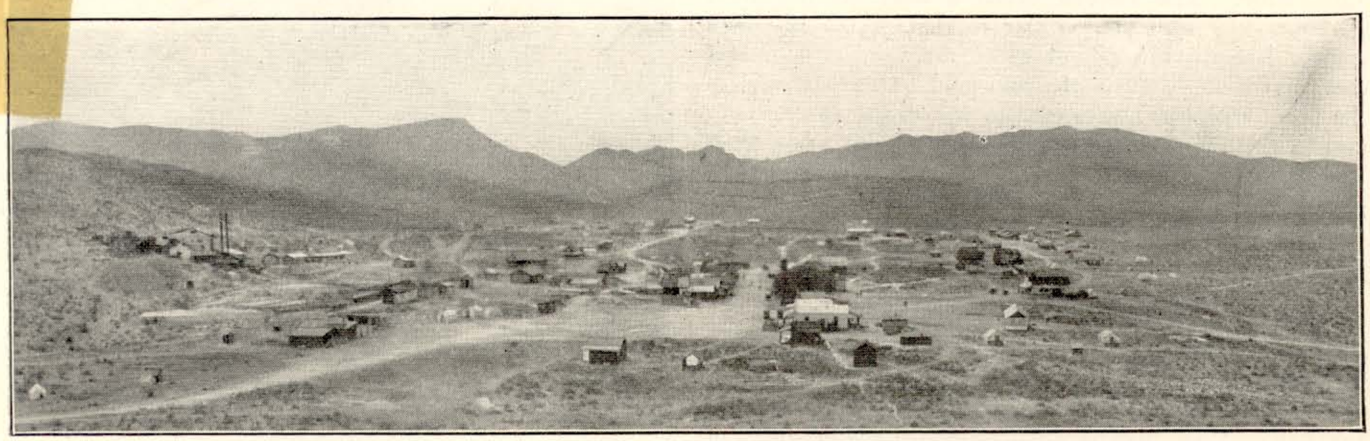
The first mining in this locality was at the Potosi, now the second largest producer of the district, which was discovered in 1860 by Mormon prospectors. This property produced rich lead ore that was mined by the Mormons and used by them in the manufacture of the bullets necessary in the border warfare of pioneer days.

Some gold and copper ores were found also, and gold and silver were associated with the copper and lead. So for years the district was a small but steady producer of these four metals, but the most momentous event of its history did not occur until 1906. Associated with the [illegible]ead ores was a heavy gray-white material of unknown [illegible]mposition, considered worthless and commonly referred [illegible] country rock. The credit of identifying this "coun[illegible]ck" as zinc ore seems to belong to Connie Brown, an engineer, who observed it while making a professional visit to the camp. These pages of the camp's history remind one of the awakening at Leadville, or the recognition of the "black iron" that was the source of much profanity among the ranches of what is now the Boulder tungsten district.

The district is about 15 mi. long and from 10 to 12 wide, toward the southern end of the Spring Mountain range and near the Nevada-California line. Goodsprings, the only town, is reached by an 8-mi. auto ride over good roads from Jean, Nev., on the Salt Lake route. The gold which, aside from that associated with the copper ores, once formed an important part of the production of the district, is found in altered igneous rocks, but no gold is produced now except as a byproduct.

The zinc-lead ores occur as replacement and fissure deposits in upper Carboniferous limestone. The two kinds of ore occur in the same orebodies, but usually with a fairly clear line of demarcation, so that it is frequently possible to mine a practically clean high-grade product that needs no milling before being shipped to the smelter. The country has been subjected to f[illegible]turing and comple[illegible] folding. The ores are found throug[illegible] vertical range [illegible] 3,000 ft. in close proximity to the f[illegible] fol[illegible]. The eastern limit of the ore zone is a [illegible]ault that passes nearly through the town of G[illegible]gs. This fault shows particularly well just nor[illegible] of to[illegible], where the displacement has been estimated at 4,000 [illegible] and the red Permian sandstone can be seen at a geographic level several hundred feet lower than the white Pennsylvanian limestones.

At some pre-Tertiary time the limestones were intruded by quartz monzonite that is found as large irregular



THE TOWN OF GOODSPRINGS, CENTER OF THE YELLOW PINE MINING DISTRICT

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masses and sills which are cut by crossdikes of a similar material. Overlying the other rocks is a series of Tertiary basalt and andesite flows. The flows bear no relation to the orebodies of the district; in fact, with the exception of those of the Yellow Pine, these are not associated with any of the igneous rocks. In this mine the ores are found both in fissures and as replacements from 40 to 50 ft. from the intrusives. In no other mine of the district, however, is there any apparent connection between the orebodies and the igneous rocks.

