

1920

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Miller, Benjamin LeRoy and Schneider, George W., "The Mining Industry of Bolivia" (1920). *Early Publications of the Lehigh Faculty*. Paper 68.

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The Mining Industry of Bolivia

Operations Conducted Since 1544—Potosi Mountain the Oldest Mining Camp in Western Hemisphere—Incas' Wealth in Part Derived From Mines—Tin, Silver, Bismuth, Copper, and Tungsten Produced

BY GEORGE W. SCHNEIDER AND BENJAMIN L. MILLER

Written exclusively for *Engineering and Mining Journal*

FROM the earliest settlement of Bolivia, mining has been the predominant industry of the country and has contributed the bulk of the nation's wealth. This inland republic contains in the Potosi Mountain the oldest mining camp of the Western Hemisphere, as mining has been carried on there continuously, according to all available accounts, from 1544 to the present. Even before the coming of the Spaniards the metalliferous ores were worked and furnished part of the wealth of the Incas.

The mineral products which Bolivia has furnished are not numerous in variety, and, indeed, until the closing years of the last century, consisted principally of silver, with subordinate amounts of gold and copper. To these have been added tin, which now constitutes the major part of the mineral wealth; bismuth, tungsten, antimony, and lead.

Although considerable rubber is annually gathered in the Amazon River drainage basin of northeastern Bolivia, and some wool and hides of alpacas, llamas, vicunas, and sheep are marketed by the residents of the Andean plateaus, the exports consist mainly of the mineral products, most of which are shipped to foreign countries as hand-picked ore or as mill concentrates. The almost complete lack of any fuel other than the llama dung (taquia) throughout the mining districts has seriously militated against the erection of local smelters. Practically all of the mineral products are exported.

The Great War at first caused stagnation in some of the mining camps of Bolivia, but this was later overcome, so that, in 1918, the exports are reported as showing an increase of 277 per cent over those of 1914.

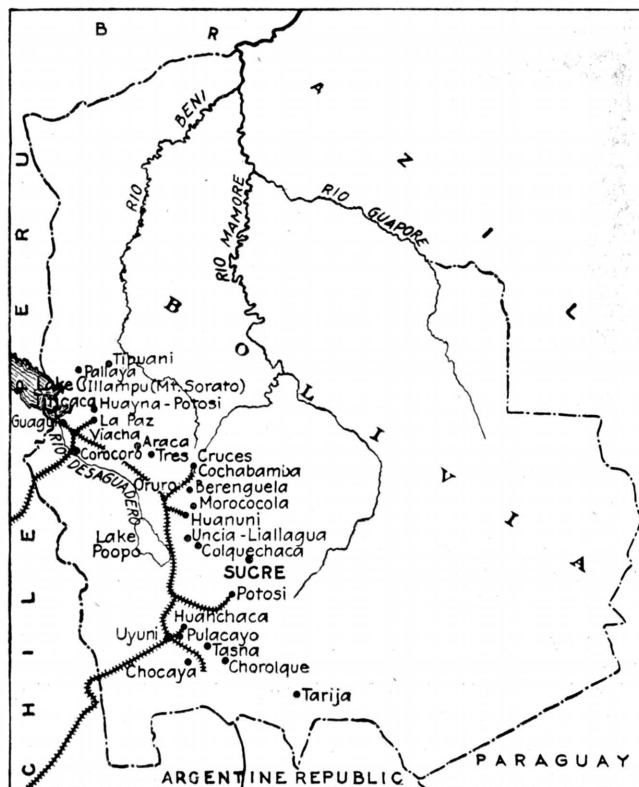
BOLIVIA APPRECIATIVE OF VALUE OF RAILROADS

Bolivia as a nation has been thoroughly awakened to appreciate the immense value of railroads, and strenuous efforts are being made to secure capital for the building of new lines. At present La Paz is connected with Antofagasta, Chile, by a direct line 711 miles in length; with Arica, Chile, by a line 278 miles long; with Mollendo, Peru, by railroad and steamboat across Lake Titicaca, a combined total of 520 miles, and lacks only about 60 miles of having a continuous connection with Buenos Aires, distant 1,640 miles. Several branch lines connect some of the principal mining districts. The total mileage of railroads in Bolivia itself is slightly in excess of 1,000, but four lines now in process of construction will increase this about one-third, and a two-thirds increase is under consideration.

