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GOLDEN SUNLIGHT MINES, INC. GOES SEMI-AUTOMATED IN SAMPLE PREP

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INTRODUCTION

The Golden Sunlight Mine, a Placer Dome owned mine, is located in South Central Montana, USA. The mine has been in operation since 1983 and is currently producing about 150,000 ounces of gold per annum.

The gold is contained mainly in pyrite and chalcopyrite, in breccia (10% quartz, 10% pyrite, 80% feldspar), shale and latite. Gold particles are small, mainly in the micron range, but the sulphides are very unevenly distributed in the rocks.

The ore body is mainly breccia which has a high Bond crushing index of 20, so there is a high load on all crushers, in the mine and in the laboratory.

SAMPLE PREPARATION

Past methods.

Samples were crushed with a TM Rhino jaw crusher to minus ½ inch, then crushed again with a Denver rolls crusher to minus ¼ inch, with 55% of the sample passing 12 mesh. The aim was to produce a finely crushed sample before splitting.

From the crushed sample a 250 gram split was taken by riffle splitting and it was pulverized in a TM ring and puck pulverizer.

In 1998 studies showed that assay results were not representative of the original sample and this was having a devastating effect on the optimization of gold recovery from the mine. Testing showed that the key to better results was to crush much finer before splitting, down to 20 mesh if possible and the current procedure was nowhere near good enough.

While test work was going on to determine if the existing sample prep equipment could achieve the needed mesh size, one of the five technicians was transferred out of the laboratory to the repair shop leaving the laboratory short handed. With gold prices falling, it was difficult to justify replacing this technician. The laboratory needed a way to do the same amount of work with fewer people. The only way to do this was to attempt to automate the sample prep area.

New Equipment.

ROCKLABS Ltd was contacted to discuss different options. . The equipment of choice would need to produce up to 200 samples per day in one shift. The typical blasthole sample size was approximately 25-50 pounds. The whole sample must be crushed finely to a P80 of 20-mesh. The grind that was needed would have to be at least 90% passing a 100-mesh screen and the sample size going to the pulverizer would be increased to 500-700 grams.

The budget was very tight, as only \$65,000 was available for re-equipping so a fully automated System could not be considered. Ian Devereux from ROCKLABS determined that the best option for the laboratory would be 2 Boyd Crusher/Rotating Sample Divider (RSD) combos and 1 Continuous flow Ring Mill (CRM). Each Boyd/RSD could produce at least 100 samples in an 8-hour day and the CRM would be able to keep up with the two Boyd crushers. This new type of equipment sounded great, but how much was it going to set us back? The prices were \$39,800 US for the 2 Boyd/RSD's and \$19,000 US for the CRM for a total of \$58,900 US. With this figure, a justification was proposed to Mine Management that showed the new equipment would take only 1 1/2 years to pay back when compared to hiring another technician. Along with a short payback period, the lab would also be getting equipment that would increase the quality of the sample being produced in the sample prep area. Mine Management approved the purchase of the new equipment in December 1998 and the order was placed in January of 1999. Through many phone conversations and faxes with Ian and his team, the new equipment was made to fit the room it was to go in and it arrived at Golden Sunlight in March 1999. The equipment was installed in the lab in June 1999.

The Boyd crusher is a double acting jaw crusher (U.S. Patent # 5,630,555) which has a high size reduction ratio. It is ideal for crushing finely in one pass (Reference 1.)

The output from the Boyd crusher can be moved to the left or the right by a vibrating feeder and then fall into a rotating sample divider. ROCKLABS RSD produces one split of any proportion from 0-50% plus the remainder (waste) that can be retained or removed by a second feeder to the waste auger.

The two Boyd Crusher/RSD combos were manufactured as mirror images, with the crushers on the outside and the RSD's on the inside, so waste from the splitting process could be removed from the RSD's by vibrating feeders to a central auger. The auger takes the waste through the rear wall of the building and dumps it outside, from where it can be taken to the Mill, by loader, every few days.

ROCKLABS began developing the CRM in the early 1980's and the first machine was put into service in 1987 for a New Zealand gold exploration project (Reference 2).