While the lead and zinc mines are the mainstay of the district, there are two other deposits of interest and doubtless of future importance. One of these is the Boss, which presents an interesting study to the geologist and mineralogist. The commercial products of this mine are gold, silver, copper and platinum, but many of the rarer metals are found in small quantities. The copper occurs in the form of chalcocite, bornite, malachite and azurite. The platinum is presumably covellite. The ore is a replacement in the limestone in a mineralized zone proved to be 190 ft. wide, with lenses up to 28 ft. in width, the deposits occurring across the bedding planes. One such lens being developed at the time these notes were made showed a length of 265 ft., a width of 12 ft. and a depth of 112 ft., with neither top nor bottom in sight. An average of one orebody, estimated to contain 11,000 to 15,000 tons, is 6% copper, 1 oz. platinum and $12 gold per ton. Other assays, not of picked samples, but of considerable bodies, have been 12% copper, 1½ oz. platinum, 3 oz. silver and $0.10 gold and 1½ to 2% copper with 4 to 5 oz. each of gold and platinum.

Another deposit out of the ordinary for this district is at the Lavena mine, between Goodsprings and the Yellow Pine mine. The Lavena is on a dike of monzonite porphyry 250 ft. wide, similar to that of the Bingham copper deposits, throughout which are veinlets of quartz carrying pyrite, chalcopyrite and gold. One 2-ft. vein in the porphyry gives assays of 2 to 4% copper, 8 oz. silver and $2.80 to $10 gold. Development on this property is limited as yet, but at the lower levels there seems to be a general dissemination of the copper through the porphyry with the possibility of their being developed into a large body of low-grade ore.

Systems of Mining Employed

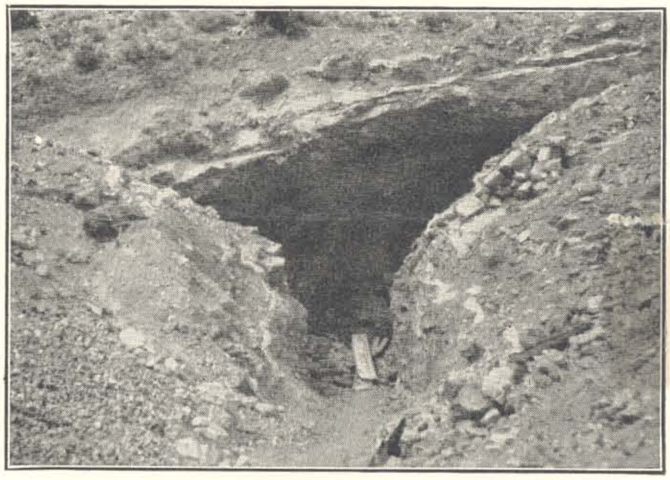
Various systems of mining are in vogue in the district. The deposits are worked by vertical and inclined shafts, tunnels and opencuts. Some of the companies, such as the Yellow Pine, that have demonstrated the existence of bodies of ore of considerable size, have sunk comparatively deep shafts and are blocking out ore ahead. Others are following the method in general use in the eastern zinc districts, of making only a temporary opening and following the orebody through its various meanderings.

The Yellow Pine, the largest mine of the district, is square-setting. The lime walls are hard, but their general nature is such that the management considers this system best adapted to them. The mine is opened by an incline, on an angle of 35° to 40°, to a depth of 930 ft. on the slope. Levels are driven every 100 ft. The fissure deposits have an average strike of N 30° W with easterly dip, and the bedded deposits strike nearly due north with westerly dip. Some of the stopes attain considerable size —up to 100 ft. in width and 300 to 400 ft. in length. While it has been considered advisable to support these stopes by means of square sets, light timbers only ar[e] required, 6x8's and 8x8's being commonly used. Afte[r] a stope is worked out, the timbers are drawn and it i[s] filled with waste.

The mine is connected with the mill at Goodsprings and with the Salt Lake route at Jean by a narrow-gage railroad operating a Shay and a gasoline locomotive. The Boss has opened up by means of tunnels, five of which have been driven or are in course of construction. The lowest will reach the vein at a vertical distance of 550 ft. The Boss uses no timber at all in stoping. The narrower deposits are worked without support, as the walls will stand while the ore is being removed. The larger deposits are worked by underground glory-holing.

