

TUNGSTEN SURVEY

A. Brodie Campbell

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INTRODUCTION

The following information was compiled by A. Brodie Campbell, Mining Engineer, who visited all potential tungsten producing areas in the State of Arizona for the Department of Mineral Resources from May 4 to July 1, 1942.

His investigation indicates beyond any doubt that the production of tungsten must be stimulated by subsidy if it is to become a factor in the nation's war effort. This point is further brought out in the fact that the principal tungsten Ore Buyer of the state, has noted a 75% decrease in purchases during the past 6 weeks. This condition is critical if the nation is looking to Arizona for any sizeable contribution to tungsten reserves.

It can be explained in many ways but all are, in fact, only variations of the one economic theme - cost of production vs. selling price. Every item used in production has increased in cost, while even in normal times the price of tungsten does not make an attractive enterprise from the standpoint of economics.

With few exceptions the tungsten producing mines of the state are, under present conditions, not suitable for company operations. They are primarily of a type best operated by small groups of active miners who can use pocket hunting and high grading methods. The aggregate production of these groups is relatively small.

In order to produce on a large scale, capital for development and equipment must be advanced, and done so on a basis which would not be attractive to private capital. Also, even after this capital has been expended, the price of the finished product must be advanced to cover actual operating expenses. This report points out that 1.5% ore is only reasonably economically interesting for the induction of capital; that 1.0% (recoverable) WO_2 is needed to maintain operation on properties on which development and equipment capital has already been expended; and that the market price of tungsten must be increased to make the 0.5% (recoverable) WO_3 ores, which is the estimated average content of most tungsten areas in the State, even of marginal value.

The production of tungsten in Arizona is not possible on a profitable basis. Whenever the need for the metal becomes critical to the extent that "any price" is not too high, then and only then can the low grade deposits of this state become assets.

E. F. HASTINGS

INVESTIGATION

This investigation deals primarily with estimating a basic figure of what the possible emergency tungsten reserves of this State are, estimating the possible annual ability of the state to produce that metal.

The whole State has been thoroughly investigated as to tungsten occurrence by the State Bureau of Mines. The general features of geology, mineralogy and structure were worked out at that time. This has been published so there is no need to include any but the most basic of those details in this report.

* UNIVERSITY OF ARIZONA BULLETIN Arizona Bureau of Mines, Geological Series No. 14, Bulletin No. 148.

TUNGSTEN DEPOSITS OF ARIZONA? Eldred D. Wilson, April 1, 1941

Over forty mining properties with a possible tungsten production were investigated. Most of the properties had some past production record or are in production at the present time. Personal investigation was made on all but three of the properties. On these three properties reports by reliable engineers were used to make the necessary calculations.

Arizona is not normally a large producer of tungsten ores. Her share of domestic production for 1942 will probably fall under 2% of the total. The State has no positive ore reserves unless certain assumptions are made. Some starting point must be had if any attempt is to be made in aiding a possible emergency demand. The writer feels justified in making these assumptions in estimating ore reserves for a possible emergency demand.

This report must be considered as a report based on an emergency necessity for tungsten. It is not intended as a guide to increase tungsten production on an economic basis. If and when an emergency arises, the report will at least serve as a starting point for Arizona's participation in supply.

The writer realizes that in the light of an ordinary engineer's report some of the assumptions made in this report are open to criticism. However, when one is familiar with the nature of tungsten ore deposits in this State these assumptions are not as hazardous as would seem.

With one exception all of the deposits in the State with any production record at all are narrow veins occurring in well defined mineralized zones. The commercial ore occurrence is always of a spotty nature and very rarely has any readily apparent parental structural feature with which to prognosticate commercial ore occurrence. The veins throughout their length always show some tungsten mineralization. With one exception, none of the well defined tungsten-bearing zones has ever bottomed as far as ore is concerned, ie, mining was not stopped because the ore had definitely quit. The one exception bottomed where a very definite structural feature had cut the vein off.

