SILVER-LEAD SMELTING

By RICHARD MARSH

The folllowing lecture on silver-lead smelting was delivered by Richard Marsh, the well known assayer, before the school of mines, on Wednesday:

The lead-silver smelting industry has become one of great importance in the United States, and will no doubt become so in British Columbia. It is of special interest to Rossland at this time. For the purposes of this lecture I will define smelting as a process by which ores are brought to a state of fusion and the valuable metals separated from the worthless portions of the ore while the whole is molten.

It differs radically from lixiviation and amalgamation processes, both as to principles involved and methods used.

Those branches of smelting by which certain compounds of the elements, sulphur, arsenic, antimony, etc., are saved as bi-products, will not be considered. They are practical and profitable only where there are exceptional advantages in the way of low scale of wages and near markets.

Lead-silver smelting I will define as a process in which lead is used as a collector of the metals gold and silver while the ores of those metals are in a state of fusion. I will state here that gold acts in the smelting furnace practically the same as silver.

In contra-distinction to lead-silver-smelting we have pyritic smelting, in which a portion of the sulphur contents of pyritic ores is used as fuel, and the matte generally a ferous sulphide, formed in the furnace, is used as a collector for the precious metals. This method is applicable only to very heavy pyritic ores

There is also matte smelting, in which cuprus sulphide, or both cuprus and ferous sulphide are formed and are the collectors for the precious metals. The collector of the precious metals in a furnace is sometimes called the wash for that furnace. Hence we have the term wet ore applied to those ores which are expected to supply the wash or collector in the furnace.

The term dry ore is applied to those ores which do not contribute to any considerable extent a collector for the precious metals. They contribute largely to the slag-making substances in the furnace. The term is usually applied to silicious ores, but in the case of a lead smelter it may be applied to ores not containing lead or containing it in such small quantities as to be of no importance as furnishing a collector for the precious metals.

Rossland ores for lead smelting purposes may be considered dry ores. The fluxes are substances not containing gold and silver values, which, added to the furnace charge form with the ore a light and easily fused slag. The fluxes added to a lead-silver furnace are generally iron ores and lime stones.

If the average of ores supplied to a furnace contains sufficient silica, iron and lime to form a light and easily fused slag, they are termed self-fluxing, and the buying of iron ores and limestone, a source of considerable expense to the smelter, is obviated.

Nearly all varieties of silver and gold ores can be successfully treated in a lead-silver smelter, provided the necessary fluxes and fuel are obtainable at a low cost. Ores carrying high percentages of copper are a possible exception.

Generally a higher percentage of values can be extracted by this method than by any other. Other methods or processes of ore treatment, such as lixiviation with cyanide or hyposulpite solutions, amalgamation, pyritic smelting, etc., are limited to ores of particular classes or compositions. On the contrary, the larger the variety of ores furnished a lead smelter, the more successful will be its operation.

Fuels.—Charcoal has been successfully used in lead-silver smelting furnaces. In the early days of Leadville a great deal of smelting was done in that camp with charcoal alone. This, however, was largely owing to the fact that coke was very expensive there at that time. As soon as it was possible to obtain coke at a reasonable cost both charcoal and coke were used in the blast furnaces. In most of the lead-silver smelting furnaces that I have seen in operation, the practice has been to use both of these fuels. In furnaces of small capacity a larger proportion of charcoal can be used than in furnaces of very large capacity.

The relative proportion in which the two fuels are to be used is generally decided to some extent by the relative cost at the smelter. If timber is scarce in the country surrounding the smelter, the cost of charcoal will be relatively high, and a smaller proportionate quantity will be used. Lead-silver blast furnaces can be operated with either fuel. The coke used should be hard and as free from silica as possible. A low percentage of ash in coke is desirable, because manifestly every percentage of ash decreases by so much the carbon or heat-producing contents of the coke. The ash is generally from 55 to 65 per cent silica. This silica must be smelted just the same as the ore itself, and requires its proportion of fluxes as well. It will thus be seen the ash contents of a fuel not only decreases the heat-producing power, but consumes a portion of the remaining heat or caloric power of the fuel. Ten or twelve per cent ash is very near the limit for good coke. The Crow's Nest coke is said to contain from three to five per cent ash, which is a very low percentage. Coke should be hard. This quality is required so that it will hold up the weight of the ore and fluxes until they reach the fusion zone of the furnace. In these days of large furnaces this quality is very important. If the coke is soft and friable, the ore and other material in the furnaces mashes down, and the combustion of the fuel is in spots, portions of the ore fail to get melted, and other portions get melted too soon—the result is all kinds of trouble. A small furnace can use successfully a larger proportion of charcoal than a large furnace, because it does not have to carry so heavy a load. Coke being the harder of the two fuels, a piece of good coke when dry will ring when struck almost like a piece of metal.

