

CARTIER RESOURCES INC.

Ore sorting test work for Chimo Gold Mine project

FINAL REPORT

No. T2885

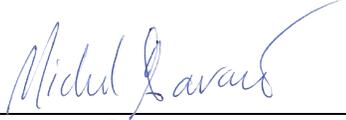
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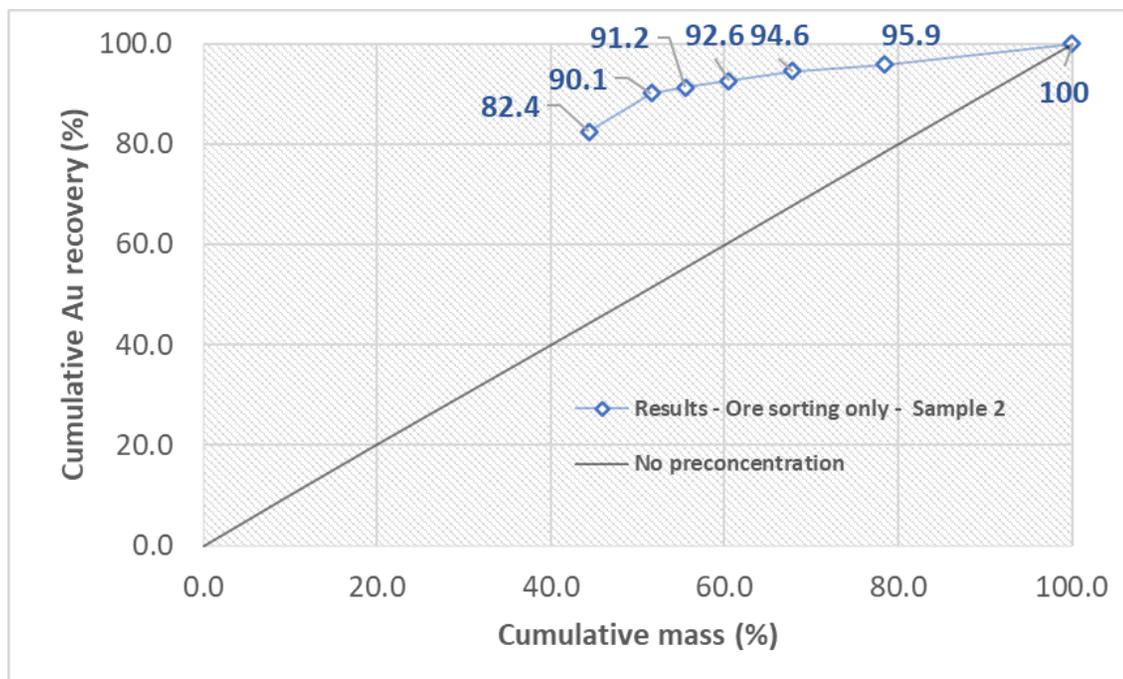
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EXECUTIVE SUMMARY

The aim of the test work was to demonstrate that the ore from the Chimo Gold Mine Project is amenable to sensor-based sorting, conferring it more value, and thus limiting the OPEX costs of the downstream processes (transportation, grinding, reagents and disposal). Gold in this deposit is mainly associated with quartz, hydrothermal silica and arsenopyrite.

Two samples were assessed for ore sorting. Prior to sorting, the received samples were crushed to 100% passing 1¼ inch and the crushed product was screened to ¾ inch. The fraction coarser than ¾ inch was used in the ore sorting tests, while the fraction smaller than ¾ inch was assayed for gold to complete the overall metallurgical balances. Several other samples were received at Corem for sorter calibration and initial continuous tests, as well as for benchmarking of Corem's analytical laboratory.

The sample 2 gave the best metallurgical performances using optical (RGB) and XRT sensors; the amenability for ore sorting and the most promising scenario of an overall metallurgical balance are presented below.



Scenario 2. 49.1% of weight is retained after sorting

	Mass (kg)	Mass (%)	Au Gr. (g/t)	Rec. Au (%)
Sorter pre-conc.	51.9	49.1	3.24	73.9
Sorter waste	48.7	46.1	0.38	8.1
<¾" fraction	5.1	4.8	8.07	18.0
TOTAL	105.7	100.0	2.16	100
Total Conc (Sorter pre-conc. + <¾" fraction)	57.0	53.9	3.68	91.9

From a sample of 105.7 kg at a gold assay of 2.16 g/t, a sorted concentrate with a gold grade of 3.68 g/t was observed in 49.1% of the mass. This represent an upgrade ratio of 170% compared to the initial gold grade. The sorted waste represented 46.1% of the mass with a gold grade of only 0.38 g/t.

Given these promising results, it is recommended to repeat the test work on larger samples coming directly from a blast to optimize the upstream and downstream processes.

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1. INTRODUCTION

Cartier Resources Inc. is an exploration company located in Val d'Or, Quebec, Canada. It holds several gold projects in Quebec province area. Among them, Chimo Gold Mine Project, for which the focus of Cartier Resources Inc. is to reduce the transport, milling and restoration costs. To achieve this, ore sorting is viewed as a promising solution. The mandate was assigned by Gaétan Lavallière, Vice-President of Cartier.

