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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Goodsprings, Nevada
November 1, 1944

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Item 12

Goodsprings

Mr. J.A.Carpenter
University of Nevada
Reno, Nevada

Dear Mr. Carpenter:

Enclosed herewith is a draft of the paper on the Goodsprings District. As is noted on page 6, the section on the Anchor mine was cut from the paper as finally presented.

I enjoyed discussing the Goodsprings problems with you during your visit, and if it will be possible for you to get down this way later on we could discuss some of the other aspects of the local geology, and I know that I would profit by getting your opinion of some of our ideas.

If at any time I can be of service, let me know.

Sincerely,

Arthur Richards

OFFICE OF WAR INFORMATION

Department of the Interior

For Release _____

COPY

Important discoveries of high-grade zinc and lead ores--two critical and essential war materials--have been made by Bureau of Mines engineers through test drilling at the Yellow Pine mine property in the Goodsprings district of Clark County in southeastern Nevada, it was announced by Secretary of the Interior Harold L. Ickes.

One block of ore is estimated to contain 35,000 tons of high-grade zinc ore and individual samples from some of the numerous test-holes drilled in the area have assayed as high as 46 percent zinc and 57 percent lead, according to information submitted to Secretary Ickes by Dr. R. R. Sayers, Director of the Bureau of Mines. One of the samples showed two percent copper in addition to the other metals.

"Preliminary diamond drilling and sampling indicates favorable prospects for developing new and important ore bodies containing zinc and lead to assist the Nation in alleviating a critical situation with regard to zinc," Dr. Sayers in formed the Secretary.

One of the more recent undertakings in the Bureau's extensive war minerals exploratory program, the Goodsprings project was started in September, 1942--less than four months ago--and the results have been gratifying in view of the fact that the engineers have been working such a short time, Dr. Sayers said.

"Unfortunately, funds allotted for this particular project have been exhausted and no further funds are available for transfer within the Bureau of Mines," the Director advised Secretary Ickes. "Therefore, it was necessary to stop work on this project the second week in January."

Determination of the approximate tonnage and grade of all the reserve lead and zinc ores in the district will depend upon additional drilling and analyses of samples, the Director explained in pointing out the desirability of completing the investigation of what may turn out to be a major mineral discovery.

In describing the exploratory work in the Goodsprings district, which is southwest of Las Vegas and near the Nevada-California state line, Bureau engineers reported that the ore discoveries were adjacent to old workings which were thought near depletion, as well as in entirely new areas.

Working far underground in the Yellow Pine mine, the Bureau's crews drilled a hole upward from the 800-foot level and out into ore assaying 17.6 percent lead and 10.4 percent zinc. A similar hole from the 900-foot level was in ore for a distance of 26 feet and it averaged 24.1 percent zinc and 11.7 percent lead. Other drill holes on the 300-foot level revealed a probable continuation of one of the larger deposits of ore.

Diamond drilling on the surface near the Yellow Pine workings revealed a body of ore more than 1,000 feet long, from 25 to 50 feet wide, and ranging in thickness from 2 to 26 feet, the engineers reported. This is the block that is estimated to contain 35,000 tons of ore assaying 22.2 percent zinc. Geological conditions indicate that its length may extend more than half a mile. However, additional drilling will be necessary to prove the continuity of the deposit.

Summarizing the Goodsprings exploratory work to date, Director Sayers said that assays of samples from the explored zones averaged 21.29 percent zinc and 9.55 percent lead, while individual samples ran as high as 46 percent zinc and 37 percent lead.

"Production in the Goodsprings area could be stimulated by exploratory work on other properties in this vicinity," Dr. Sayers stated. Some of the properties which show promise are Potosi, Milford No. 1, Milford No. 2, Sultan, Root Hill, Whale, Argentina, Carbonate King Zinc Mine, Anchor and Hoosier.

Arthur Richards (30)
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MINING AND GEOLOGY OF THE GOODSPRINGS DISTRICT

The mines ofthe Goodsprings district are scattered over an area 18 miles long and 7 miles wide, 25 miles southwest of Las Vegas in the Spring Mountains. The northern and higher extension forms the prominent range west of Las Vegas. A few mines, such as the Yellow Pine in the center of the district, are readily accessible by road, but many are locate on cliffy slopes high in the mountains and must be reached by tortuous trails and the ore lowered to the base of the mountains by aerial trams.