In the larger furnaces the present tendency is to use coke alone.

The condition necessary to the successful operation of a lead-silver smelting plant, it may then be stated, are a supply of a variety of silver ores, lead ores, cheap fluxes and cheap fuel of good quality. Since no one mining camp can be expected to fulfill all of these conditions, the experience in the United States has led to the erection of large lead-silver smelting plants at such transportation centers as Denver, Pueblo, Kansas City, Omaha, St. Louis and Valejo.

The reverse is the case with other methods of treating ores. The plants for copper smelting, lixiviation works and amalgamation mills are usually erected in the vicinity of the mines producing ores peculiarly adapted to those particular methods of treatment. This difference is quite striking. At any of the large lead-silver plants of the States may be seen ores from Mexico, British Columbia, Alaska, and from nearly all the silver producing states of the United States.

We now come to the furnace. Lead-silver smelting is generally conducted in a blast furnace. The various parts of the furnace are the crucible, the water jacket, tuyeres, lead well, stack or body of furnace, down take, and dust chambers. The body of the furnace is constructed of fire brick, as is also the crucible. The jacket is allowed to flow. The dust chambers and flues may be constructed of brick, is two sheets of iron between which water stone or iron. The fumes from the furnace are passed through these flues and chambers, where the dust settles and is collected from time to time. It amounts to from 1 to 2 1-2 per cent of ore charged into the furnace, and generally has nearly the same assay value.

Before being introduced into a lead furnace of this description a great many ores require preliminary treatment.

Ores containing a great deal of sulphur must be calcined, or roasted, otherwise there would be an undue amount of matte formed in the furnace. Also infusable compounds would be formed causing freeze ups.

Some ores can be sufficiently calcined by ordinary heap or stall roasting.

In this method the ore is piled on a layer of cordwood, which starts the fire, and the combustion of the sulphur in the ores accomplishes the rest. By this method the sulphur contents can be reduced to from 3 to 6 per cent, and a large portion of baser metals is oxidized.

Most lead smelters, however, prefer regular roasting furnaces, of which there are a great many different paterns in use. In these the sulphur contents are reduced to from one-half per cent to 3 per cent. Much of the arsenic, antimony and other objectionable substances are all eliminated.

When a smelter receives a large amount of fine concentrates and fine ores, it is necessary to sintre or aglomerate them to avoid excessive dust being driven out of the furnace by the blast, and to prevent packing of the charge in the furnace.

If the material charged into the furnace were very fine there would be no chance for the fire to be distributed evenly through the charge.

Sintering consists in bringing the ore a semi-plastic condition in a suitable furnace. By this the fine ore is stuck together in lumps.

The ores for a lead-silver furnace must be mixed so that their average contents will form a light and easily fusable slag, and so that there will be sufficient lead to collect all of the gold and silver values.

It has been found in practice that unless there is at least 8 per cent of the charge lead, the loss of gold and silver is excessive. Twelve per cent is about the general average used.

The office of the slag is to hold in solution or suspension the worthless portion of the ore, and at the same time allow the molten lead to pass through it, collecting the valuable contents. The mixing of the ores is one of the most important operations in connection with the smelter, and should always be in charge of a thoroughly practical and experienced metallurgist. The slag should contain nearly equal portions of silica and ferous oxide of iron, and from 12 to 28 per cent lime.

These proportions can be varied within certain limits.

They will generally form about 90 per cent of the total contents of the slag. The remainder will be alumina or (aluminum oxide) magnesia, (magniseum oxide) and other impurities of the ore.

The following are some of the slags used:

	Per cent. Si O2	Per cent. FeO	Per cent. CaO
A.....35	28	28
B.....34	34	24
C.....34	34	17
D.....30	40	20
E.....30	48	12

Slag C is a favorite with Colorado smelters, as it runs well with a high percentage of zinc. As the zinc decreases the lime charge is increased. Slag A is a good slag for ores carrying considerable alumina, but cannot be used where the ores contain much zinc. It would be used in a smelter where ores containing high iron percentages were hard to obtain. Slag B is a good slag where iron ores could be obtained cheaply and there was considerable silica in the ores and not much zinc. It is more fusable that A and smelts more rapidly. Slag D is a good slag, known as the half slag, and is adapted to localities where the iron contents of the ores is large. E is a slag known as the quarter slag, and can only be used where the percentage of iron in the ores is exceptionally high.