Besides the building of new lines of transportation, there seems to be considerable agitation for the acquisition of a portion of northern Chile that would obviate the necessity of sending all exports and imports through the ports of Chile or Peru, even though amicable commercial relations are maintained. In the disastrous war ending in 1883, in which Peru and Bolivia were defeated

by Chile, Bolivia lost her coastal territory, which now constitutes a part of the Chilean province of Antofagasta. Although she cannot hope to recover the rich nitrate territory which she formerly possessed, if reports can be credited there is a probability that Chile will grant her a port in the Tacna-Arica region, to which Peru still lays claim. The possession of an outlet to the Pacific Ocean within her own territory would undoubtedly be of extremely great value to Bolivia.

In 1919 mining operations were somewhat reduced, on account of the derangement of the metal markets following the signing of the armistice. The demand for



SITUATION OF MINING PROPERTIES IN BOLIVIA

tungsten ores ceased temporarily, and the prices of other metal ores were lowered. More recently the mining industry again became prosperous, especially in the tin, silver, and copper districts. With the material increase in the price of silver, and the activities of the Guggenheim Exploration Co. in the tin industry, the future of the Bolivian mining industry is especially promising. There are many old silver mines that will doubtless be reopened under the increased stimulus of high prices, and developments may be expected in the mines long operated for silver. The investigations of the Guggenheims, which are being carried on in a systematic manner, and their extensive purchases or leases, would lead one to expect decided advances in

the tin industry during coming years, so that Bolivia may finally become the predominant tin-producing country of the world.

TIN, SILVER, BISMUTH, AND TUNGSTEN ORES IN CLOSE ASSOCIATION

There is such an intimate relation between the tin, silver, bismuth, and tungsten ores of Bolivia that it is difficult to separate the districts on the basis of metaliferous ores. This is especially true in regard to the tin and silver minerals, which in many cases are found in the same veins or in different veins in the same region. Bismuth and tungsten minerals are also found in conjunction with the tin-silver ores, but less widely distributed. Up to 1890, in all such ores, no attention was given to anything other than silver, whereas since

tematic examinations are being carried on, as well as extensive exploration work with a force of about 100 American engineers and geologists. Much development work is planned, including the construction of a branch railroad line to connect with the Oruro-La Paz line, tramways, concentrating mills, and other equipment. A large tin production is assured with these improved facilities.

In the Berenguela district, the Berenguela property, operated by a British company, is producing about thirty tons a month. The ore, which is low grade, occurs in large orebodies. The mill has recently been remodeled.

In the Oruro district the principal operators are the Compañía Minera de Oruro, owning concentrating mills at Machacamarca, and the Compañía Minera de San



LLAMAS LOADED WITH YARETA, A COMPACT, MOSS-LIKE PLANT WHICH, WHEN DRIED, MAKES A DESIRABLE FUEL

that date the attention has been mainly given to tin. Thus, many old mines now abandoned are known only as silver mines, and many of the modern tin-silver mines are commonly described as tin mines, with little reference to the silver values. In a few places the bismuth or the tungsten minerals are sufficient to make the ores more valuable for these metals than for the tin or silver. Therefore, in any classification of the ore districts of Bolivia, this intimate association of tin, silver, bismuth, and tungsten must always be kept in mind. It is probable that the formation of all these orebodies represents a single period of mineralization, constituting a metallogenetic epoch.

The production of the Araca mines amounts to about 100 tons a month. In the Tres Cruces (Quimsa Cruz) district the Guggenheim Exploration Co. has purchased or holds under option practically the entire granite (so-called) area, which includes several large properties. The principal mine is the Coracoles, which, at present, with a small experimental mill, is producing thirty tons of concentrates per month. Comprehensive and sys-

José, with mills at Poopo, both owned by Chileans. In addition to the tin content, the ore contains from 30 to 60 oz. of silver per ton. The usual production was maintained during 1919, and the companies are preparing to increase their output, in response to the stimulus of the high price of silver.

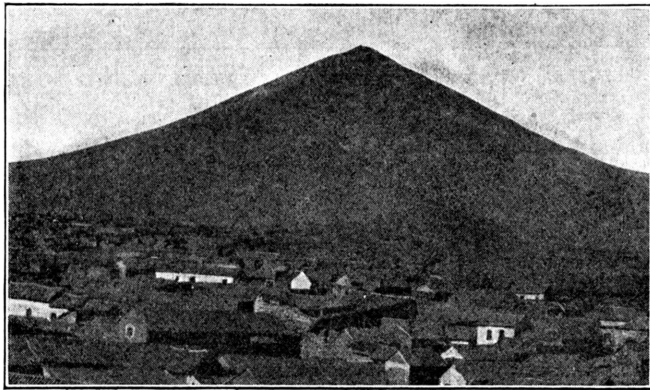
The Totoral property, in the Pazna district, is operated by a Chilean corporation, as is also the Chaulla Grande, at Avicaya, owned and operated by Señor Abeli and associates, and situated in the opposite side of the hill. At the latter plant the old mill has been remodeled, and a campaign of development is under way, for the purpose of increasing the production to what it was formerly.

