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The Recovery of Alluvial Gold

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INTRODUCTION

THIS paper is submitted primarily to put on record the results of a number of experiments carried out at the Wingdam mine of Consolidated Gold Alluvials of B.C., Ltd., with the object of establishing a reliable method of concentration of 'wash' and a maximum recovery of gold from the concentrate.

It will be generally admitted that, during the last two decades, a tremendous amount of research work has been carried out, both by private companies and Government departments, with a view to improving the technique of the recovery of gold from quartz veins or lodes. So thorough have been these investigations that milling practice at a modern quartz gold mine is almost an exact science, carried out with meticulous accuracy.

In placer mining, on the other hand, very little departure from old traditional methods can be noted, with the exception perhaps of the more modern gold dredges. This may be due to the fact that the concentration of placer gravels, up to a certain point, is comparatively easy. Only a simple equipment of sluice box and riffles seems necessary where the gold is coarse and the gravel free from clay.

In the early days of placer mining, when claims were rich and fairly shallow, nobody worried very much about fine gold; and, if clay was present, an enlarged dump box was constructed in which the gravel was subjected to a rather desultory puddling.

That large quantities of gold are lost in normal placer practice is generally admitted. Some 26 years ago, I had inspectorial charge of many bucket dredges on the Ovens river, in Australia. Occasionally it was necessary for a dredge to work through its own tailing to reach a new section, and almost without exception enough gold was recovered from these tailings to defray the total cost of moving the dredge. Since those days, the technique of gold recovery in dredging has been considerably improved and it is still receiving close attention.

Outside of dredge mining, most placer operations, deep or otherwise, are as they were—notorious gold losers, paying little attention to the recovery of fine gold and taking an absurd amount of time over each clean-up.

In the Cariboo district of British Columbia, the alluvial gold is usually associated with varying quantities of black sand (magnetic) and grey sand (non-magnetic); and it can be taken as axiomatic that, if you save all the black sand and grey sand, you save practically all the gold. It is on this hypothesis that we have carried out our research work and brought our recovery system up to its present highly satisfactory standard.

We are all familiar with the old-time sluicing arrangements, when no attempt was made to classify, and boulders of anything up to twelve inches were rushed through sluice boxes with excess water specially reserved for that purpose. This excess water, while necessary in order to keep the sluice boxes clear under these circumstances, inevitably carried also the fine gold with it. In addition to this excess water, it was often found necessary to employ several men busily forking out boulders from the sluice box in order to keep it from choking.

WINGDAM PRACTICE

It was decided, before resuming sluicing from the Sanderson mine some eighteen months ago, to reorganize the whole of the sluicing arrangements; and it was at this stage that our experimenting began. As a preliminary, the shaft-house was raised twenty feet to allow for tailing disposal and for the introduction of a grizzly screen. This grizzly screen has a screening area of eleven feet by three feet eight inches. The grizzly bars were of standard type and spaced two inches apart. Underneath the grizzly was a steel chute twelve feet long and four feet wide, hung by suspension link bolts. Four eccentrics were fitted on the eccentric shaft, two for the grizzly and two for the steel chute. Vibration was reduced by having the steel chute and grizzly in opposition. The oversize was generously sprayed with high-pressure water before dropping into the dump car. The undersize dropped from the steel chute into the sluice boxes for further concentration.

Double sluice boxes were built, each 21 in. wide, with a central partition dividing them. The sluice boxes were 74 feet long, at which point they converged into a common tail-race.

Hungarian riffles, 3½ in. by 2 in., protected by a 2-in. angle iron and spaced 4 in. apart, were used. At the end of a week's run, the gravel feed was switched into the idle box and the clean-up proceeded by the ordinary laborious method of using a rocker to bring the concentrates down to an ordinary bucket full. The gold was extracted from this final concentrate by panning, magnet, and blowing—the whole operation occupying about 50 man-hours.

The interglacial deposit that we are developing at the Sanderson mine contains numerous pieces of country schist, and it was noticed that quite a number of the smaller flat pieces worked their way through the bars of the grizzly and into the sluice box, where they got wedged between the riffles in an upright position, thus setting up a scouring action which was quite undesirable. We overcame this trouble by replacing the grizzly bars with a steel plate perforated by one-inch-diameter holes at one-inch pitch.

We also put into the circuit, on trial, a No. 4 Lorentsen gold-saving machine to speed-up the recovery of gold from the concentrate. This centrifugal machine requires careful 'tuning in' if the best results are to be obtained.

With a regulated supply of sluicing water the whole recovery operation was much improved and the clean-up period reduced to 16 man-hours.

The flow-sheet was now as follows:

The mine-car was run into a gravity dumping apparatus designed and manufactured at the mine. This dumping machine requires no mechanism or counter balances; and, after the loaded car has been emptied, it reverses itself and brings the empty back. As a consequence, we are able to use a simple box-car of rugged construction, minus the tipping and swivelling mechanism usually supplied with a metalliferous mine-car, with a saving in our rolling-stock prices of $80 a car.