Manganese oxide up to 7 or 8 per cent can take the place of ferrous oxide.

Generally the silver ores supplied to a smelter carry a large excess of silica. Consequently the smelter must buy iron ores for flux. They charge from 10 to 15 cents for each unit of per cent of silica in excess over iron in the ore. If there is an excess of iron over silica they will pay from 10 to 15 cents per unit for the excess.

It will be seen from this that the metallurgist must be guided in making these mixtures, not only by what is best metallurgically, but must also consider the cost of his fluxes. What might be good metallurgically might be so expensive as to destroy profits.

Lime Ca O is generally supplied by adding limestone, Ca C O3 (which is Ca O 56 per cent plus 44 per cent C O2.) It can usually be obtained from 94 to 98 per cent free. When the metallurgist in charge has decided on his slag, the ore is generally piled in a large bed near the furnace, the various ores in the proper proportions with the fluxes, although frequently the fluxes are added asthe ore is charged into the furnace, thus admitting of a change in the slag formula, if the one adopted should from some cause prove unsatisfactory. An ore bed will have from one to three thousand tons in it. The ore mixture is charged into the furnace at the feed hole, from 600 to 1,000 pounds at a time, according to the size of the furnace. The fuel is generally charged alternately with the ore. The quantity of the fuel varies with the character of ore charge and the altitude. It varies from 12 to 24 per cent of the total weight of the ore and fluxes, exclusive of such slag from previous operation which may be added. Some of the sulphur in the ore will act as fuel and affect the quantity of the regular fuel charge.

Altitude also has an effect, for instance at Leadville, 10,000 feet above sea level; 20 to 22 per cent fuel charge is required, while 15 to 17 per cent fuel charge will answer for practically the same ores at Denver, 5,000 feet above sea level.

The blast is supplied to the furnace from pressure blowers, of which there are several patterns on the market. A fan blower does not furnish the necessary pressure. The pressure of the blast must support a column of mercury from three to four inches high, equal to 25 to 35 ounces.

In starting the furnace several tons of lead bullion from previous operations are put in the crucible of the furnace, a wood fire built on it and coke and charcoal shovelled in, the blast turned on moderately, and the ore and fluxes added, and the fuel added as the furnace commences to work. If everything is all right the slag will commence to run in from one to three hours.

The slag is generally run into a settling pot, particularly if there are any matte forming compounds in the furnace. The matte will settle to the bottom of the settling pot, from which it may be obtained later.

The slag runs from the settling pot to the slagpots, which are emptied onto the slag dump.

The base, or lead bullion, is dipped out of the lead well into molds holding generally about 100 pounds, with ladles. The fusion zone of the furnace is immediately below the tuveres. The fire zone immediately above. The fire should never be allowed to climb very far above the jackets into the brick portion of the furnace. If this happens there is sure to be trouble, and often a freeze-up, which is a very expensive thing for the company owning the furnace. Furnaces, if working well, can be run from three to eight months without being shut down for repairs. If the fire "climbs" in the furnace the fuel is exhausted before the proper time, partially melted ore sticks to the sides of the furnace, and it gradually closes up, necessitating the cooling off of the furnace and barring off the accumulated slag and ore, a very expensive and uncomfortable operation. An accumulation on the sides of the furnace is generally called by the furnacemen a sow.

The silver saved in a lead-silver furnace should equal 95 to 98 per cent of the assay value of the ores. The gold will generally equal the full assay values in the ores, while the lead saved will equal from 90 to 94 per cent of the assay values.

Most smelters endeavor to have thin lead bullion run from 200 to 300 ounces silver to the ton. It is generally refined by one of three methods, cuppellation, the Pattison process and the Parks process, or a combination of these processes.

The Pattison process consists in putting the bullion in large iron pots, where it is melted and then cooled to a point where the lead commences to crystalize. It has been found that lead that crystalizes first contains very little silver, that which remains liquid containing most of the values. The crystals are removed with a perforated ladle into an adjoining pot, and the operation repeated from one pot to another, until the lead in the last pot on the right is found to contain too small a quantity of silver to pay for further refining.