About 25 kilometers southeast of Oruro, Messrs. Penny and Duncan are operating the Morococala property. Extensive developments are under way, including the sinking of a shaft and the installation of Diesel engines, which have effected a saving of 20,000 bolivianos (about \$660) per month. The Diesel engines operate General Electric generators, and the power is

distributed to the mill and to the hoists and pumps of the mine. The old buddle method of concentration, the buddles arranged in series, is still employed in the mill. The production has been increased from 100 tons to 200 tons per month.

The mines of the Huanuni district, owned and operated by Simon I. Patiño, have an output of 250 tons of tin concentrates per month. A new 350-ton mill, operated with power furnished by Diesel engines, designed to treat $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent tin ore, has just been completed.

The Uncia and Llallagua mines, operating on opposite sides of the same hill, are the two leading tin mines of Bolivia. The Uncia mines, owned by Simon I. Patiño, have a production of 850 to 1,000 tons of concentrates per month; the adjoining Llallagua mines, owned and operated by the Chilean Compañía Estanifera de



PART OF THE TOWN OF POTOSI AND THE FAMOUS CERRO RICO DE POTOSI

Llallagua, have a monthly output of 2,000 tons of concentrates, averaging 68 per cent tin, and the production is being increased. In both cases the power for mines and mills is furnished by Diesel engines. The ore reserves of the Llallagua are more extensive than those of any other tin mine of Bolivia, and place it among the big mines of the world.

It has long been known that the Uncia-Llallagua ores carry a high bismuth content in the form of bismuthinite, and extensive experiments are being carried on by Durward Copeland, metallurgist in charge of the Llallagua plant, for the purpose of separating the bismuth from the tin concentrates. The results obtained are promising. The Llallagua company owns and operates a tin smelter at Arica, Chile

SIX IMPORTANT COMPANIES OPERATE IN DISTRICT OF POTOSI

In the famous silver-tin district of Potosi six important companies are at present operating. The symmetrical conical hill known as the Cerro Rico de Potosi, with an elevation of about 16,000 ft., is honey-combed with old workings from summit to base, and is supposed to have yielded more than one billion ounces of silver and perhaps double that amount. Mining seems to have been carried on continuously since the discovery of rich silver ore in 1544, but only within the last twenty-five years has much attention been given to the tin content, which within recent years has been more important than the silver. Louis Soux, a Frenchman, is the largest operator on the mountain. Hydro-electric power is used in both mines and mills. Recently, an Ingersoll-Rand air compressor has been

installed at the mines, and improvements have doubled the capacity. Another French company, Bebin Hermanos, has just completed the erection of a modern fifty-ton mill using Diesel engines for power.

The total production of the Potosi mines is from 400 to 500 tons of tin concentrates per month. The concentrates carry considerable silver. In the past there have been attempts to consolidate all of the workings on the mountain, and there is now a rumor to the effect that such a consolidation is about to be effected. If this should be done an early output of 1,000 tons of tin-silver ore could be expected.

In the Chocaya district, the Oploco mine, owned and operated by the Compañía Minera y Agrícola de Oploco, a Chilean corporation, is producing from 500 to 600 tons of tin concentrates per month. The ore and the concentrates carry some silver. The mine has large ore reserves in a long, continuous oreshoot. Preparations are under way for a much larger production.

Tin and silver ores have been discovered recently in well-defined veins north of Mount Sorata (Illampu), in the neighborhood of Ancoma. This is important, as it enlarges the area of the tin belt to a total distance of about 400 miles in the eastern Andes (the Cordillera Real). Reports from the other outlying tin districts of Bolivia are favorable and indicate larger production in the near future.

SILVER PRODUCTION ACTIVE IN RESPONSE TO HIGH PRICES

In the foregoing descriptions mention has been made of the silver in several districts, especially in the Potosi and Oruro mines, and if the price of silver remains at its present high level it may be that some of these mines will in time yield greater returns from their silver content than from the tin values.