The aim of the project was to demonstrate that the ore is amenable to sensor-based sorting. Gold in this deposit is mainly associated with quartz, hydrothermal silica and arsenopyrite. Given this be the case, more value would be conferred to the project and the OPEX costs of the downstream processes (transportation, grinding, reagents and disposal) could be downsized.

A number of samples were received at Corem among which two bulk samples to be tested for sorting: sample 1, from the zone 5NE and sample 2, from the zones 5M4 + 5B4. Zones 5M4 + 5B4 are the most representative zones of the future Chimo Gold Mine.

The sorting methodology and the results obtained in pursuing the objective are detailed in the next sections.

2. METHODOLOGY

2.1 Sample reception and preparation

Several samples were received at Corem to carry out this project:

- Fifteen core fragments for the calibration of the ore sorter. These core fragments represented the different mineralizations of the deposit: quartz, hydrothermal silica, high-grade arsenopyrite, mid-grade arsenopyrite, low-grade arsenopyrite and waste;
- Six lots of core fragments of about 2 kg each representing the same mineralization as the 15 core fragments for the preliminary ore sorting tests:
 - After the initial continuous tests, a synthetic sample composed of 54 core fragments (Figure 1) representing the deposit was prepared as follows:
 - 3 core fragments from lot 1 (quartz)
 - 6 core fragments from lot 2 (hydrothermal silica)

- 3 core fragments from lot 3 (high-grade arsenopyrite)
 - 6 core fragments from lot 4 (mid-grade arsenopyrite)
 - 9 core fragments from lot 5 (low-grade arsenopyrite)
 - 27 core fragments from lot 6 (waste)
- Two bulk samples composed of core fragments weighing 122.2 kg (sample 1) and 105.7 kg (sample 2) for the production tests.
 - Eleven samples for benchmarking the chemical analyses performed by Corem's analytical services laboratory.



Figure 1. Photo of the synthetic sample

The 15 core fragments and the six lots were used as received. The two bulk samples were prepared as described in the following paragraphs.

Sample 1 was crushed to 100% passing 1¼ inch using a lab-scale jaw crusher and the crushed product was screened on a ¾ inch screen. The coarse fraction (from ¾ inch to 1¼ inch) was weighed and then further used for the ore sorting production run. The fine fraction, (under ¾ inch) was weighed and assayed for gold.

After discussions with Cartier Resources Inc., to avoid generating too much fine particles, it was decided to crush the core fragments of sample 2 using a cold chisel tool and then to screen the fragments on 1¼ inch and ¾ inch screens. The fragments coarser than 1¼ inch were crushed again with the same tool until they passed the 1¼ inch screen. The coarse fraction (from ¾ inch to 1¼ inch) was weighed and then further used for the ore sorting production run. The fine fraction, (under ¾ inch), was weighed and assayed for gold.

The aim of the gold analyses of the 11 samples was to compare the analyses performed by Corem against another laboratory subcontracted by Cartier Resources Inc. The method used to determine if there was a significant difference between these data sets was the independent student t-test, which is a common method used to compare sample means. The details of the calculations are described in Reference 1. It was assumed that there was a common variance between the two samples and the significance level (alpha) was set at 5% (with an interval of confidence of 95%).

2.2 Ore sorting

Corem's ore sorter is a COMEX industrial unit with 1-m belt width and four sensors: an optical camera (RGB), a dual-energy X-ray transmission (XRT) sensor, one hyperspectral camera covering the visible and near-infrared spectrum (VISNIR) and one hyperspectral camera covering the short-wave infrared spectrum (SWIR). Table 1 presents more details about these sensors. The sorter has 110 nozzle air jets, so it can perform rock by rock separation.

Table 1. Details of the sensors installed on the ore sorter

Detector	Specifications	Material Property	Comments
XRT	Dual energy XRT active on 1-m width (entire sorter belt)	Atomic density	Volume technique Thickness dependent (top size 3-4") "Full" dry process Most of the applications
RGB	Visible light optical camera (4K Basler RGB camera) active on 1-m width (entire sorter belt)	Reflection, Brightness, Transparency	Surface technique Thickness non-dependent. Water involved. Water treatment needed. Hyperspectral cameras more sensitive into an industrial environment.
VISNIR	Hyperspectral camera active on 0.5 m width (400-1000 nm)	Reflection, Absorption	
SWIR	Hyperspectral camera active on 0.5 m width (900-1700 nm)	Reflection, Absorption	

Two testing modes are possible with this ore sorter: static mode and continuous mode. In static mode, only scanning of the core fragments is performed without any separation. The objective of this type of test was to evaluate the heterogeneity of the core fragments and to define a calibration algorithm for the continuous test. In continuous mode, rock by rock separation using the air jets was performed on bulk samples and thus two products (pre-concentrate and waste) are obtained. Figure 2 presents a 3D scheme of the ore sorter installed at Corem.