Mining began in the district in 1856 but the production remained small until the turn ofthe century. It reached it's peak during the decade from 1910 to 1920. About one fourth of the 74 mines have accounted for 95% of the production. In the past two years only 14 of the mines have operated and most of the production has come from 6 mines, namely the Anchor, Argentena, Green Monster, Root, Sultan, and Yellow Pine. The gross yield of the district from the 90s to the present is in excess of $10,000,000, half of which is to becredited to the Yellow Pine mine.

The ore deposits of thedistrict include those which have been exploited for gold, silver, copper, cobalt, molybdenum, vanadium, platinum, palladium, lead, and zinc. The quantity and value of the lead-zinc ores for exceeds those of the other metals. During 1943 and the first half of 1944, about 30,000 tons of ore containing An ave. of about 4.0% zinc and ~~2.5~~% lead were shipped from the district ~~sold to the Metals Reserve Company stockpile at Jean, seven miles east of Goodsprings~~.

In the lead-zinc mines very little timber is required. Some of the larger stopes have been mines by benching from the top of the stopes; some by using square sets purely as a means of extracting the ore and not as supperts for the backs. Generally the square sets were removed after extraction of the ore and used over again. In the Potosi mine rock walls and fill were used in the bottoms of the stopes as an aid in extracting the ore from the backs.

Only a very few stopes were timbered to support the country rock. These stopes are in areas where the stopes were in contact with porphyry which weathers rapidly and sluffs off; locally timber has been required where the stopes are against the Bird Spring sandstone which tends to slab off. Generally speeking, despite the intensity of faulting and the general broken nature of the ground, the country rock stands indefinitely with no timber.

The zinc- lead ratio of the ores is variable. A few lead mines contain little or no zinc and a few zinc mines little or no lead, but considering the district as a whole, the zinc-lead ratio averages between 3 and 4 to 1.

The mineralogy is generally quite simple. The zinc sulphide in all but a few deposits is almost completely oxidized to the silicate Calamine, and to the carbonates hydrozincite and smithsonite. Galena, the lead sulphide, is quite common but is locally oxidized to the sulphate anglesite, and to the carbonate Cerussite.

The stratified rocks exposed in the area attain a thickness of 13,000 feet and range in age from Cambrian to Recent. All systems of the Paleozioc are represented in the 8,500 feet of beds exposed. Of the Paleozoics, limestone and dolomite make up more than 7,000 feet. All of the lead-zinc deposits are in paleozoic beds older than the Permian and the vast majority lie within a 500 foot zone of Mississippian strata.

The Mesozoic section attains a thickness of over 4,000 feet and is,made up largely of sandstone, shale, and conglomerate, with some limestone at the base. The prominent red and tan sandstone cliffs southwest of Las Vegas belong to this system.

The Tertiary is represented by tuffs and lava flows.

Although to the casual observer the structure appears simple, the region reveals an amazing record of folding, thrust faulting, and normal faulting. At some time between the late Jurassic and middle Tertiary, the beds were folded to different degrees depending on the massiveness of the bedding. Toward the

end of the epoch of ~~thrust~~ folding thrust faults began to form. The Goodsprings area displays 4 major and many minor thrusts, which generally dip west. Near the end of the epoch of thrusting, sills and dikes of granite porphyry were intruded. After the thrusting a few normal faults developed which were later mineralized. These faults were followed by other normal faults which are younger than the ore deposits but older than the middle tertiary lavas.

The ore deposits are limestone replacements which generally parallel the bedding. Some are tabular but many are irregular in outline. Most occur where fractures have broken the more massive beds. Thrust faults parallel or nearly parallel to the bedding locally brecciated the rock. Sulphide solutions rising on the high angle faults encountered the breccia zones, spread out in them and replaced the breccia and to a certain extent the unbroken wall rock. Later these deposits were oxidized with little migration taking place during or after oxidation as is evidenced by the usual occurence of sulphide relicts, ~~usually~~ commonly galena, ~~but aphalerite has also been found in the several of the mines~~. Small bodies of white hydrozincite have been found below some of the larger ore bodies and are believed to have been formaed by downward ~~mi~~ migration of part of the zinc during oxidation. These bodies of white hydrozincite, however, are relatively small and few in number.