The Sultan, next to the Yellow Pine the largest producer of the district proper, is working two glory holes by a typical milling system. One tunnel has been run in to a point 60 ft. below the surface and a raise driven to the orebody, which at the time these notes were made had been worked from the surface 100x20x30 ft. The other tunnel is connected by a 175-ft. raise to a glory hole 50x60x40 ft.

At the Anchor a short tunnel has been driven in and a shaft and winze sunk to 450 ft. below the surface. The



OPEN CUT AT MONTE CRISTO MINE

ore is in a replacement on an average dip of 38° and a maximum width of 32 ft. It is mined by a typical overhead stoping system, stulls alone being used to support the walls.

Many "gopher" methods are employed. At the Monte Cristo, leasers are taking out a high-grade, 37% zinc ore carrying less than 1% lead, by means of the opencut shown in the illustration.

About a mile up the cañon from the Monte Cristo and well up the mountainside, where a wagon road is hardly to be considered, is the Barnes, Hickman & Flesher lease on the Palace and Porter group, belonging to the Yellow Pine. This lease is following several bunches of high-grade zinc ore by means of short tunnels and opencuts. Shipments to the loading platform at the Monto Cristo is by means of burro train.

The lime, in which practically all of the development work is carried on, does not make for high costs. Amo[ng] the companies operating systematically there is unifor[mity] in the cost of the various kinds of development. F[or] the larger mines much handwork is done, especia[lly in] the stopes. The Yellow Pine sank its main two-com[partment]

ment shaft 5½x9½ ft. in the clear, the last lift of 116 ft. at a cost of $20 per ft., including timber. At the Anchor its single-compartment shaft, 5x7 ft., was sunk 200 ft. from the first tunnel level for $11 per ft. The Yellow Pine was sunk with two shifts, one drilling and one mucking. Progress varied considerably, from 30 to 75 ft. per month. The work was done both by hand and with 3¼-in. piston machines, 9 to 16 holes constituting a round. At this mine the drifts are an average of 4x7 ft. in cross-section and have been driven both by hand and with Temple-Ingersoll air-electric drills. Four to 16 holes are used to a round, and as high as 9 ft. has been broken with a round of four holes. This, of course, is unusual. Drifting costs at the Yellow Pine are $5 to $5.50 per ft., a fair average for the entire district, in which they run from $4.50 to $6.50.

With the exception of the Yellow Pine, costs of stoping and timbering are not available. These are $3.15 and $0.29 per ton respectively. It is probable that the other mines of the district are accomplishing this work at a lower figure, since the Yellow Pine is the only one in which it is necessary to resort to square-setting the entire deposit.

Milling Methods Adopted

The milling of the ores of the Goodsprings district presents an interesting variety of practice. The Yellow Pine has the only wet mill hereabouts, and it is probable that dry milling is more extensively applied here than in any other locality. Most of the mills are not concentrators, strictly speaking, but are separators, which separate one class of ore from another, making a variety of products, all of which are shipped and none rejected.

The Yellow Pine mill, which has a capacity of 100 tons per 24 hr. does not differ markedly from any other ore-dressing mill. The ore is fed over a grizzly to a jaw crusher, thence to rolls, impact screens, jigs and tables. Three products are made—lead concentrates, zinc concentrates and zinc slimes. The first two are trammed direct from the mill to the narrow-gage cars, but the slimes are settled in ponds before being shipped. The accompanying table gives an idea of the result of this system of treatment.

RESULTS OF TREATMENT OF ORES

Class	Pb, %	Zn, %	Ag, Oz.
Mill head	10.2	31.8	5.4
Lead concentrates	53.2	13.75	28.1
Zinc concentrates	4.4	33.2	2.5
Zinc slime	7.3	35.1	4.0

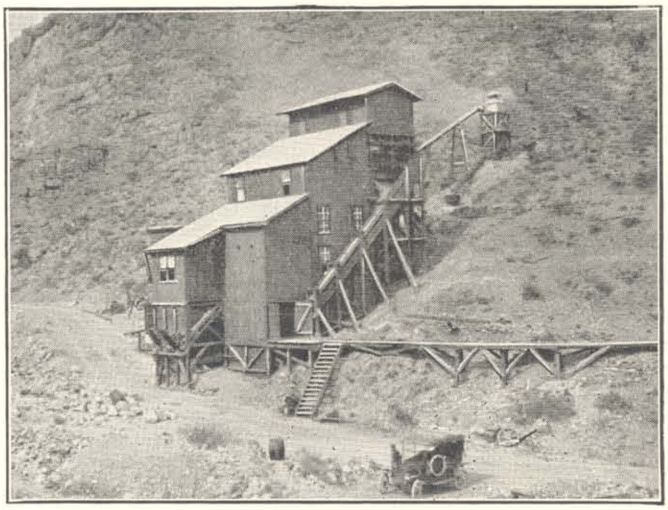
Milling costs during 1915 were $1.46 per ton. Two general systems of dry treatment are in vogue, the Plumb jig and the Stebbins table—both doing satisfactory work. The usual practice is to put the ore through a crusher and rolls, thence to impact screens or trommels, which return the oversize to the rolls and send the undersize to the concentrator. The various products are removed by screws or belts or by tramming. All machinery is kept tightly housed, and suction fans are used to draw off the dust; but, as has always been the case with the dry mills, the best that can be done in that respect is to alleviate the unpleasant condition to some extent.