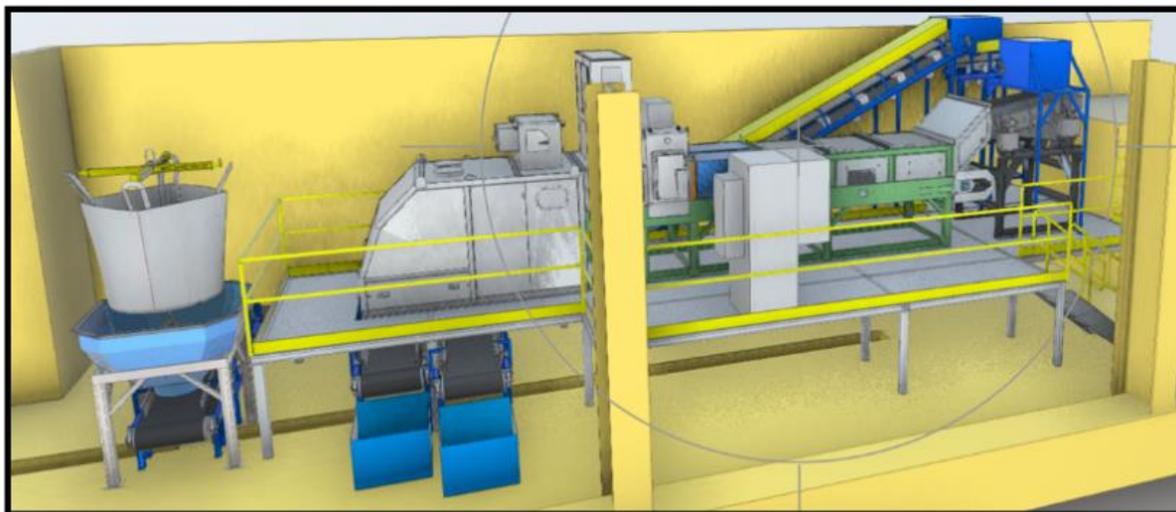
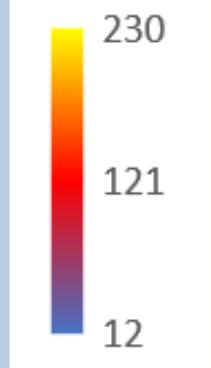


Figure 2. Sketch of the ore sorter set-up

The optical (RGB) and XRT sensors were employed in this work. Their calibration was done with the 15 core fragments representing a scope of the deposit. The initial continuous test work and the production runs were performed adopting a stepwise strategy, optical sensing followed by a XRT sensing at different settings of XRT sensitivity. In each XRT step, the optical sensor was kept active. The optical setting was fixed at a relative value to maximize the recovery of all quartz and silica core fragments and kept constant during all steps. Also, the percentage area of the rock for the XRT setting was fixed at 20%, value experimentally determined after preliminary tests. This means that a particle showing at least 20% of its area exceeding a given relative absorption would be ejected in the concentrate. The variation of the relative absorption for the XRT during each test is given in Table 2. The synthetic sample was treated in seven steps, while for the bulk samples six steps only were judged sufficient.

Table 2. Operation conditions for the tests performed in continuous mode

Step	Condition	XRT Relative absorption*
1	Optical	
2	Optical + XRT 1	200
3	Optical + XRT 2	150
4	Optical + XRT 3	100
5	Optical + XRT 4	52
6	Optical + XRT 5	25
7	Optical + XRT 6	12



* - Relative Absorption: Max 230; Min 0

After each step, two products were obtained: a concentrate (ejected product) and a waste (non-ejected product). The waste of the first step was used to feed the following step and so on (scavenger strategy). The concentrate of each step and the final waste were weighed, prepared, and assayed and the metallurgical performances were established.

2.3 Preparation and chemical analyses

The sorting products and the 11 benchmarking samples were analyzed for gold with an Inductively Coupled Plasma (ICP) instrument by Corem's analytical services laboratory; this lab is certified ISO/IEC 17025:2017. Details of the chemical analysis method are reported in Appendix 1. The following preparation was made for each sample prior to the chemical analyses:

- Crushing to 90% passing 2 mm (10 mesh);
- Splitting of the crushed sample to obtain subsamples of 2.5 kg;
- Splitting of each 2.5 kg to obtain a subsample of 500 g;
- Pulverizing the 500 g subsample to 90% passing 75 µm (0.075 mm);
- Splitting of the pulverized sample to obtain a 50 g subsample to be submitted to chemical analysis.

3. RESULTS AND DISCUSSIONS

3.1.1 Crushing of the bulk samples

Table 3 presents the mass proportions between the two fractions, coarser and finer than $\frac{3}{4}$ inch, after crushing.

Table 3. Mass proportions of the fractions coarser and finer than $\frac{3}{4}$ inch after crushing

Fraction	Sample 1		Sample 2	
	Mass (kg)	Mass (%)	Mass (kg)	Mass (%)
<1¼ in > ¾ in	87.3	71.4	100.6	95.2
< ¾ in	34.9	28.6	5.1	4.8
Total	122.2	100.0	105.7	100.0

Sample 1 led to a much higher proportion of particles finer than $\frac{3}{4}$ inch. This high proportion was not produced because of the friability of the material, but rather because of the form of the crusher feed composed of pieces of drill cores having a high aspect ratio. Pieces of drill core with high length to width ratio could pass through the jaw crusher undergoing only partial (if any) fragmentation. Therefore, multiple passes were required to generate a material 100% passing 1¼ inch; the high proportion of particles smaller than $\frac{3}{4}$ inch was the direct consequence of these multiple passes, that will not be suitable for sorting.