The most common impurities in the ore are limonite and unreplaced ribs and blocks of dolomite. Locally, as at the Argentena mine, barite is a common gangue mineral.

At what depth the sulphide zone will be encountered is not known from data on hand and will probably not be known until exploration extends to much greater depths than has been attained in any of the mined. The present distribution of zinc sulphide offers no clues. The highest mine in the district, the Potosi, contains the largest amount of zinc sulphide, some of which is within 200 feet of the surface.

Of the mines which ahve operated in recent years the Yellow Pine, Anchor, and Argentena, have ben selected for brief discussion.

The Yellow Pine is the largest and deepest mine in the district with 27,000 feet of workings on 12 levels reaching a depth of 600 feet. The Yellow Pine has produced 50,000 tons of zinc and 30,000 tons of lead. Most of the production was during the 20 years from 1908 to 1928.

The mine workings explore three members of the Mississippian Monte Cristo limestone. The oldest, the Bullion member, is here a massive gray dolomite. Overlying the Bullion is the Arrowhead which consists of 10 feet of limestone and dolomite in units a few inches thick separated by thin seams of black shale. Above the Arrowhead is the Yellow Pine member, here consisting of about 100 feet of thinkbedded limestone and dolomite. Although the ore deposits of the mine lie in these three members, the Yellow Pine member has been by far the most productive horizon. The Yellow Pine is unconformably overlain by the Bird Spring formationwhich here has 40 feet of sandstone at it's base. The sedimentary rocks are cut by dikes and sills of granite porphyry. The largest porphyry body is a sill with its base along the top of the basal Bird Spring sandstone.

In general the Yellow Pine mine reflects the general structure of the Goodsprings district on a small scale. The sediments strike northest and dip northwest at an average of 40°. They are broken by thrusts which likewise dip west but ate flatter than the bedding. Displacement on individual thrusts is small and amounts to only a few scores of feet. Brecciation along the thrusts varies in amount fron place to plce. Locally the shearing may be distributed through a zone 20 feet thick and elsewhere the shears cut cleanly through the rock with little or no breccia being present. Although the evidence is inconclusive, the larger masses of breccia appear to be at places where bedding shears and steeper thrusts branch from the main

thrusts.

The thrusts are displaced by two systems of moderately to steeply dipping f faults along which the movement is believed to have been mostly horizontal. The older of these two systems includes faults trending between northwest and west-northwest; the younger, or Alice system, includes arcuate faults which generally trend north. The displacement is usually but a fe feet although faults with displacements of as much as 250 feet are present. Both sets are believed to be premineral as indicated by the occurrence of galena in fissures which can be assigned to one or the other of the two systems. Galena is most common along faults of the Alice system. As a consequence of an early stage of thrusting and two stages of high angle faulting, the ground is generally briken throughout.

The Yellow Pine ore bodies are typically tabular with the longest dimension paralleling the strike of the bedding.

Past records indicate that the zinc content of the crude ores has varied from 5 to 45%. No doubt the primary ore bodies were predominantly sphalerite and galena. Subsequent to its deposition the ore has been oxidized to some unknown depth below the deepest workings in the mine.

Judging by the ore now showing in the mine, the typical ore is a friable agregate of calamine crystals intergrown with small hydrozincite crystals and coated with limonitic material, or is massive pink hydrozincite. Between the richer stringers of ore barren ribs of dolomite which may be as much as 10 feet thick but which in the richer zones average less than one foot and comprise less than 20% of the material extracted.

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This section on the Anchor mine was omitted from paper as finally presented.

The Anchor mine, 5 miles south of Goodsprings, is high in a rugged canyon in the Spring Mountains. The ore is transferred from the mine to the base of the mountain by a 2,000 foot aerial tram. A 200 foot inclined shaft leads to the 3 principal levels of the mine.

Since 1908 the production has been over 4,000 tons of zinc and 3,000 tons of lead. Some of the ore mined during the last war contained as high as 40% zinc but during the past few years the ore shipped 20% zinc and a few percent lead. During the past two years the Anchor has been the largest producer in the district.

