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## Platinum Assaying at the Boss Mine

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Upon assuming my duties as assistant superintendent at the Boss mine, Goodsprings, Nevada, it became apparent at once that some assaying method must be devised rapid enough to test the daily samples and yet secure a commercial degree of accuracy. When it is understood that the assay for gold, copper, platinum, palladium, and at times silver, in the same sample must be completed in time for the next lot (say of from ten to twenty samples) it at once becomes apparent to the assayer that methods involving less than two to four days must be devised. It will be interesting to follow the course pursued in eliminating the older methods and developing the new. Each of the standard methods had its strong points, but the vital factor of time made each out of the question for our purpose, especially as these methods required, in most cases, from three to five assay-tons, of which the fusion and cupelling alone would take nearly a day.

The first method used is the one chiefly in vogue on the Pacific Coast, the procedure being the same as with gold, only, instead of the smaller charge of a half or one assay-ton, 5 A. T. is required; an estimated amount of silver, equal to at least 12 times the amount of platinum, being added to the fusion. After cupelling, the button is parted in dilute  $\text{HNO}_3$ , then in concentrated  $\text{HNO}_3$ , leaving the gold as residue. The silver is precipitated with  $\text{HCl}$ , added drop by drop, the solution being then filtered twice and washed thoroughly. Silver-free zinc-dust is added in excess of any acid reaction, the solution filtered, the filter-paper dried and ignited, a known amount of silver added, and the whole then mixed with a proper flux and reduced to a lead button. Proof-silver is run alongside this, and in weighing the cupelled buttons the loss in silver is used as a correction on the Pt-Pd button. This method proved unreliable, as the zinc invariably precipitated some of the silver still in solution, resulting in silver being weighed as platinum-palladium.

Another method, described by J. Ohly, in his 'Analysis, Detection and Commercial Value of the Rare Metals,' on pp. 79-82, was used in combination, so as to include both platinum and palladium. This method, though accurate and by far the most satisfactory of any of those used, took more time than could be given, inasmuch as the treatment necessitated an additional step; not combining the two elements in one single operation but allowing the use of the same solution throughout. As copper in the ore interfered and complicated the assay, Ohly's method for eliminating this element (page 86) was used.

Ricketts & Miller, in 'Notes on Assaying,' pp. 130-135, give two methods for the determination of platinum. In the assaying at the Boss mine, palladium must also be

determined. To do so by this method, a complicated series of steps is necessary, involving the method described by Ohly as well as the addition of formic acid. The method naturally took more than the available time, but for accuracy of results compared favorably with the others.

Furman, in 'A Manual of Practical Assaying,' pp. 310-311 and 246-249, gives the assay for gold bullion. This was modified with several additions in such a manner as to allow the assaying of ore to determine the palladium. The method is very clumsy, though as accurate as the others. Another method noted, but not used on account of its length, was recently described in the *Mining Journal* of New York. Other schemes, not worthy of mention on account of their unreliability, were tried and, though aiding, each in a small way, in devising the final method, cannot in themselves be termed worthy of note.

The method now in use, the one finally developed, makes use of the solution after parting platinum, palladium, and silver from the gold in an ordinary assay upon  $\frac{1}{2}$  to 1 A.T. of pulp, depending upon the content. In assaying hundreds of samples, the assayer is soon able readily to distinguish a low-grade from a high-grade ore. Silver, estimated at about 15 times the platinum-palladium content, is added to the crucible-charge. The fusion is made at a high heat throughout, and in cupelling the lead button a moderately high heat is maintained: a heat above that required to 'flower' being the more satisfactory. The button is parted first in ordinary dilute nitric acid, and when the parting is apparently complete, 5 c.c. of concentrated nitric acid is added and boiled 10 minutes. Then pour into a casserole; the residue (gold) is washed in a 1 to 10 solution of nitric acid and the washings added to the casserole; the assay for gold is then finished in the ordinary way.

At first the solution was taken up in  $\text{HCl}$  after evaporation, and the silver eliminated by filtering twice. This step, however, proved unsatisfactory, owing to there being some silver still in solution. This, when the platinum-palladium content is above 2 oz. per ton, has a tendency to precipitate with them. The discovery led to a development of the present method, after the use of  $\text{HCl}$  was discarded. The precipitation of the platinum-palladium is somewhat the same, without alcohol and without boiling prior to adding formic acid.