The narrowness and spotty nature of these ores, the difficulty of transportation to these isolated districts, general lack of water development, lack of interest of capital in as speculative an investment as these mines are coupled with a poor pre-war price and an established ceiling price that has not taken into consideration an increased cost, have created a condition where in a mine has to have a blocked out tonnage of ore that will average 1.5% WO_3 before it can be put into production. Lower grade ores can not be handled unless the necessary starting capital was expended before this situation was created. At the present time there is

probably not 5000 tons of 1.5% WO_3 ore blocked out in all the mines in Arizona.

One of the peculiar features of tungsten mines of a small nature is that they never block out ore in the sense that other mines do. When the ore is sufficient grade and the price is attractive, the commercial pockets are extracted as soon as found. In this respect they are very similar to high grade gold ores and mercury ores. In the barren pillars between pockets the ore usually runs about 0.5% WO_3 . When the price falls, and tungsten prices have fluctuated greatly, what little ore is present is extracted and the last workings left so that they give the mines the appearance of being worked out; and reopening usually requires some preliminary development or following an unworked surface exposure to an unmined area.

METHOD OF ORE RESERVE ESTIMATION:

Ore reserve estimations were made in the following manner: The length of traceable favorable structure, in most instances a definite vein, the average width estimated from available openings and surface showings, and an average depth based on the lowest structural exposure were used to compute possible cubic content. 15 cu. ft. per ton for rock in place was used to compute tonnages from cubic content. 0.5% recoverable WO_3 has been arbitrarily chosen as the value of rock in place with one exception to be noted later on.

ESTIMATES BY DISTRICTS:

No attempt will be made to detail the individual properties in the possible producing districts. The characteristics of occurrence and probably method of treatment are the same for the individual properties as they are for that particular district. Should data be desired on properties, a report on each of the individual holdings can be obtained from the Department of Mineral Resources of the State of Arizona.

Over forty properties with supposed tungsten potentialities were investigated. Only those in which structure, past production, visible occurrence of tungsten ore and possible quick production are included in this report.

Only the more prominent and better developed veins in each district have been used as a basis for these calculations. Most of the districts considered have many parallel veins that, if they are taken into consideration, considerable more tonnage will be available. The opening of any one mine in any of the districts would tend to promote interests in the others of that area, with a possible subsequent production greater than that estimated in this report. Where, in this report, one length of structure is used for the tonnage calculation, it should be remembered that this length is an aggregate of the most prominently developed or out-cropping vein or veins. Also, the veins may not be one continuous undisturbed structure, but in all instances they are traceable on the surface or have sufficient openings to warrant the assumption that the structure is present. Faults may have occurred to upset the continuity of structure, but in most instances the structure is traceable throughout the mineralized zone.

DISTRICTS CONSIDERED AS POSSIBLE PRODUCERS OF TUNGSTEN:

BORIANA DISTRICT

The Boriana Mine in Mojave County is located on the western side of the Hualapai Mountains 18 miles northeast of Yucca. The mine is now operating at about half capacity producing approximately 40 units of WO_3 daily from the same number of tons milled. If some stimulation is given it is probably that the production can be increased from 40 units of WO_3 to 80 units a day.

The ore occurs in two quartz veins about 1 foot thick paralleling the schistosity of a wide and extensive schist bed. The veins, striking about N 35 E and dipping steeply to the SE are traceable for over 5000 feet. The vein structure fades out in the schist to the SW. The vein structure enters a granite intrusion to the NE but the tungsten content drops rapidly on the granite side of the contact. The values in these veins occur as wolframite scheelite and chalcopryrite. A recoverable 1.0% WO_3 ore is mined from these veins.

The lowest workings on these veins are 700' below the outcrop. Considerable stoping has been done. Records are incomplete, making a tonnage estimate difficult. From the records available and the structure continuity it is estimated that there are at least 25,000 possible ton of 1.0% WO_3 ore.

This property could furnish an additional 40 units a day, or 12,000 units a year with no additional capital outlay. The district has a past production record of approximately 80,000 units of WO_3 .