Given these observations after treating Sample 1, Sample 2 was crushed with a cold chisel tool; consequently, it presented a much lower proportion of particles finer than $\frac{3}{4}$ inch, this result was more realistic of what would be expected in terms of weight distribution after crushing of low aspect ratio core fragments with this mineralization.

3.1.2 Calibration of the ore sorter

Figure 3 and Appendix 2 present photos of the 15 core fragments used in the calibration of the ore sorter. The upper row in the figure below presents four core fragments: two representing quartz mineralizations (on the left), and two others representing hydrothermal silica mineralizations. The middle row presents arsenopyrite core fragments: from left to right, two core fragments corresponding to high-grade arsenopyrite, two corresponding to mid-grade arsenopyrite and the latter two, low-grade arsenopyrite.

The bottom row presents waste core fragments; the first rock on the right side corresponds to pyrrhotite (a mineral having a high specific gravity).



Figure 3. Photo of the 15 core fragments use for the calibration of ore sorter

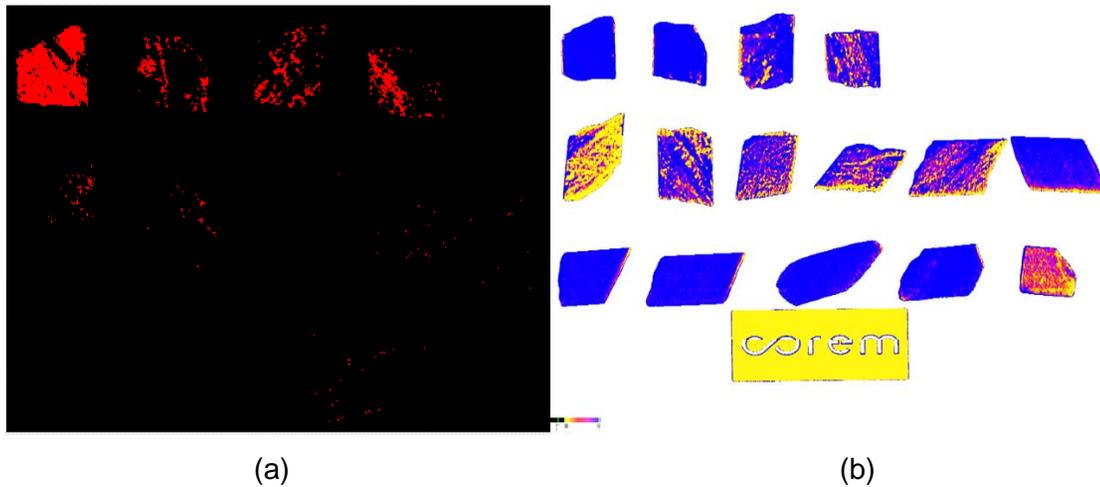


Figure 4. Photos of the 15 calibration core fragments as sensed by the optical (a) and XRT (b) sensors

Figure 4 shows the calibrations of the optical and XRT sensors. The optical calibration shows that it was possible to sort quartz and hydrothermal silica core fragments. The high-grade arsenopyrite core fragments were visible, but with lower intensity. Low-grade arsenopyrite and some waste fragments were also visible but with much lower intensity. The XRT photos allowed to see a clear discrimination between the high-density and low-density core fragments. As expected, almost all core fragments of arsenopyrite (high, medium, and low-grade) could be classified as high-density core fragments. Interestingly, the hydrothermal silica core fragments showed the same contrast as the medium and low-grade arsenopyrite core fragments. This means that these core fragments could be captured by the XRT sensor, too. Most of the waste core fragments appeared as low-density ore, except for the rock located on the right side: the high density pyrrhotite fragment. After discussion with Cartier Resources Inc., it was established that the pyrrhotite content expected in the mine is very low.

The results suggest that using a combination of RGB and XRT sensors could be suitable for achieving a successful separation.

3.1.3 Ore sorting tests with the lots and the synthetic sample

The initial ore sorting continuous tests were conducted with the lots. Only the number of core fragments collected in the concentrate and reject products was counted after each trial; the results of these tests are reported in Appendix 3.

The first trial with the synthetic sample was a repeatability test. Five tests were done with the same conditions (optical + XRT); the core fragments that reported in either the concentrate or waste were counted, and photos were taken. The counted proportion of fragments in the concentrate during these tests varied between 48% and 54% with an average of 51% and a standard deviation of 2%. The details of these tests are reported in Appendix 4.

The cumulative distribution of the core fragments in the concentrate after each sorting step in testing the synthetic sample is given in Figure 5. With the optical sensor only, all quartz core fragments and most hydrothermal silica core fragments (four out of six) reported to the concentrate. Interestingly, a few of the mid-grade arsenopyrite fragments (two out of six) also reported to the concentrate, but no high-grade arsenopyrite.