The present method, after parting the gold, takes less than three hours for 20 samples and is conducted as follows: The silver is precipitated by a super-saturated solution of sodium chloride, filtered first with a wash, then re-filtered without a wash. The filtrate is neutralized with ammonium-hydrate in slight excess and brought

to a boil. Formic acid is then added till the solution becomes distinctly acid, even strongly so, and boiled briskly for from 20 to 30 minutes. (If the platinum content is high, 10 to 15 c.c. alcohol is added after the formic acid. This is readily determined, as the parted solution shows strongly yellow if over  $\frac{1}{2}$ -oz. per ton platinum-palladium is present.) After boiling, the solution is filtered without washing, the filter-paper dried, ignited, and the residue wrapped in lead-foil and cupelled, allowing the completely cupelled button to remain in the muffle about 10 minutes more and raising the heat. The resulting button is weighed and recorded as platinum-palladium, a further parting not being necessary for ordinary purposes. It is not necessary, but preferable, to ignite the filter-paper; this, however, can be omitted and the filter-paper wrapped in lead-foil and cupelled. The difference in results is very slight, but in favor of ignition first. The results of tests are given below:

Sample No. ....	1.	2.	3.	4.	5.
Filter ignited .....	0.63	0.18	0.32	0.07	2.42
Filter cupelled .....	0.61	0.18	0.31	0.07	2.38

the error being a little more than 1%.

When a silver determination is necessary, a known amount is added, the button weighed before parting; after the gold and platinum-palladium assay is complete, the silver content is readily computed by difference. It is well to run a proof at the same time for correction purposes.

The following table is inserted in order to compare the various results by the different methods. They were picked at random from a score of comparative assays, and for the three grades of ore. These results are averaged from three assays each on each method employed and on the same pulps:

Method.	High grade.		Medium grade.		Low grade.	
	Au.	Pt-Pd,	Au.	Pt-Pd,	Au.	Pt-Pd,
	oz.	oz.	oz.	oz.	oz.	oz.
J. Ohly .....	79.62	246.12	1.53	0.67	0.18	0.22
Zinc-dust .....	81.33	272.48	1.51	0.84	0.18	0.31
Ricketts No. 1....	80.86	233.19	1.53	0.51	0.18	0.16
Ricketts No. 2....	84.37	239.63	1.53	0.54	0.17	0.19
Furman .....	82.66	249.37	1.52	0.65	0.18	0.20
New (no alcohol).	81.99	245.83	1.53	0.67	0.18	0.20
New (alcohol) ...	82.87	247.21	1.53	0.69	0.18	0.21

It is probable that the lower platinum-palladium results by the Ricketts & Miller method are due to the incomplete precipitation of palladium, while the high assay by the zinc-dust method is due, of course, to silver being weighed with the button, having been precipitated by the zinc. Otherwise, the table speaks for itself.

It can be seen at a glance that the new method compares most favorably with the older ones. Inasmuch as the assay for gold was made on all the samples, it is inserted, though it has no distinct bearing on the platinum-palladium assay. Assays for comparison on the silver were not made, but it is reasonable to expect that the check would be as close as in any other silver assay.

Extreme accuracy is not claimed for the method, but merely an accuracy commensurate with the relative im-

portance of daily samples for a mine in process of being developed. It is only fair, however, to say that 0.05 to 0.06 would be the extreme error per ounce of platinum-palladium, by this method.

It is a pertinent fact, and one worthy of note, that reports on samples of pulp first assayed at the mine and then sent to representative and reliable assayers would show a wide variation from each other, and a sample of the same pulp, submitted to one assayer was reported differently each time. This seems to be the rule rather than the exception, and naturally leads one to the conclusion that assayers either are not familiar enough with the determination of platinum or show a marked degree of carelessness. Possibly the methods employed are not the proper ones; at any rate there is something wrong. The following table, on the assay of six samples, is inserted for comparison:

Assayer.	1.	2.	3.	4.	5.	6.
Self .....	0.16	1.15	0.11	1.18	0.11	0.65
No. 1 .....	0.32	...	...	...	0.08	0.76
No. 2 .....	...	0.82	0.07	...	0.03	...
No. 3 .....	...	...	0.32	3.57	...	0.48

The results, of course, are for platinum-palladium only. It is hard to tell which are correct and which are not; the wide variation would seem to indicate, however, that the proof of accuracy is yet a factor to be determined and that co-operation and the exchange of ores as well as of notes by the different assayers would be a step in the right direction. It would appear to me that the more numerous the steps in an assay, the greater the chance of error. The elimination, wherever possible, of all but the basic steps, lessens the chance of loss and gives results more uniform throughout. The following table of an assay on the same ore by two methods, both comparatively short, the shorter being the Boss method, shows the variation to be wide, even when conducted by the same assayer.

Only method.	Boss method.
1.61 -0.73	1.62 -0.69
1.64 -0.70	1.64 -0.71
1.62 -0.62	1.62 -0.66
1.62 -0.66	1.62 -0.69
Average 1.622-0.677	1.625-0.687

The averages here check as well as could be desired; however, an extreme variation of 0.11 oz. is noted by one method and 0.05 oz. by the other, a little too much for even commercial work on metals of which each 0.01 oz. is equal to 40 cents.