The liquid metal in the first pot used is transferred to one on the left, and is melted and cooled in the same manner, the crystals removed being put in the pots on the right, while the liquid and more fusible alloy is removed to pots on the left. In this way it is found that there will be a very rich alloy of silver in the extreme left hand pot, and nearly pure lead in the furthest right hand pot. This rich alloy is further refined by cuppellation, which consists in putting it in a clay or bone ash receptacle and blowing a blast of air over it while it is in a state of fusion. The lead is oxidized and drawn off as litharge, (lead oxide) while the gold and silver remains 999 fine.

The Parks method consists in melting the lead bullion and putting into it molten zinc. The zinc has a stronger affinity for the silver than the lead, and consequently attracts it. The zinc and silver having a lighter specific gravity and higher fusion point, rises to the surface and is taken off as a crust. The zinc crust containing the silver is then put into a properly constructed furnace, where the zinc is driven off as an oxide, the silver remaining nearly pure. The zinc fumes are conducted to a chamber where they are condensed and saved as a commercial product.

LARGE RESERVES OF ORE

Major Leckie Tells of His Recent Inspection of the B. C.

There Is 3000 Tons Ready for the Smelter Taken Out in the Course of the Development.

Major R. G. Edwards Leckie, in speaking about his recent trip to the Boundary Creek country yesterday, said: "The development work on the 50-foot level of the B. C. mine has opened up a large body of ore. A drive has been made to the north from the shaft for a distance of over 70 feet, and is in clean shipping ore all the way. In the lower, or 150-foot level, the north drift has been extended for 80 feet, and has opened up considerable shipping ore. In the work recently done there has been extracted 1,000 tons of ore, which, added to the 2,000 tons recently taken out, gives a total of 3,000 tons that is ready on the dump for shipment to the smelter as soon as the railway is finished and ready to receive it. The ore recently extracted consists of two grades. The higher grade carries $1 in gold, six ounces in silver and 12 per cent copper, or about $30 per ton. The second grade ore carries $1.50 in gold, three ounces in silver and six per cent copper, or a total value of $15 per ton. The 3,000 tons of ore was all taken out during the progress of the development work. There has been no attempt made to stope any of the ore. It has been blocked out and left. This shows what large reserves of ore there is in the mine. Twenty men are now employed in the mine. A new 40-horse power boiler has just been installed. The plant, before this boiler was put in consisted of a 30-horse power boiler, a5-drill compressor, etc. This plant will be used until the new one is installed. The new plant will consist of two 80-horse power boilers, a 20-drill compressor and a new hoist. This will be shipped in just as soon as the Canadian Pacific railway is finished. The work of constructing the branch railway from the main line of the C. P. R. from Eholt to Summit camp has already been commenced. The branch is two miles in length.

"Considerable development work is being done on other mining properties in the Summit camp. This is notably the case with the R. Bell. There is in this property from three to four feet of high grade copper ore, which is believed to be the richest in the Summit camp. The Remington, another property in Summit camp, has a good surface showing. Work is also being vigorously pushed on the Rathmullen and the Homestake. The outlook for Summit camp as a copper producer is very encouraging.

"In Smith's camp, near Boundary Falls, four miles south of Greenwood, recent developments show some very good copper ore in some of the claims there."

The New Teacher.

A reply to the communication of the board of school trustees asking for a new teacher has been received by Chairman Lalonde, of the board of school trustees. The letter states that the matter will be referred to the acting minister of education. The reply is not satisfactory to the board, as early action is necessary, not to say imperative. But the trustees feel that Rossland is a long way from Victoria.

THE EIGHT HOUR LAW

The Government Has Suspended Its Operation.

PREMIER SEMLIN'S VIEWS

The Law Will Come Up Again at the Next Session For Discussion—Space For British Columbia at the Paris Exhibition.

Victoria, April 15.—As a result of the representations made by the mine owners the provincial government has definitely suspended the operation of the legislation prohibiting the employment of men under ground in auriferous mines more than eight hours a day.

Hon. Fred Hume, minister of mines, says that it will stand suspended until the opinion of the miners, the other parties to be considered, could be heard. Speaking on the same subject, Premier Semlin said the government proposed to proceed slowly and to do nothing which would cause friction btween the mine owners and miners.