The car load of gravel slowly works itself onto the grizzly where the over-size is subjected to high pressure water sprayed at all angles over it, and leaves the grizzly free of any sand or other fine material that might carry gold.

The undersize is water-transported to the sluice boxes, where sluicing takes place without any manual attention.

Every second day, a clean-up is made by first of all switching the feed into the idle sluice box and then lifting the riffles in the box to be cleaned. A trap-door at the lower end of the sluice box is replaced by a steel plate screen with ½-in holes, and the concentrate swept over this plate, all over-size going to the tail race. The minus-½-in. concentrate falls into a hopper in the recovery room, from whence it is fed by gravity over a fast moving vibratory screen of ⅛-in. mesh. The oversize from here is taken over a water concentrator, where the coarse gold is saved. This coarse gold, on the average, represents less than one per cent of the total gold recovered.

The undersize, on the other hand, falls into an elevator boot, from where it is elevated into a chute leading into the Lorentsen machine. This will be dealt with later.

The tailing from the machine flows over several traps before being finally discharged into Lightning creek. Amalgam from the machine is retorted and the quicksilver returned to the machine for future use.

As underground development proceeded in the Sanderson mine, we ran into a patch of gravel containing a certain percentage of clay. Unpuddled clay is a menace in any sluice box, even in small pieces, as it balls up and may rob the riffles.

Our tests indicated that small percentages of gold were being thus carried through, and it was decided to remove the Hungarian riffles from one sluice box and to substitute four superimposed layers of expanded metal of (starting from the top) 4-in., 3-in., 2-in. and 1-in. mesh. Subsequent tests proved that the expanded metal riffles disintegrated the clay and released any gold that was contained therein. This sluice box worked so well that we lost no time in adapting the second one to the same principle.

About two months ago, to meet the demands of an expanding output, the grizzly was replaced by a rotary trommel screen twelve feet long and three feet ten inches in diameter. The screen is perforated with holes 1 in. in diameter and about 1 in. pitch.

With these later improvements, the total time for a clean-up from the lifting of the expanded metal riffles to the placing of the retorted gold on the scales, occupies 2¼ hours of two men's time, i.e., 4½ man-hours

THE LORENTSEN GOLD-SAVING MACHINE

A grief description of the Lorentsen gold-saving machine might be of interest. It consists in the main of a cast-iron bowl mounted in a casing and rotatable at any desired speed. The model we use has the following dimensions:

Diameter at top of bowl	23¾ inches
Diameter at bottom of bowl	17 inches
Speed of bowl	150 r.p.m.
Thickness of mercury on wall after being built-up by centrifugal pressure	¼ inch
Superficial area of mercury on wall of bowl	8.5 sq. ft.
Amount of water used with 'feed'	About 50 g.p.m.

The concentrate is fed into the machine with water through a vertical feed-pipe leading into a centrifugal distributor arranged to deliver the concentrate from the bottom of the bowl and at an angular velocity exceeding that of the bowl.

Attached to the vertical feed-pipe are arms that revolve at the same speed as the pump. Affixed to the arms are small fins which are adjustable to suit varying conditions and are used to agitate the concentrate as it travels upward over the mercury wall.

Under the conditions we are working the machine, 100 lb. of mercury is a normal charge; and the fact that we are still using the same charge that we started with more than 12 months ago shows that there is no appreciable loss.

At the speed we run the machine, an accentuation of 5.6 is maintained; in other words, the pressure due to centrifugal force is 5.6 times greater than the difference in the specific gravity of gold and mercury.

It follows, therefore, that the rotating speed of the machine is very important. The centrifugal force increases with the square of the velocity and, that being so, there is a critical speed for any type of centrifugal amalgamator, which, if exceeded, will force the concentrate, and even the mercury, out of the machine. It is, perhaps, due to this fact that many of the high-speed centrifugal machines put on the market fail. Another important point to note is that the concentrate introduced into the machine must never be allowed to 'lag'. This is overcome by having the agitator arms and pump rotating at a faster speed than the bowl. Excellent results can be obtained by these machines if they are 'tuned in' to the conditions under which they have to work, and this can only be done by an experienced operator.

The accentuation quoted above can be worked out mathematically by the formula:

$$C = \frac{W}{G} \times \frac{V^2}{M}$$

where C = Centrifugal force
W = Weight of element
G = Constant (32.16)
V = Periphery velocity of bowl
M = Distance of element from revolving centre

Rusty and greasy gold complicate to some extent a ready amalgamation; but we have found, after 12 months' practice with the Lorentsen machine, that all rusty and greasy gold is retained in the machine and does not escape. Under these conditions a small amalgamating bowl is recommended as a quick method of preparing the rusty gold for quick amalgamation.

The following are the results of several tests made through the machine:

(1) 1,200 lb. concentrate from sluice boxes.
Gold recovered in machine, 85 oz. 14 dwt.
Representative sample of tailing assayed and showed a loss of $1.40 per ton of concentrate.