Since then CRMs have been used in gold exploration in Papua New Guinea and Tanzania, steelworks in Australia and New Zealand, standards manufacture in Canada and USA, a nitrate mine in Chile, a copper smelter in the USA and many more diverse laboratories. However, the CRM at Golden Sunlight is the first CRM to be used for mine samples in a gold mine.

The CRM has two chambers, one on top of the other, fitted with various options of rings, pucks and plates. The crushed sample is fed in the top and the pulverized sample comes out the bottom, both through flexible rubber tubing. The pulverized sample falls into a plastic cup which sits in a metal holder, mounted on the cabinet door. When the sample cup is removed and the door is closed, air is sucked through the CRM for a few seconds, away to the laboratory dust extraction, via a cyclone in the cabinet, which removes any coarse particles. This vacuum cleaning of the CRM removes all remaining dust, a few grams from each sample.

The CRM is fitted with a hopper and vibrating feeder. The split from the RSD is taken in its stainless steel bin and emptied into the hopper. The feeder and CRM operate continuously, but should be turned off during breaks, to cool down.

The CRM has two stages of pulverizing and at Golden Sunlight the best combination of components is three rings in both chambers.

Testing the new equipment

Once the new equipment was installed, it was put through several types of test to determine its capabilities.

The first set of testing involved putting a 11 lb sample through each Boyd crusher to test the crusher plate settings. The two Boyd's produced about the same results, 34-40 % passing a 20-mesh screen with the largest fragments being 3/16 inch. The jaws of both crushers were then tightened to produce a product that was 80% passing the 20-mesh screen with the largest fragments being 1/8 inch.

The next series of testing would involve the CRM. The first questions asked were how long does it take to pulverize the needed amount of pulp (500 grams) and would the particle size of the material feeding the CRM have an affect on the fineness of the pulp? See Table 1

**TABLE 1
SAMPLE TYPE, WEIGHT, % RECOVERY, AND TIME TO PULVERIZE**

Sample ID	Sample Mesh Size	Sample Weight (grams)	Sample Weight Recovered (grams)	Sample Weight % Recovery	Time to Pulverize (minutes)
A	All +6 Mesh	661.2	654.0	99	3.0
B	75% +6 Mesh	576.7	563.1	98	2.0
C	50% +6 Mesh	641.8	630.2	98	2.5
D	25% +6 Mesh	785.9	747.0	95	2.5
E	All -6 Mesh	809.9	797.2	98	3.0

The test showed that it would take approximately 2 minutes to produce a 500-gram pulp with a 98% sample recovery. Therefore, if the Boyds were putting out a sample every 2 1/2 minutes, the technician would be able to feed the CRM without any delays. The next question was, if the CRM ran continuously, would that have an effect on the quality of the pulp being produced? See Table 2

Temperature of a 500 gram pulp after 3 hours of continuous operation
= 140F

Temperature of a 500 gram pulp after 4 hours of continuous operation
= 150F

Temperature of a 500 gram pulp after 4.5 hours of continuous operation = 150F

Set #	Sample Weight (grams)	-100 Mesh Fraction (grams)	%-100 Mesh (grams)
1	100.0	96.69	97
2	100.0	97.50	97
3	100.0	95.91	96
4	100.0	96.89	97

To determine the average % passing 100 mesh for a given set of samples, a tablespoon of each pulp was collected and placed into a container. At the end of each set of samples, the composite of all the samples is mixed and a 100 gram portion is screened through a 100 mesh screen.

Each set contained 22 samples weighing between 500 and 700 grams.

After the 102 samples were pulverized, the pulp temperature was taken and found that it never got above 150F. Average time to pulverize the samples was 2.5 minutes/sample.

CRM Configuration

Upper Pot 3 rings and no puck.

Lower Pot 3 rings and no puck.

**TABLE 3
PULP TEMPERATURE AND FINENESS (SECOND TEST)**

Temperature of a 500 gram pulp after 3 hours of continuous operation
= 142F

Set #	Sample Weight (grams)	-100 Mesh Fraction (grams)	%-100 Mesh (grams)
1	100.0	98.27	98
2	100.0	98.60	99
3	100.0	94.40	94
4	100.0	95.82	96

To determine the average % passing 100 mesh for a given set of samples, a tablespoon of each pulp was collected and placed into a container. At the end of each set of samples, the composite of all the samples is mixed and a 100 gram portion is screened through a 100 mesh screen.