The dry mills are mostly of limited capacity and have been in operation but a comparatively short time, so there is not much definite data as to their operation. One of them, the Anchor, using a Stebbins table, takes heads carrying 24% zinc and 35% lead and makes 34% zinc and 67% lead concentrates. The zinc concentrates carry 6% lead, but the lead concentrates are practically clean. The mill dust will average about the same as the heads.

The work described is on the separation of a lead-zinc ore in which no rejection is made. In treating a straight lead ore, tailings are rejected and disposed of by tramming. A saving of 65% is effected, 35% going into the tailings and dust, mostly the latter, from which it is hoped to recover it.

About 20 mines in the district are making a gross output of 6,000 tons a month, the average at present prices being about $65 a ton in lead and zinc. The Yellow Pine is the largest shipper. During 1915, with the mill out of commission for two months during which time only crude zinc ore was shipped, this company mined 18,400 tons. About 15% was shipped crude and the remainder milled. Gross receipts were $850,000, of which $700,000 was profit.

Next to the Yellow Pine the largest producer is the Potosí, which is employing 60 men and shipping 1,200 tons of crude zinc ore per month, although this mine is not considered within the Yellow Pine district proper.



THE ANCHOR DRY-CONCENTRATING MILL

Next to the Potosí is the Sultan, working 35 men and producing 360 tons per month. This mine is of interest in that it was opened only a year ago, commencing operations with three men, and has always paid its own way.

The other mines have still smaller outputs, some of the leases shipping a car or less a month. As an example of what some of the smaller mines are doing, the Bullion might be cited. This company is shipping monthly about 120 tons of lead concentrates carrying 62% lead and 6 oz. silver; 35 tons crude lead assaying 70% and 30 tons crude zinc assaying 38%. While the tonnage is not high, such values, coupled with the present high prices of the metals, make the output mount up in worth.

There seems to be plenty of ore in sight in the district. Mining and treatment conditions are not unfavorable, so it is reasonable to expect that the district will continue to produce while its metals command a fair price on the market.

Protected Thermoelements are discussed by Arthur W. Gray, in scientific paper No. 276 of the U. S. Bureau of Standards. It is pointed out that usually the wires of thermoelements are either entirely unprotected or else merely have portions adjacent to the junctions in glass or porcelain tubes. Believing that this is insufficient, Mr. Gray describes a type of mounting developed and used by the Bureau of Standards.

Tungsten-Molybdenum Ore Concentration*

An examination of ore from Callie Soak, Poona, Murchison Goldfields, of Western Australia, showed that it consisted of a mixture of molybdenite, scheelite and a smaller amount of wolframite in a gangue of quartz, mica and kaolin. The ore was too close-grained for hand sorting, although other portions of the lode might be suitable for grading in this way. An analysis of the ore showed 2.02% molybdenite and 9.07% tungstic oxide. The mineral composition was approximately 2% molybdenite, 10% scheelite, 1½% wolframite and 86½% gangue.

For marketing, concentrates should run at least 90% molybdenite in the case of molydenum ores and for tungsten ores, at least 60% tungstic oxide. Since all the minerals are heavier than quartz and the other gangue, water concentration appears reasonable. Molybdenite, however, has the property of floating on water, and this prevents successful gravity concentration, since it is almost impossible to overcome completely this floating effect. An attempt was made to concentrate the molybdenite by gravity, but it was a failure. Scheelite and molybdenite are extremely fragile, particularly when in the granular condition, and considerable loss is to be expected by sliming. The method of operation finally decided upon was first to remove the molybedenite by flotation, then to obtain the scheelite and wolframite from the residue by gravity concentration.