AGUARIUS DISTRICT

The mines in the Aguarius region are about 75 miles SE of Kingman in Mohave County on the western flank of the Aguarius Mountains.

There are several quartz veins of varying width in granite. These veins strike in a general NW-SE direction and dip to the NE in degrees varying from 30 to the vertical. The values occur as wolframite and scheelite with wolframite predominating. There are some attendant sulphides, principally pyrite.

There are five veins in this area of sufficient importance to be considered. They have an aggregate length of 11,500' an average depth of 300' and an average width of 1'.

$11,500 \times 300 \times 1 = 3,450,000$ cu. ft.

$3,450,000$ cu. ft. @ 15 cu. ft. per ton = 230,000 tons.

The ore in this district is higher grade than in most districts and it is estimated that there is 1.0% recoverable WO_3 per ton. Available in this district--230,000 units WO_3 .

This region has produced approximately 1,000 units WO_3 in the past. It is producing at the rate of about 50 units a month by crude methods at present.

The nature of the deposit and the availability of water in this district leads to the possibility that the installation of a 150 ton per day combined gravity-flotation mill could be operated at full capacity following some developments. With this installation, the district should produce at the rate of 150 units a day or 45,000 units a year.

CAMP WOOD DISTRICT

The Camp Wood region is located in the south end of the Santa Maria Mountains 15 miles southeast of Camp Woods Post Office. Camp Woods is in Yavapai County 45 miles west of Prescott.

The mineralized zone in this region is about one and one half miles long and about one-quarter mile wide. There are several quartz veins in that area that cut through the predominating granite formation. The veins strike considerably south of east and dip almost vertically to the southwest. The veins contain wolframite as the valuable mineral. Pyrite is attendant in considerable quantities.

One vein, the major one, has been used in tonnage calculations. This vein is traceable over a length of 2000 feet, has an average depth of 300' and an average width of 3'.

$2000 \times 300' \times 1 = 1,800,000 \text{ cu. ft.}$

$1,800,000 \text{ cu. ft.} @ 15 \text{ c. ft. per ton} = 120,000$

Recoverable WO_3 estimated per ton 0.5% = 60,000 units

This district has produced in excess of 3,500 units in the past. It is dormant at present.

The local conditions in this district indicate the installation of a 50 ton per day capacity gravity mill would ultimately be requires. With this installation the district should produce at the rate of 25 units or 7,500 a year.

DRAGOON DISTRICT

The Dragoon region is located on the eastern flank of the Little Dragoon Mountains. The district is in Cochise County about 25 miles NE of Benson and about 6 miles west of Dragoon.

The mineralized zone of this district appears to be about 2 miles long and 1500' wide. The tungsten bearing veins occur as quartz filled fissures in granite. These veins, of which there are more than ten, vary in width from 4" to 3". They have a general NE-SW strike and dip to the NE in degrees varying from 30 to 55 degrees. The values occur as hubnerite and scheelite, hubnerite predominating. There has been considerable faulting in this zone but the veins are traceable on the surface throughout that portion used in the calculations.

One vein that is traceable for 6000' having an average depth of 125' and an average width of 2' has been used in the tonnage calculations.

$6000 \times 125 \times 2 = 1,500,000 \text{ cu. ft.}$

$1,500,000 \text{ cu. ft.} @ 15 \text{ cu. ft. per ton} = 100,000 \text{ tons}$

Recoverable WO_3 estimated at 0.5% = 50,000 units

The district has a past production record of about 75,000 units. Small operations are attempting to start on two of the higher grade sections.

Water availability is the controlling factor of possible mill installation. If sufficient water could be made available the district would possibly support a 150 tons per day combined gravity-flotation mill. Indications from old copper mines in this area are that water could be developed. With this installation the district should produce at the rate of 75 units a day or 22,500 units a year.

LAS GUIJAS DISTRICT

The Las Guijas district is in the northwest end of the Las Guijas Mountains. The district is six miles northwest of Arivaca. It is in Pima County.