Four core fragments out of 27 waste fragments were captured by the optical sensor in the concentrate. All core fragments of lots 1, 2, 3 and 4 were captured in the concentrate after three steps of waste recirculation (condition Optical + XRT150 in Figure 5). The core fragments of lot 5 (low-grade arsenopyrite) started to be captured in the fifth step but after the seventh step they were not all captured. After the seventh step, it was observed that a total of 52 core fragments out of 54 had been captured in the concentrates; given this very high score it was decided to eliminate this step in the production run.

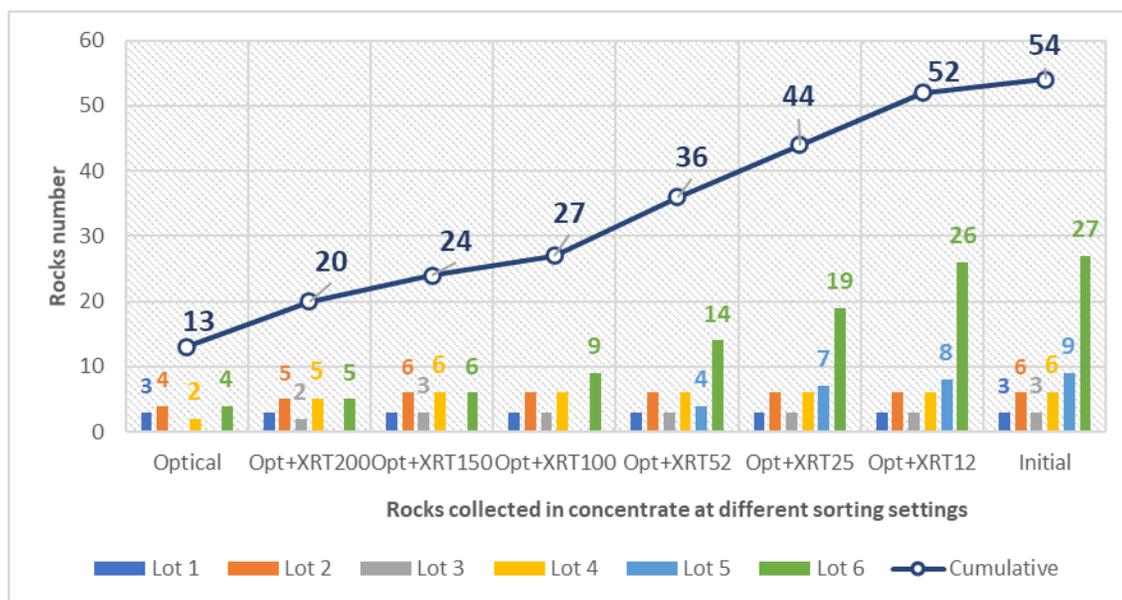


Figure 5. The cumulative distribution of the synthetic sample core fragments in the concentrate after each sorting step (lots description is given at the section 2.1)

The metallurgical information after each step is presented in Table 4 and Figure 6. Some 99.1% of the gold was recovered after three sorting steps. The gold grade, measured after the optical sorting step only, was much lower than the gold measured after two sorting steps involving the XRT; the grade was in fact even lower than the calculated feed. From step 4 and onwards, very low gold grades were measured in the sorted concentrates. The highest values observed for these products was 0.99 g/t; this could be explained by the presence of low-grade arsenopyrite in the Opt+XRT52 product (Figure 5).

Figure 6 shows the great amenability of this synthetic sample to be sorted for gold: the overall concentrate composed by products 1 to 3 shows that 99.1% of the gold was concentrated in 44.4% of the core fragments (by count) with a grade of 56.3 g/t; this represents an upgrade ratio of 223%. The calculated waste (products 4-8) contained only 0.9% of the gold and graded only 0.40 g/t.

Table 4. Metallurgical balance for the sorting tests with the synthetic sample

Step	Product	Nb. of core fragments	Core fragment proportion (%)	Au Gr. (g/t)	Au Rec. (%)	Cumul. Core fragment proportion (%)	Cumul. Au Gr. (g/t)	Cumul. Au Rec. (%)
Optical	Prod. 1	13	24.1	21.8	20.8	24.1	21.8	20.8
Opt+XRT200	Prod. 2	7	13.0	96.9	49.8	37.0	48.1	70.6
Opt+XRT150	Prod. 3	4	7.4	97.2	28.5	44.4	56.3	99.1
Opt+XRT100	Prod. 4	3	5.6	0.15	0.03	50.0	50.0	99.2
Opt+XRT52	Prod. 5	9	16.7	0.99	0.65	66.7	37.8	99.8
Opt+XRT25	Prod. 6	8	14.8	0.08	0.05	81.5	30.9	99.9
Opt+XRT12	Prod. 7	8	14.8	0.18	0.11	96.3	26.2	100.0
	Prod. 8	2	3.7	0.23	0.03	100.0	25.2	100.0
	Total	54	100	25.2	100			
	Pre-concentrate (Products 1-3)	24	44.4	56.3	99.1			
	Waste (Products 4-8)	30	55.6	0.40	0.9			