(2) 1,200 lb. concentrate from sluice boxes.
Gold recovered through machine, 42 oz. 14 dwt. 7 grains.
Plus-⅛-in. gold saved on water concentrator, 9 dwt. 5 grains.
100 lb. of tailing treated over concentrating table and panning showed only a trace of gold—estimated at a few cents per ton.

(3) 1,300 lb. from sluice boxes.
Gold recovered from machine, 49 oz.
Plus-⅛-in. gold saved on water concentrator, 6 dwt. 9 grains.
100 lb. of tailing treated showed a trace only of gold.

(4) 1,300 lb. concentrate from sluice box.
Gold recovered from machine, 40 oz. 5 dwt.
Plus-⅛-in. gold saved on water concentrator, 9 dwt. 5 grains.
All tailing tested and 3.52 grains recovered.

(5) 1,300 lb. concentrate from sluice box.
Gold recovered from machine, 72 oz. 11 grains.
Plus-⅛-in. gold saved on water concentrator, 1 oz. 1 dwt. 12 grains.
All tailing tested and 7.70 grains recovered.

The above tests are important inasmuch as they show the uniform high recovery through the machine.

The following is one typical example of the data compiled in the recovery house before the trommel was installed some few weeks ago:

No. of mine cars treated	925
Length of run	2 days
~~Ratio of concentration in sluicing~~	~~2101 to 1~~
Amount of minus-½-in concentrate	6 cubic feet—910 lb.
Amount of minus-⅛-in. concentrate	5 cubic feet—757 lb.
Specific gravity of concentrate	2.43
Gold recovered from machine	53.97 oz.
Fineness of gold	911
Total time occupied in clean-up	3½ hours

Remarks: No colours found in the tailings.

General Observations

There are several points arising out of our experiments that should be of value to placer operators who are desirous of getting the best recovery possible. The following typical example of the large losses of gold in normal placer work should demand serious attention.

A parcel of 135 lb. of black sand concentrate was brought to our recovery plant by a well known operator for testing purposes. As far as the sand was concerned, he was through with it, as he had extracted all the gold he could economically get out of it. We ran the sand through our machine rapidly and recovered over 6 ounces of gold, valued at about one hundred and ninety dollars. The operator admitted that many tons of sand of similar type must have been thrown away.

We employ two experienced placer recovery men, in Messrs. Lorentsen and Nordlund, who, between clean-ups, spend all their time in improving the recovery technique.

The machine itself has been considerably improved by the introduction into the bowl of an expanded metal basket, and by the lengthening of the agitator arms.

Our ultimate aim is to make the whole of the recovery operation one continuous process; and, as a further step towards this end, we are now introducing a 32 feet long section of undercurrent into one of the sluice boxes. The minus-¼-in. product from this undercurrent or classifier will be continuously fed into the hopper of the recovery plant and the Lorentsen machine kept running as regularly as required.

We are also contemplating a settling tank to take care of any very fine gold that might get away with the muddy water; in fact, there is no logical reason why the muddy water itself cannot be fed through the machine.

After the second day's run, and just before cleaning up, the sluice box has been frequently inspected to determine the character of the gold, if any, at the lower end, and the location generally of the gold. We find that 95 per cent of the gold is located in the first ten feet of the box. Tests half way down the box give from *nil* to a trace.

Superficial examination of gold particles carried past the first 10 feet usually shows heavy surface contamination, with very little bright gold showing. We believe that these dull pieces have been released from pieces of clay owing to the cutting action of the expanded metal.

We also find that the further concentration of a classified gravel by means of expanded metal riffles is much more efficient than with the Hungarian type of riffle. A richer and heavier concentrate is produced, which greatly reduces the time occupied in the clean-up.

The gravels mined from the Sanderson mine are from an interglacial deposit. The gold ranges in size from minus-150-mesh to minus-⅛-mesh —less than one per cent being retained on a ⅛-mesh screen. A big proportion of the gold is of the 'flaky' variety.

We do most of our sluicing with drainage water from the mine, which has a temperature, winter and summer, of 45 degrees Fahr., thus enabling us to sluice throughout the year even when surface temperatures drop to 45 degrees below zero.

We have now reduced the time for a total clean-up from 50 man-hours to 4½ man-hours, which time also includes the retorting of the amalgam. Our total cost for each clean-up, including gasoline for the retort burners, and the relaying of the expanded metal riffles, does not exceed $5.00.

Conclusion

This paper has been submitted in the hope that the information we have gained after 12 months' intensive study of placer recovery may be of some help to other operators.

Under the conditions outlined in this paper, but particularly if fine gold is present, the following points are important:

(1) Classify the gravel before it reaches the sluice box. Nothing over minus 1½-in. should be sluiced.

(2) Make certain that the oversize is thoroughly sprayed with high-pressure water in such a position that the spraying water returns to the sluice box, carrying with it any auriferous sand that may have been adhering to the oversize material.