The mineralized zone is approximately one and one-half miles long and one-half mile wide. Several quartz veins, at least five, are traceable throughout this zone. The general country rock is granite. A few dikes of a mere basic nature are in evidence. The veins are faulted in several places but they can be traced throughout this zone with a good degree of certainty. The veins strike west of northwest and dip from 45 to 85 degrees to the north. The veins vary from 6" to 6' in width. The values occur as hubnerite. Pyrite, chalcopyrite, and galena are attendant in these veins.

Only one vein has been used in this calculation. The vein is traceable for 5000', has an average depth of 200' and an average width of 2'.

$5000 \times 200 \times 2 = 2,000,000 \text{ cu. ft.}$

$2,000,000 \text{ cu. ft.} @ 15 \text{ cu. ft. per ton} = 133,333 \text{ tons}$

Recoverable WO_3 estimated at 0.5% = 67,667 units

This district has a past production record of over 75,000 units. It is producing at present from hi-grade operations at the rate of about 35 units a month.

Water for milling might present a problem. It is thought that sufficient water could be developed to support a 150 ton mill. The district will probably warrant a 150 ton mill, with some development and, with this installation, the district should produce at the rate of 75 units a day or 22,500 units a year.

HUACHUCA DISTRICT

The Huachuca region is practically on top of the Huachuca Mountains. The tungstiferous region starts about five miles east of the Fort Huachuca Military reservation and runs west into the reservation. This section is about thirty-five miles west of Bisbee in Cochise County.

The mineralized zone occurs in two groups. It has not been definitely determined if these two sections were originally one or not. There is however, a definite relationship between the two. The ore occurrence and characteristics are the same.

JANE GROUP

The mineralized zone in this section has not been very thoroughly delineated. The ore occurs in a quartz vein varying from 2' to 12' in thickness. These veins occur in a relatively old limestone bed that forms the top of the Huachuca Mountains. The limestone is underlain by granite. The veins strike northwest and dip to the southwest in degrees varying from 0 to 45. The values occur as scheelite with small amounts of galena attendant.

There are several veins in this section. Only one, the largest, has been considered. Due to the nature of the deposit this vein is not definitely traceable with the assurance that those in the other districts are. However, there are sufficient workings along the strike combined with one opening into the vein along the dip of 200' to give reasonably assurance to the calculation. The vein can be seen at places along the strike for 1000'. One drift 200' long has been driven on the dip. The vein averages in excess of 5' in width.

$1000 \times 200 \times 5 = 1,000,000 \text{ cu. ft.}$

$1,000,000 \text{ cu. ft.} @ 15 \text{ cu. ft. per ton} = 66,600 \text{ tons}$

Recoverable WO_3 estimated at 0.5% = 33,300 units

This group has a past production record in excess of 1000 units. It is producing at the rate of about 25 units a month under very difficult conditions.

The width and continuity of this deposit indicate the installation of a relatively large mill. However, due to the inaccessability of the property, the attendant difficulties in starting operations in a section where transportation is extremely difficult coupled with a poor water situation lead to the recommendation of a 25 ton flotation mill. The afore mentioned difficulties will probably increase the initial cost considerably above the average of others in the state.

REEF GROUP

The Reef Group is located three miles air line east of the Jane Group. The elevation is about the same, but the country in between the two properties is extremely rugged.

There are two rather flat quartz veins in limestone overlying granite in this section. They vary in thickness from 1' to 10'. The veins are parallel and lie from 2' to 20' apart. They strike to the northeast and dip less than 15 degrees. to the southwest. The values occur as scheelite. Small amounts of galena are attendant.

The limits of the ore-body have been determined by the U. S. Bureau of Mines. The field work was done in 1941. The data obtained is not public property so it cannot be included in this report. The surface showings and underground development show considerably more tonnage than has been estimated for this group. The out-crops indicate a length of 1500' a width of 700' and a thickness of at least 6'.