The government would institute no proceedings for the present, or in any way seek to disturb the existing relations between employers and employees. Should the miners in any district ask for its enforcement their request will be granted. In such case one month's notice has been assured the mine owners before the act comes into force. The government has instructed Inspector MacGregor to this effect. The question of retention or repeal of the law is a matter that will be left to the house at the next session.

The Provincial government this morning received the plans for the British Columbia pavilion, to be erected at the Paris exposition for British exhibitors. The entire floor space is 3,900 square feet, of which about an eighth is available for Canada, and a proportinate area for British Columbia. At the World's Fair at Chicago the province had 14,000 square feet of space, every inch of which was used.

At the last session of the legislature a vote of $15,000 was included in the estimates to meet the expenditures of the exhibit, and as the space is to be so small this appropriation is likely to be ample.

When it became known that the British Empire would be so cramped for accommodation, the British Columbia representative suggested hiring a building apart from the exposition structure, where an ample display could be made. This concession, however, was refused.

The steamer City of Seattle, three days overdue from northern points, was the cause of some anxious speculation today, until word arrived of her having been towed into Juneau by the Amur of this city, who found her helpless with a broken crank shaft.

COAL-LOADING RECORDS.

What Nanaimo Can Do at Her Collieries—Some Comparisons

Nanaimo as a coal mining center is steadily forcing itself to the front and is fast becoming the chief coaling port on the North Pacific for all deep sea vessels. Yesterday the monthly shipments of coal from the island collieries were published. These showed that during the quarter ending March 31, 150,306 tons have been shipped the majority of which was for American users. Out of this total the New Vancouver Coal company shipped in March alone, 31,547 tons; the Wellington collieries, 17,150, and the Union mines 11,208 tons, making a total of 59,905 tons for the month.

The New Vancouver Coal company, without any extra exertion, has placed 750 tons of its superior quality of Nanaimo coal per hour, for five consecutive hours, in the steamer Titania. This is at the rate of 12 1-2 tons per minute. Not very long since 9,000 tons were loaded into steamers by this company in 50 hours. The vessels were the Burma and Siam. They arrived in the port within a few hours of each other and took on coal simultaneously from the bunkers. This not only shows the superior loading facilities of the company, but demonstrates the fact that its storage facility is sufficient to load nearly 9,000 tons without depending on the simultaneous output of the mines.

Only last week the steamer Mineola completed loading 3,200 tons of coal in 11 3-4 hours, which is one of Nanaimo's record times. Vancouver News-Advertiser.

A SPLENDID MAP.

Coryell's New Map of Grand Forks and Kettle River Divisions Corrected to April 1, 1899.

Another map has just been issued by John A. Coryell, C. E., P. L. S., etc., of Grand Forks, of the Grand Forks and Kettle River Mining divisions. It shows the mineral claims located up to April 1, 1899, in these two mining divisions. The map is similar to the one issued in 1897, corrected to date. The map shows all the claims in the vicinity of Grand Forks, on Hardy mountain, in Wellington, Seattle, Summit, Brown's, Knight's and Pass Creek camps; and in the Kettle River Mining division the claims in Central, Skylark, Summit, Greenwood, Smith's, Graham's Providence, Deadwood, Copper, Long Lake, and Kimberley camps. The map covers territory from about six miles east of Grand Forks to six miles west of Midway and extends north from international boundary for about 20 miles. At present blue-prints are being issued to supply the great demand. The price is $1.50 per copy and all dealers will have them.

Mr. Coryell and his draughtsmen have been working at this map for two and a half months. The publication is copyrighted both in Canada and the United States.

Slatan Pasha has been discussing Mr. Rhodes telegraph and railway scheme. He is not unfriendly to either project; but is frankly of the opinion that the extension of the telegraph wire south of the Soudan would probably be of little value so long as no direct means of transport existed between Cairo and the Cape. Still, such a telegraph line might be of advantage in creating such a connection. That barrier of vegetable floatsam, the "sudd," puts difficulties in the transport of necessary material. So far as relates to the railway, which would closely follow the course of the Nile, and pass through marshy districts, these difficulties are greater. It is not an opportune time, in his view, to construct a railway from Dufile to Khartoum. Break through the vegetable barrier on the White Nile, and it would be possible for the "sudd" to form again. Since an African railway will affect the greatest interests of Germany, Slatin Pasha considers that nation ought to give its support to Mr. Rhodes' proposal.