The ore bodies lie in the Anchor member of the Monte Cristo limestone. This member underlies the Bullion member which is the ~~eldest~~ lowest stratigraphic unit encountered in the Yellow Pine workings. The Anchor member is largely a dolomite in the vicinity of the mine. Lenticular pods of chert locally make up from one third to one half of the beds. A 25 foot cherty unit in the Anchor with from 3 to 4 feet of very cherty beds at the top and bottom, is the key horizon in the mine. All of the ore has been mined from this general zone and from the immediately overlying beds.

A series of low angle thrusts cut the mine workings. Some thrusts are essentially bedding slips but others are steeper or flatter than the bedding. There are gentle flexures in the bedding both along the strike and down the dip. The thrusts are believed to have originated as bedding slips which broke into thrusts at flexures in the bedding. Brecciation is generally greater in the cherty units and is possibly due to the chert lentils acting as pegs in the bedding planes, preventing simple slipping.

The top of the hanging wall stope over the main ore body and the lower end of the main ore body were in lead ore containing little zinc. The chief ore mineral for the mine as a whole, however, is ~~largely~~ pink hydrozincite.

Pre and post mineral normal faults are present. Most of these strike roughly parallel to the bedding. Those dipping west are believed to be

premineral and a few of these were probably feeders. Those dipping east are post mineral. The largest known displacement on any of these faults is 20 feet.

Near the lower end of the main ore body, two west dipping faults have unsheared galena along them. The ore in the vicinity of the westernmost of these two faults contained mostly lead but up dip from the eastern fault zinc was the most important metal mined.

The Argentena mine is 2.5 miles southwest of Goodsprings near the crest of the Spring Mountains. As at he Anchor, the ore is lowered to the base of the mountains by an aerial tram but unlike the Anchor, the mine can be reached by road.

The ~~su~~ total production from the Argentena is much less than many mines in the district but in recent years it has been one of the leading producers of lead-zinc ores. Most of the developement work has been done on the property since 1928. Approximately 12,000 tons of ore have been shipped, about one one fourth of which contained 38% combined lead and zinc and the remainder including the recent production about 23% combined metals. The zinc-lead ratio varies from 3.6 to 1 to 7 to 1.

The ore bodies at the Argentena lie entirely within the Yellow Pine dolomite and are largely concentrated in the upper 30 feet of the formation. In the Argentena area dips of over 10° are not common.

The mine workings and surrounding area are cut by a strong anastomosing series of north-south trending tear faults in the hanging wall of the Keystone thrust. ~~That~~ The movement on these faults was almost horizontal . These faults are believed to be premineral although locally it would appear that there has been some post mineral movement as well. Underground these breccia zonesshow many closely spaced shears along many of which the dolomite is ground to a flour. In contrast to the other mines discussed, the breccia of these

strong zones rarely contains ore, although the minor faults between the major breaks are locally highly mineralized. In contrast to the rocks along the major breaks, these minor fractures are more open and apparently furnished easier passage for the ore solutions than the major fault zones.

Thrusts are relatively unimportant and few in number in the Argentena workings. The ore tends to make to a large degree along the bedding but also makes along the high angle faults.

The ore is largely calamine with irregular pods of smithsonite and hydrozincite. Locally an earthy vanadate, probably descloizite is abundant.

As at the Yellow Pine and Anchor mines the ore contains ribs and boulders of dolomite. The ore in some of the workings contains a considerable amount of barite. Locally the barite is so abundant that the ore can not be profitably mined bt present hand sorting methods.

Since almost all mining in the district is done by leasors, and much of that by local residents with limited capital, little attempt is made to block out ore and known reserves at any one time are small. In the mines which I have seen, there is only a relatively small amount of high grade oe in sight. Locally the low grade reserves are much larger but do not add up to any great tonnage. With few exceptions the ore bodies that have been explored in the district were exposed by erosion.

The ore controls for the district as a whole, and even for the mines here discussed are as yet theories that have not been conclusively proven. The problem is a difficult one but in time, by setting up theories based upon actual observation, and by constant reevaluation of these theories as more and more deposits are examined, it is hoped that the ore controls can be worked out a and can be applied to areas away from the present workings as well as to ground adjactent to them.

Considering that the 74 mines and numerous prospects are scattered over a district containing more than 100 square miles, the job of detailed study is an enormous one. However, when one considers the shallowness of exploration to date, it is only reasonabe to assume that there must be many times the tonnage of past production remaining to be found in the area.