Each set contained 22 samples weighing between 500 and 700 grams. After the 106 samples were pulverized, the pulp temperature was taken and found that it never got above 142F. Average time to pulverize the samples was 2.5 minutes/sample.

CRM Configuration

Upper Pot 3 rings and no puck.

Lower Pot 3 rings and no puck.

A series of 4 sets of 22 samples each all weighing between 500-700 grams, were put through the CRM one set after another. On the 21st sample of each set pulverized, the temperature of the pulp was taken. After 3 hours of continuous running, the temperature was taken on the pulp and it ran 140°F. After 4 hours of running, the temperature of the pulp was 150°F. The temperature did not go any higher than 150°F. The temperature did not appear to have an effect on the amount of material that was produced. To test this, a tablespoon of each sample pulverized was placed into a container and then 100 grams of this composite was wet screened through a 100-mesh screen to determine the % recovery. Three of the four samples tested had a 97% recovery and one had 96%. The average time to pulverize all 102 samples was 2 1/2 minutes per sample. The same test was conducted the next day with the same kind of results being produced. The recoveries ranged from 94% to 99%. See Table 3. .

ASSAYING

The next test involved taking an 11 pound blasthole sample and putting it through the Boyd crusher/RSD until 12 splits were taken. Each of the 12 splits was then pulverized in the CRM. See Table 4 for the split weights, % recoveries, and pulverizing times. Next, the 12 pulverized splits were fire assayed in duplicate using a 1 A.T. charge. The average % deviation between the duplicates was 2.68%. See Table 5 and [Graph 1](#) for the fire assay data. The same test was conducted on a different sample. The sample was split into 10 splits this time instead of 12.

TABLE 4
CRUSHER MATERIAL SIZE AND PULVERIZED MATERIAL % RECOVERY

TEST RUN #1					
Split #	Splitter Setting %	Split Weight (grams)	Recovery Weight % (grams)	Recovery	Time to Pulverize (minutes)
1	15	535.6	510.0	95	2.5
2	15	460.8	438.2	95	2.5
3	15	384.0	372.0	97	2.5
4	15	339.6	333.0	98	2.5
5	20	435.2	396.5	91	2.5
6	20	350.4	345.1	98	2.5
7	20	263.8	252.6	96	2.0
8	25	280.8	271.0	97	2.0
9	25	223.0	218.3	98	2.0
10	30	186.0	184.1	99	1.5
11	40	169.4	163.3	96	1.5
12	50	75.9	75.5	99	1.0

TEST RUN #2					
Split #	Splitter Setting %	Split Weight (grams)	Recovery Weight % (grams)	-35 Mesh	Time to Pulverize (minutes)
1	5	678.3	517.1	24	2.5
2	5	583.3	422.9	27	2.5
3	5	492.6	352.8	28	2.5
4	15	916.3	656.3	28	2.5
5	15	818.9	590.8	28	2.5
6	15	654.2	469.1	28	2.5
7	15	578.8	419.6	28	2.5
8	25	881.3	633.3	28	2.5
9	25	589.8	425.3	28	2.5
10	25	530.0	384.0	28	2.5

This time, the splits were weighed and screened through a 35-mesh screen and then re-weighed. This was done to determine how consistent the crushed material was for each fraction. The different screen fractions varied from 24-28%. Next, the 10 splits were fire assayed in duplicate to determine how much variance there was between splits. However, when fire assayed, the sample selected at random this time contained a low gold value (0.005 opt). The results of this test can be seen in Table 6 and [Graph 2](#).

TABLE 5
ASSAY RESULTS (TEST 1)

Split	Sample "A"	Sample "B"	Average	Difference A-B
Number	Au (oz/t)	Au (oz/t)	Assay Au (oz/t)	Au (oz/t)
1	0.068	0.070	0.069	0.002
2	0.065	0.065	0.065	0.000
3	0.056	0.057	0.057	0.001
4	0.046	0.042	0.044	0.004
5	0.067	0.065	0.066	0.002
6	0.062	0.062	0.062	0.000
7	0.045	0.044	0.045	0.001
8	0.046	0.045	0.046	0.001
9	0.052	0.056	0.054	0.004
10	0.052	0.052	0.052	0.000
11	0.052	0.053	0.053	0.001
12	0.056	0.055	0.056	0.001
Average =	0.0556	0.0555		0.0014
Standard Deviation =	0.0083	0.0089		

The average lead button size for Splits "A" = 24.92 grams and 24.68 grams for Split "B".