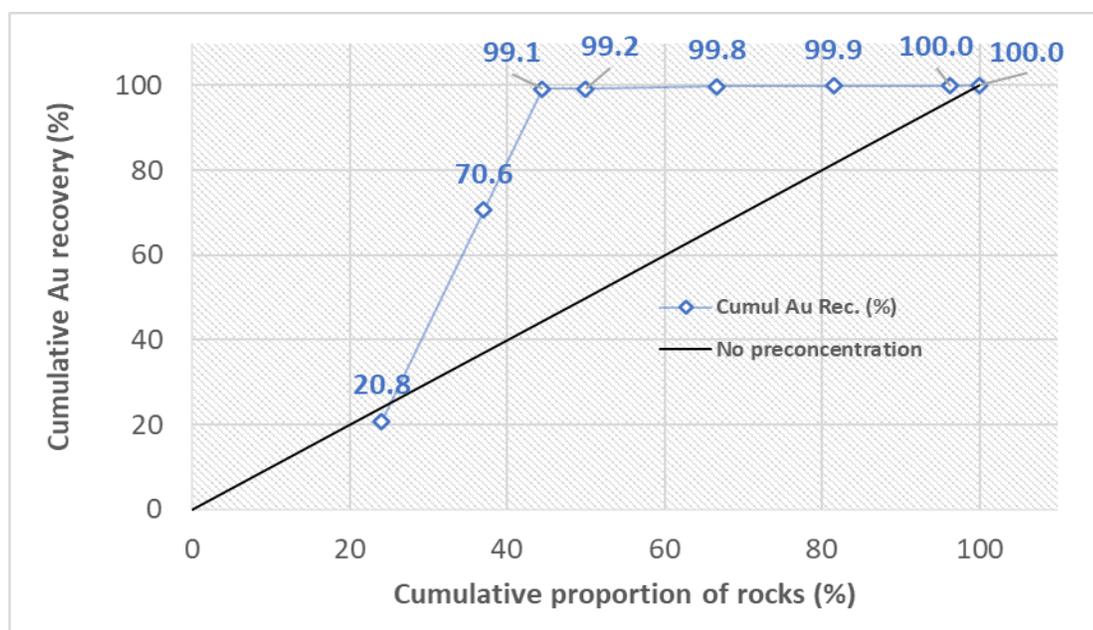


Figure 6. Cumulative gold recovery versus the number proportion of core fragments for the synthetic sample

3.1.4 Ore sorting production tests

Sample 2

Sample 2 showed great amenability to sorting (Figure 7): the optical sensor alone led to a concentrate containing 82.4% of Au into 44.4% of the mass (Table 5) and an upgrade ratio of 185%. The Opt+XRT200 brought an additional 7.7% of Au into 7.2% of the mass, while each subsequent step showed that the mass recovered was higher than that of gold, in other words, more gangue than gold was reported in the concentrate. From these results, three scenarios were calculated that led to results close to the expectations of Cartier Resources Inc. (Table 6). Further economic calculations will determine which scenario is the most suitable.

Table 5. Metallurgical balance for the sorting tests with sample 2

Step	Product	Mass (%)	Au Gr. (g/t)	Au Rec. (%)	Cumul mass (%)	Cumul Au Gr. (g/t)	Cumul Au Rec. (%)	
Optical	Prod. 1	44.4	3.45	82.4	44.4	3.45	82.4	
Opt+XRT200	Prod. 2	7.2	1.98	7.7	51.6	3.24	90.1	
Opt+XRT150	Prod. 3	3.9	0.55	1.2	55.5	3.05	91.2	
Opt+XRT100	Prod. 4	5.0	0.52	1.4	60.5	2.85	92.6	
Opt+XRT52	Prod. 5	7.4	0.49	1.9	67.9	2.59	94.6	
Opt+XRT25	Prod. 6	10.5	0.23	1.3	78.3	2.27	95.9	
	Prod. 7	21.7	0.36	4.1	100	1.86	100	
	Total	100	1.86	100				
		Mass (%)	Au Gr (g/t)	Au Rec (%)	Mass (%)	Au Gr (g/t)	Au Rec (%)	
	Pre-conc (Prod. 1)	44.4	3.45	82.4	Waste (Prod. 2-7)	55.6	0.59	17.6
	Pre-conc (Prod. 1-2)	51.6	3.24	90.1	Waste (Prod. 3-7)	48.4	0.38	9.9
	Pre-conc (Prod. 1-3)	55.5	3.05	91.2	Waste (Prod. 4-7)	44.5	0.37	8.8