Series of Experiments Carried Out

Two series of experiments were carried out, one on a portion crushed to pass an 80-mesh screen, the other on a portion crushed to pass 30-mesh. Satisfactory results were obtained only from the latter, as may be seen by Table 1.

Of the 80-mesh sample, a great deal was much finer. A 100-gram sample was taken and the ore sprinkled on

TABLE 1. TESTS ON 80- AND 30-MESH CRUSHING

Size of Ore	Kind of Concentrates	Weight of Concentrates of Ore	Assay Value	Recovery on Original Ore
80-mesh........	Molybdenum	1.71%	37.8% MoS_2	31.9%
	Tungsten	12.9 %	36.3% WO_3	51.7%
	Molybdenum crude	6.01%	20.8% MoS_2	61.9%
	Molybdenum refloated	1.01% (A)	75.0% MoS_2	37.5%
30-mesh........	Molybdenum treatedon 90-mesh screen	0.87% (B)	92.9% MoS_2	39.8%
	Tungsten	12.60%	57.5% WO_3	79.9%

the surface of water in small quantities. The molybdenite-bearing scum was decanted through a filter, the residue stirred briskly, and the extra molybdenite brought to the surface by this means was also filtered off. Total concentrates weighed 1.71 grams and assayed as shown in the table. This material is unprofitable on account of not only the low grade of concentrates, but also poor extraction. No oil was used in these tests, and this may in part account for the poor extraction. At the same time the large amount of clayey slime present reduces the molybdenite value of the concentrates by simple adulteration. It seems also to give a poor extraction by incasing the molybdenite particles with fine dust, thus fouling or clogging them and preventing them from floating freely. The residue, after the removal of molybdenite, was panned down in the usual way to obtain the tungsten. There was again a good deal of sliming, and much of the scheelite was lost in this way. The weight of concentrates was 12.9 grams and assayed as shown. Here, too, both the grade and recovery are unsatisfactory, a result largely due to the overgrinding of the ore.

Of the 30-mesh material, much of it was ground too much—half of it would pass a 60-mesh screen. This lack of uniformity in the crushed product is undesirable, and it is believed that with more uniform crushing even better results could have been secured. Owing to the diversity and hardness of the ingredient minerals, more than ordinary care is required in crushing ore of the kind. This extra care will be more than paid for in the greater effectiveness of the subsequent treatment and the ensuing higher grade of extraction. The crushing plant should not be fed with excessive quantities of ore at one time, for if it is, overcrushing will surely result. Every endeavor should be made to obtain uniformity in size of ore particles, in this case between 30- and 40-mesh. Some sliming is of course unavoidable, but it can be reduced to a very small amount.

In testing, 100 grams of the sample were taken, as before, and the molybdenite removed first. This time the effect of oil and acid were investigated in addition to simple flotation on water. The separation was carried on in three stages. First, using water flotation alone, the ore was sprinkled on the surface and the scum decanted off. Vigorous stirring and blowing of air through the pulp caused very little more sulphide to rise. Oil was then added in different proportions, from 1 in 10,000 to 1 in 1,000, the whole being vigorously agitated in a closed vessel with each addition. The amount of scum formed each time was noted, and when the proportion of oil added had reached the latter figure, it was found to be sufficient. Further addition of oil did not extract any more molybdenite. The total scums from oil flotation were set aside. Possibly with a richer ore more oil would have been required, the amount being determined by experiment. The oil used was the ordinary commercial phellandrene, obtained from the eucalyptus tree.

Results of Acid and Oil Treatment

An acid treatment was then combined with the oil, and the ore residue was shaken vigorously with oily water, 1 in 1,000, and varying amounts of sulphuric acid were added in proportions of 1 in 10,000 to 1 in 1,000. The use of acid is not warranted, because as will be seen from Table 2, the additional recovery of sulphide is so small. The acid did no harm, but was unnecessary so long as air was carried into the pulp by agitation or blowing. The weights of various extracts were as shown in Table 2.

TABLE 2. WEIGHT OF CONCENTRATES RECOVERED

Treatment:	Weight of Concentrates, Grams
Water alone	2.785
Water and oil	2.948
Water, oil and acid	0.276
Total	6.009

Each concentrate contained a good deal of slime in addition to molybdenite, but as the aim was primarily to obtain high recovery, even at the risk of producing lower-grade concentrates, it was found impossible to avoid this. The assay results, as already given, was 20.8% of molybdenite, equal to an extraction of 61% of the total molybdenite in the ore. This recovery was rather disappointing,

*Abstract of an article by A. J. Robertson, in Bulletin No. 64 of the Geological Survey of Western Australia.