I do not claim any originality for the new method, and wish to give due credit to the aid afforded by older ones. The Pacific Platinum works uses, it is understood, a formic acid method similar to the one in use at the Boss mine, and it is primarily through study of that method that the present one was evolved.

COPPER AND SULPHUR DEPOSITS are reported to have been discovered in the Planchon pass, between the Colorado and Atuel rivers, province of Mendoza, Argentina. Their altitude is about 6500 ft., according to a consular report of June 12 from Rosario.

scope shows that it is an aggregate of quartz, chalcocite, and brochantite, with octahedrite present as a rare accessory mineral; the brochantite occurs in partial replacement of the quartz and is somewhat more abundant than would be estimated from inspection by the unaided eye. An oxidized bismuth compound is associated with some of the chalcocite.

**GENESIS OF THE ORE.** The Boss deposit represents in the main an irregular silicious replacement of dolomite along a series of vertical fractures. On account of the prevalent oxidation and the inconsiderable depth to which the workings have penetrated, primary sulphides have not yet been reached. The chalcocite, the only sulphide so far found, most probably originated as a precipitate from downward-moving solutions whose copper was derived from primary sulphides formerly exposed to oxidation near the surface.

The deposit yields as yet no especially strong evidence concerning the genetic conditions that prevailed at the time it originated. Some clue is perhaps afforded by the presence of the titanium oxide minerals, octahedrite, and rutile. Both of these are rather uncommon in metalliferous deposits. Of the two, rutile is the more common. It is, for example, somewhat abundant in certain of the auriferous deposits of the Juneau gold belt, which are veins that originated at high temperature; in fact, according to W. H. Emmons,\* rutile is restricted to high-temperature veins. Octahedrite occurs in the tourmaline-bearing copper veins of Las Condes, Chile;† in tin veins of Saxony associated with apatite, fluorite, and chlorite; and in fissure-fillings in the Alps, but these veins are not notably metalliferous. The Alpine veins are thought to have formed at temperatures between 250 and 400°. In view of the affiliation generally shown by the octahedrite and rutile with deposits of high-temperature origin, the suggestion is advanced that the primary ore of the Boss deposit was formed under conditions of moderately high temperature.

The facts at hand cannot of themselves be held to prove that the ore deposition was genetically connected with the intrusion of any particular dike or igneous mass now visible at the surface. It is probable, nevertheless, that the mineralization followed as a sequel to the intrusion of the magma from which the granite-porphry dikes were derived, for these are the only intrusives that penetrate the rocks of the district.

The deposit, as already described, is highly oxidized and contains abundant oxidized copper compounds and plumbojarosite. These minerals indicate that the primary sulphides will be found to carry copper, iron, lead, bismuth, and precious metals. The extraordinary richness in gold, platinum, and palladium of ore containing notable quantities of plumbojarosite raises an important problem. It is not impossible that the plumbojarosite may have originated essentially in place by simple oxidation of sulphides that were extremely rich in precious metals. A partial analogy for this supposition is fur-

nished by the development of the brochantite in the chalcocite-bearing ore; the brochantite appears to have formed in place from the chalcocite without any important migration of copper. For the origin of the plumbojarosite, however, the following explanation appears to fit the known facts more closely. B. S. Butler,‡ who has recently shown that in the oxidized ores of Utah plumbojarosite is rather common, although heretofore unrecognized, believes that in the occurrences studied by him the plumbojarosite was produced by the action of ferric solutions on galena; the lead has remained essentially in place, but the iron may have come from some distance. It is therefore suggested that in the Boss orebody descending solutions rich in ferric sulphate attacked primary galena, forming the plumbojarosite, and that this reaction caused the concomitant precipitation of the gold, platinum, and palladium. According to this explanation, an efficient solvent for the precious metals was active and in this connection the fact established by R. C. Wells, during the chemical investigation of the plumbojarosite, that the precious metals are rather soluble in hydrochloric acid in the presence of plumbojarosite is highly suggestive.

On the whole, then, it is likely, in view of the probable mode of origin of the plumbojarosite and of the evidence of leaching indicated by the porous nature of the silicious ore, that a certain amount of re-distribution of gold, platinum, and palladium has taken place by the action of descending surface solutions. It would follow, then, that in depth, below the zone of oxidation, the pockets of extremely high-grade ore, such as are now being extracted, will be found to give way to ore of moderate grade.