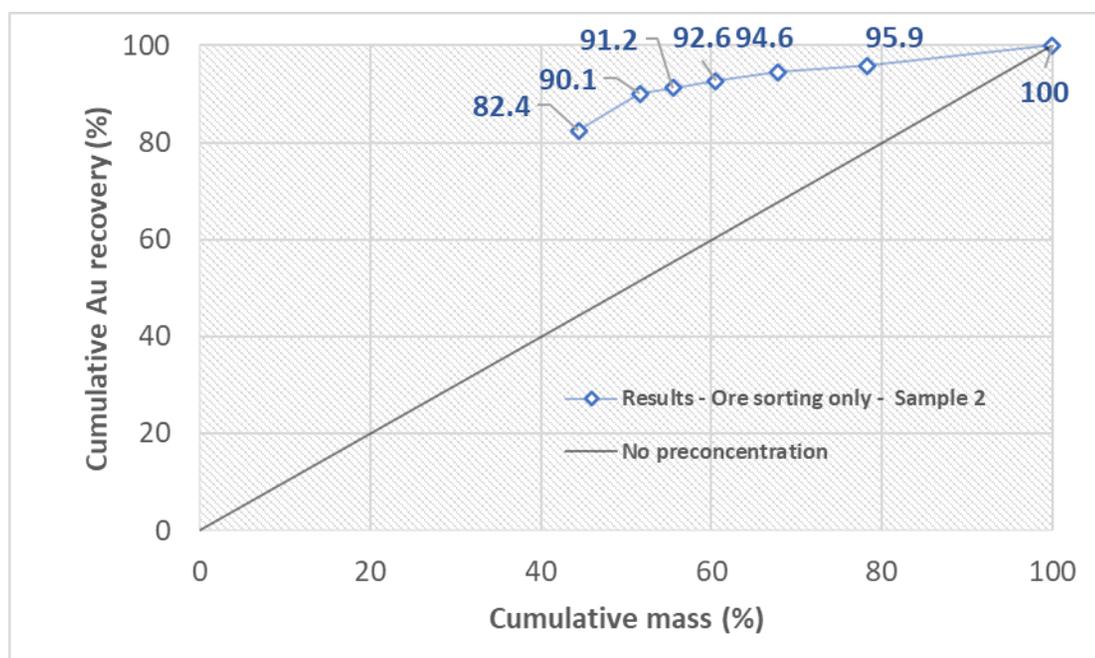


Figure 7. Cumulative gold recovery versus cumulative mass for sample 2

The overall metallurgical balances were calculated for sample 2 by combining the different sorting concentrate products with the $\frac{3}{4}$ -inch crushing/screening undersize. The complete results are reported in Appendix 5.

A total of 18.0% of the initial Au content was recovered in the fraction finer than $\frac{3}{4}$ inch; this fraction represented only 4.8% of the overall mass, hence the high Au recovery is due to its high Au grade (8.07 g/t). Scenario 2 (Table 6) seems to be a best compromise from the metallurgical perspective. It allows to obtain an overall concentrate (combination between the sorting concentrate and the fraction finer than $\frac{3}{4}$ inch) containing 91.9% of the initial Au into 53.9% of the initial mass with a gold grade of 3.68 g/t, an upgrade ratio of 170%. Scenario 1 shows a higher upgrade ratio, 181%, but a lower overall gold recovery (85.6%). The main advantage of scenario 2 is an additional 6.3% gold in 6.8% mass.

Scenario 3 shows the highest gold recovery, but the additional 0.9% in gold brings almost four times more gangue in the total concentrate.

Table 6. Various scenarios of overall metallurgical balances after processing sample 2 throughout crushing/screening and ore sorting

Scenario 1: 42.3% of weight was retained after sorting				
	Mass (kg)	Mass (%)	Au Gr. (g/t)	Rec. Au (%)
Sorter pre-conc.	44.6	42.3	3.45	67.6
Sorter waste	55.9	52.9	0.59	14.4
<3/4" fraction	5.1	4.8	8.07	18.0
TOTAL	105.7	100.0	2.16	100
Total Conc (Sorter pre-conc + <3/4" fraction)	49.7	47.1	3.92	85.6

Scenario 2: 49.1% of weight is retained after sorting				
	Mass (kg)	Mass (%)	Au Gr. (g/t)	Rec. Au (%)
Sorter pre-conc.	51.9	49.1	3.24	73.9
Sorter waste	48.7	46.1	0.38	8.1
<3/4" fraction	5.1	4.8	8.07	18.0
TOTAL	105.7	100.0	2.16	100
Total Conc (Sorter pre-conc + <3/4" fraction)	57.0	53.9	3.68	91.9

Scenario 3: 52.8% of weight is retained after sorting				
	Mass (kg)	Mass (%)	Au Gr. (g/t)	Rec. Au (%)
Sorter pre-conc.	55.8	52.8	3.05	74.8
Sorter waste	44.7	42.3	0.37	7.2
<3/4" fraction	5.1	4.8	8.07	18.0
TOTAL	105.7	100.0	2.16	100
Total Conc (Sorter pre-conc + <3/4" fraction)	60.9	57.7	3.47	92.8

Sample 1

Sample 1, for which the crushing step produced too many fine particles not fit for sorting, showed only partial amenability for concentration by the ore sorter compared to sample 2 (Figure 8). The optical sensor led to a concentrate representing 40.0% of the mass, grading 3.94 g/t in gold, but with a low Au recovery (50.1%) (Table 7). The XRT sensor led to concentrates grading between 5.12 g/t and 1.32 g/t. However, only Product 2 allowed to concentrate more gold in less mass (Table 7); the products 3-6 showed more gangue than gold in the pre-concentrate and this despite the higher ore sorter feed grade of sample 1.