$1500 \times 700 \times 6 = 6,300,000 \text{ cu. ft.}$

$6,300,000 \text{ cu. ft.} @ 15 \text{ cu. ft. per ton} = 420,000 \text{ tons}$

Recoverable WO_3 estimated at 0.5% = 210,000 units

The size, ease of mining, accessibility, and probably ease with which water could be developed indicate the installation of a relatively large mill. A 300 ton capacity flotation mill will probably be recommended for this property.

With this installation this group should produce at the rate of 150 units a day or 45,000 units per year.

ORACLE DISTRICT

The Oracle region is located on the top eastern side of the Santa Cataline Mountains. The possible tungsten bearing area is quite extensive. The mineralized zone lies in both Pima and Pinal Counties. The distances range from 12 to 25 miles south of Oracle.

The possible mineralized zone is about 15 miles long and three miles wide. This section contains many limestone pendants on top of an extensive granite batholity. There are two distinct types of ore occurrences in this section: (1) There are numerous quartz filled fissures in limestone occurring near the granite-limestone contacts. The values in these veins are scheelite. In most instances there are attendant sulphides of lead, iron and copper. Very little has been done to ascertain the extent of these veins. This section is well timbered and quite rugged making surface determinations difficult. (2) Certain portions of the granite-lime contacts

have been highly mineralized. Very little work has been done in prospecting these contacts for scheelite. One mine, a copper mine that has been operating in one of these contact zones for the past two years, discovered less than three months ago that all of the copper ore mined contained some scheelite. In places where exploratory drifts had been driven along the contact, scheelite pockets of a high grade nature were found. The values in these ores occur as scheelite and chalcopyrite.

This region is, in the writers estimation, the most likely new area for a possible future tungsten production in the state. It is possible that under proper stimulation several worthwhile producers might be developed.

Not sufficient evidence is available to warrant a tonnage estimate of ore in this section. However, tailings to the extent of 60,000 tons with a recoverable 0.4% WO_3 are piled adjacent to the afore mentioned copper mine. It is possible to treat these at the rate of 50 tons a day with a flotation plant.

Estimated reserve tailings ----- 60,000 tons
Recoverable WO_3 estimated at 0.4%-- 24,000 units

SUMMARY

An analysis of Table 1 shows that there are possibly 1,154,933 tons of ore with an average grade of 0.63% WO_3 available in the state. It is estimated that this could be mined at the rate of 915 tons a day or 274,500 tons a year. The anticipated operation would produce at the rate of 575 units of WO_3 per day or 174,250 units a year.

CONCLUSIONS

1. The State of Arizona has, under the present conditions, no blocked out economic tungsten ore reserve.
2. There is a considerable ore reserve available of a low grade nature. This could furnish a limited supply of that metal if an emergency occurs.
3. There will be very little increased production in the State under the present conditions.
4. Increased production will only be obtained by a partial or total subsidy for the initial outlay necessary to start production from these low grade reserves.
5. An increased price to about \$35.00 per unit will have to be granted to make it possible for the production to continue from these reserves after the initial capital outlay is supplied.
6. An annual production of 1742 tons of WO_3 may reasonably be expected, if development and equipment capital is advanced and a price put upon tungsten whereby operations can be paid for from sales.

SUMMARY OF PRODUCTION

DISTRICT	POSSIBLE RESERVES		ESTIMATED PRODUCTION			
	TONS	UNITS	DAY		YEAR	
			TONS	UNITS	TONS	UNITS
BORIANA	25,000	25,000	40	40	12,000	12,000
AQUARIUS DIST.	230,000	230,000	150	150	45,000	45,000
CAMP WOOD DIST.	120,000	60,000	50	25	15,000	7,500
DRAGOON DIST.	100,000	50,000	150	75	45,000	22,500
LAS GUIJAS	133,333	66,667	150	75	45,000	22,500
JANIE GROUP	66,600	33,300	25	12.5	7,500	3,750
REEF GROUP	420,000	210,000	300	150	20,000	45,000
ORACLE	60,000	24,000	50	20	15,000	6,000
TOTALS	1,154,933	698,967	915	547.5	274,000	164,250