The Pulucayo (Huanchaco) district, near Uyuni, contains the famous Pulucayo mine, operated by the Compañía Huanchaco de Bolivia, a French company. The railroad line from Antofagasta to Uyuni was constructed in 1891 to afford better transportation facilities for this rich mine. Since 1895, when hot waters with a temperature of 70 deg. C. broke into the mine, it has been difficult to operate, but plans are now under way for the installation of an extensive plant to handle the warm acid waters. The monthly shipments to the coast amount to about 800 tons of ore carrying 100 oz. of silver per ton.

The Colquechaca district, which formerly contained very productive silver mines, is being revived. Simon I. Patiño has recently taken over one of the old producers and is installing hydro-electric power for the purpose of unwatering the old workings, after which development work on a large scale will be undertaken. A Bolivian-Chilean company has recently installed a flotation plant to treat the silver-tin ores.

Unlike the other metallic products of Bolivia, copper deposits of commercial importance are found in a single belt near the western edge of the high interior plateau, and practically all the copper production of the country comes from the Corocoro district. The greater part of the ore occurs as native copper, and in the list of native copper districts Corocoro ranks second only to the important Lake Superior region.

The country rocks are sandstones of a prevailing red color, shales, and conglomerates. The orebodies consist of layers of the sandstone through which are disseminated numerous small particles of native copper. Con-

siderable gypsum is present in the beds. Near the surface some of the ore-bearing strata contain chalcocite, cuprite, malachite, and azurite. Occasional large sheets of native copper are encountered. The bulk of the ore contains from 2½ to 4 per cent copper.

Only two important companies are operating in the district. The Compañía Corocoro de Bolivia, a Chilean concern, has recently completed a new flotation mill for the treatment of ores containing chalcocite and cuprite. The company's monthly production amounts to about 750 tons of 52 per cent copper concentrates. The Corocoro United Copper Mines, Ltd., an Anglo-French company, is treating about sixty tons of ore per day, yielding approximately 150 tons of high-grade concentrates per month. In addition, a quantity of 20 per cent copper concentrates is produced for the company's new smelter on the Chilean coast.

BISMUTH PRODUCTION A LARGE FACTOR IN WORLD'S SUPPLY

Bolivia continues to furnish the greater part of the bismuth of the world, much of which comes from some mines in which tin is the chief product. The firm of Aramayo Francke & Co., with its principal mines at Tasna and Chorolque, is the chief producer. The Llallagua and Uncia tin mines also produce some bismuth, as do several small mines in the Huayna Potosi district north of La Paz.

TUNGSTEN PRODUCTION STOPPED SINCE ARMISTICE

The production of tungsten has practically ceased since the signing of the armistice, owing to the decrease in the demand, and there is little promise for it in the future if it occurs independently of other ores. If an import tax is placed on tungsten ores by the United States, the tungsten industry of the country will be still further reduced, even though some persons are of the opinion that, next to China, tungsten ores can be produced in Bolivia at a lower cost than anywhere else in the world. In association with tin or silver minerals some tungsten concentrates will continue to be produced in Bolivia.

The occurrence and geologic features of tungsten ores are similar to those of the tin deposits, whether the tungsten minerals are found alone or associated with tin minerals. Wolframite is the most common mineral, although in some cases scheelite occurs. Tungsten has been produced in the departments of Potosi, Oruro, La Paz, and Cochabamba.

GOLD PLACERS ALONE ACTIVE

The Incaoro mines, at Pallaya, and the Olla de Oro mine, east of La Paz, the only lode gold mines of consequence operated within the last few years, were idle during the last year, owing to the present unfavorable conditions for gold mining.

In the placer-gold district northeast of Lake Titicaca, the natives continue to wash gold along the banks of several gold-bearing streams. The entire gold production for the year probably came from this source. It is supposed that some of this gold is surreptitiously taken across the border into Peru without the payment of customs duties, and hence not accounted for in the figures of annual production.

The operations on the Tipuani River have been confined to development work carried on by the Bolivian Gold Exploration Co., a North American concern, that owns and controls the principal placer deposits of the

lower course of the river, a region which was formerly fairly productive. The company has been engaged in the construction of a ten-mile ditch, which has taken considerable time, owing to adverse climatic conditions, scarcity of labor, and difficult construction. It was necessary to build nine tunnels. The ditch will be com-



BOLIVIAN WOMEN SORTING ORE. LLAMAS AND MINE BUILDINGS IN THE BACKGROUND

pleted in March, 1920, when water taken from the Gritado River will afford ample power for the continuous operations of the hydraulic elevators installed on the Colorado playa. Active operations, however, were to begin Jan. 1, 1920, as the water supply during the wet season was considered sufficient to run the operations until the completion of the ditch.