TABLE 6
ASSAY RESULTS (TEST 2)

Split	Sample "A"	Sample "B"	Average	Difference A-B
Number	Au (oz/t)	Au (oz/t)	Assay Au (oz/t)	Au (oz/t)
1	0.005	0.005	0.005	0.000
2	0.004	0.005	0.005	0.001
3	0.005	0.005	0.005	0.000
4	0.005	0.004	0.005	0.001
5	0.007	0.005	0.006	0.002
6	0.004	0.004	0.004	0.000
7	0.005	0.005	0.005	0.000
8	0.005	0.005	0.005	0.000
9	0.005	0.006	0.006	0.001
10	0.006	0.005	0.006	0.001
Average =	0.0051	0.0049		0.0006
Standard Deviation =	0.0009	0.0006		

The lead button sizes ranged between 25-32 grams.

PROBLEMS ENCOUNTERED

As mentioned above, all samples must be fully dried or moisture will be drawn from the sample as it passes through the hot CRM. This moisture can condense out in the cooler exit tubing. If there was appreciable moisture, samples might cake up in the CRM chambers and not be removed during the cleaning period.

Because the CRM is noisy, it was supplied in a noise-proofed cabinet but there was too little air flowing through the cabinet to keep the electric motor cool. In addition the Golden Sunlight Mine is situated at 5500 feet above sea level and high altitude makes motor cooling more difficult. After 6 weeks use, the motor burnt out and it was repaired. It burnt out again after a further 4 weeks and was repaired again, this time with advice from ROCKLABS.

It was decided to lift the cabinet $\frac{3}{4}$ of an inch off the floor, so cool air would flow into the cabinet and cool the motor as it passed upwards through the cabinet. The size of the eccentric weight was reduced by 10% to reduce the load on the motor while giving no reduction in pulverising performance. Since this was done, the CRM runs cooler and there have been no more motor burn-outs. Very little noise escapes from the gap under the cabinet.

OPERATING COSTS

The two motor repairs mentioned above were paid for by ROCKLABS under their Warranty. Our cost so far, for 10 months' operation are:

Repairs and maintenance \$ 400.00
Repair Parts \$ 200.00
Wear parts Nil

Electricity

All three large machines have 5.5 kw motors but draw about 4 kw each, 12 kw in total. Allowing for the RSD's and feeders, the total current draw would average 15 kw or less i.e. 120 kw hours per 8 hour shift.

Equipment should be turned off for coffee breaks, lunch etc. At a cost of \$0.12/kwh, daily cost of electricity is \$14.00

Based on an average of 150 samples per day for a five day week, the cost per sample so far is 12 cents. Once the wear parts need replacing, the cost will rise.

Assuming one complete Head replacement for the CRM per year (\$3000.00), one and a half sets of Boyd jaw plates per crusher per year (\$3000.00), and other repairs (\$1000.00) the cost per sample is 36 cents including electricity but excluding labor costs.

SUMMARY

With the new Semi-Automated Sample Prep equipment in place for almost one-year, the Assay Laboratory has been able to meet the needs of production. Since July of 1999, the laboratory has been operating with one technician in each of the four areas of the lab, thus allowing the one sample prep technician to keep up with the flow of blastholes.

Random samples over a 6-month period showed pulps with 92-96% passing a 100-mesh screen.

Operators have remarked that the work is now much easier than in past years. Each machine operates by itself. There is a minimum of lifting.

The purchase of this new equipment from ROCKLABS has not only helped with the productivity, but also the quality of the sample being produced from sample prep. If a sample is not correctly processed, the resultant fire assay will be incorrect, regardless of how well the fire assay was carried out. In order to achieve good numbers, you need to start with a good sample. We believe that this can be accomplished with the ROCKLABS Sample Prep equipment described in this Paper.

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[Back to top::](#)

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