### Milling Costs at Goldfield Consolidated

In 1914 the 100-stamp mill and cyanide plant treated 332,750 tons of ore at the following cost:

Department.	Per ton.	Department.	Per ton.
Crushing and conveying.	\$0.046	Surface and plant.	.....\$0.005
Stamping .....	0.124	Steam heating .....	0.001
Chilean mills .....	0.103	Store and office.....	0.013
Elevating and classify-		Stable .....	0.002
ing .....	0.020	Watchmen .....	0.022
Tube-mills .....	0.242	Superintendence .....	0.045
Concentration .....	0.052	Lighting .....	0.018
Neutralizing .....	0.061	General expense .....	0.007
Settling .....	0.069	Mill tools .....	0.003
Dissolution .....	0.461	Electrical department..	0.018
Filtering .....	0.062	Pumping battery water	0.025
Residue .....	0.002	Experimental .....	0.002
Assaying .....	0.019	Clean-up .....	0.024
Precipitation .....	0.062		
Refining .....	0.046	Total .....	\$1.606
Water .....	0.052		

In the total charges, labor absorbed 21.86%, supplies 56.60%, and power 21.54%, and in the combined cost of milling and concentrate treatment these were reduced to 18.44%, 47.77%, and 18.18% respectively.

\*'A Genetic Classification of Minerals,' *Economic Geology*, Vol. 3, p. 625, 1908.

†Lindgren, Waldemar, 'Mineral Deposits,' p. 655, 1913.

‡'Occurrence of Complex and Little-Known Sulphates and Sulpharsenates as Ore Minerals in Utah,' *Economic Geology*, Vol. 8, pp. 315-316, 1913.



## CONCENTRATES

Readers of the MINING AND SCIENTIFIC PRESS are invited to ask questions and give information dealing with technical and other matters pertaining to the practice of mining, milling, and smelting.

EVERY EXPLOSIVE when exploded exerts pressure in all directions.

MOST EXPLOSIVES suitable for use in such work as quarrying are unsuitable for use in deep mines or in close workings.

PLATINUM found its first use as a material for resisting chemical action. It is now used in jewelry, particularly for setting diamonds; also in electrical apparatus.

GRANULATED NITRO-GLYCERIN POWDER such as is generally sold in the United States contains about 5% nitro-glycerin, 35% combustible matter, and 60% sodium nitrate.

A RELIABLE THERMOMETER should be placed in all thawing-houses for explosives. It should be visible from the outside. The maximum temperature is not to exceed 80° Fahrenheit.

CHROMITE at Selukwe, Rhodesia, is found in schist in lenticles that are original crystallizations of the igneous magmas from which the schist has been derived by metamorphism.

CADMIUM is a deleterious impurity in zinc, as employed in the making of brass, if present in excess of 0.5%. Up to 0.25% the presence of cadmium in spelter exerts no unfavorable effect.

POTASH SALTS occurring in the mud of Columbus marsh, Nevada, have been absorbed from solution and are held in loosely combined form, according to the investigations of W. B. Hicks.

ELECTROLYTIC BATHS are not of service in cases of lead poisoning, according to the views of a recent investigator, as the lead accumulated in the tissues is a part of organic compounds not easily ionized.

CHROMITE BRICK can be used to advantage in reverberatory furnaces for smelting antimony, arsenic, bismuth, and tin, because the slags produced in the reduction of these metals are extremely corrosive and the

oxides act as acids in attacking a basic lining, so that a neutral material is desirable.

PYRITE CONCRETIONS in South African sandstones are derived from pyrite nodules formed by replacement of the sandstone. Atmospheric and surface-water action on these produce the concretions, according to R. B. Young.

THE PANAMA CANAL is now operating at a profit. In March the tolls amounted to \$560,785. Operation and maintenance cost \$423,275. The surplus was \$137,510. Since July 1, 1914, the total revenue is \$2,895,300; charges, \$3,018,889; deficit, \$123,588.

CONCRETIONS containing large amounts of iron, manganese, and alumina found in Germany lying about a foot below the surface of soil overlying diluvial sand are thought to have originated from the precipitation of iron and manganese coming in solution from below.

MINE TIMBER should be properly cared for on the surface while waiting to be used underground. Important factors affecting the amount of deterioration are as follows: position of the yard, method of piling the lumber, climate and season of the year, and dimension of the stock.

PLATINUM production of Russia decreased in 1914 from 173,642 to 156,775 oz. The market for the metal was principally France and Germany. In July 1915 there is to be an export duty of about 30% placed on raw material. This will result in refineries being started in Russia.

LOCAL TERMS in the Wisconsin zinc district are as follows: 'dirt,' ore and waste as broken in the mines; 'sulphur,' iron sulphide; 'jack,' zinc sulphide; 'lead,' galena; 'tiff,' calcite; and 'velvet,' profit, referring to the galena when not too intimately mixed with blende to allow easy separation.

PICRIC ACID is used in the manufacture of ammunition. It is made by mixing carbolic acid with strong sulphuric