Table 7. Metallurgical balance for the sorting tests with sample 1

Step	Product	Mass (%)	Au Gr. (g/t)	Au Rec. (%)	Cumul mass (%)	Cumul Au Gr. (g/t)	Cumul Au Rec. (%)
Optical	Prod. 1	40.0	3.94	50.1	40.0	3.94	50.1
Opt+XRT200	Prod. 2	12.2	5.12	19.9	52.3	4.22	70.0
Opt+XRT150	Prod. 3	8.7	2.48	6.8	60.9	3.97	76.8
Opt+XRT100	Prod. 4	9.3	2.61	7.7	70.2	3.79	84.5
Opt+XRT52	Prod. 5	11.0	2.59	9.1	81.3	3.63	93.6
Opt+XRT25	Prod. 6	11.9	1.32	5.0	93.1	3.33	98.6
	Prod. 7	6.9	0.67	1.4	100	3.15	100
	Total	100.0	3.15	100			

	Mass (%)	Au Gr (g/t)	Au Rec (%)		Mass (%)	Au Gr (g/t)	Au Rec (%)
Pre-conc (Prod. 1)	40.0	3.94	50.07	Waste (Prod. 2-7)	60.0	2.62	49.93
Pre-conc (Prod. 1-2)	52.3	4.22	69.99	Waste (Prod. 3-7)	47.7	1.98	30.01
Pre-conc (Prod. 1-3)	60.9	3.97	76.80	Waste (Prod. 4-7)	39.1	1.87	23.20
Pre-conc (Prod. 1-4)	70.2	3.79	84.51	Waste (Prod. 5-7)	29.8	1.64	15.49

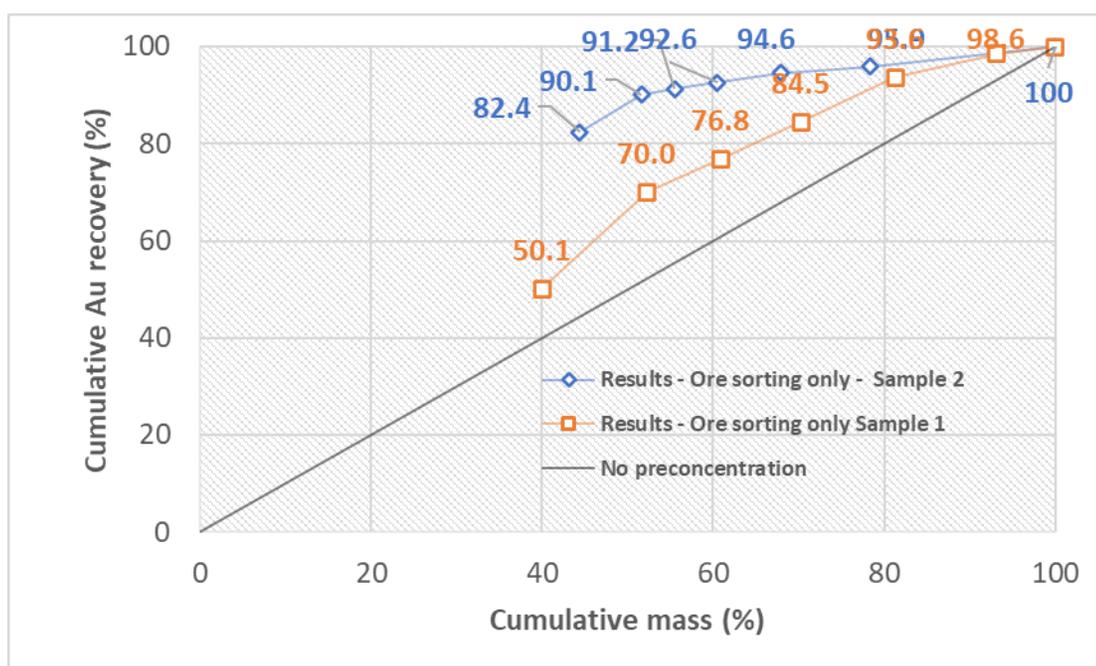


Figure 8. Cumulative gold recovery versus cumulative mass curves for samples 1 and 2

The overall metallurgical balances were also calculated for sample 1 by combining the crushing/screening step with the different sorting steps. The complete results are reported in Appendix 6.

A total of 22.4% of the initial Au content was recovered in the fraction finer than $\frac{3}{4}$ inch that represented 28.6% of the overall mass (Table 8). As the mass proportion was higher than the Au recovery, the crushing/screening step led to partial department of the gold toward the coarser fraction. The $\frac{3}{4}$ -inch fraction graded only 2.27 g/t Au (compared to 8.07 g/t for sample 2). The sorting concentrate was therefore, for sample 1, the only fraction in which the proportion of Au recovery was higher than the mass recovery. Combining the sorting concentrate with the $\frac{3}{4}$ inch fraction led to an overall Au recovery of 88.0% into 78.7% of the initial sample mass.

Table 8. Overall metallurgical balance for sample 1 throughout crushing/screening and ore sorting

	Mass (kg)	Mass (%)	Au Gr. (g/t)	Rec. Au (%)
Sorter pre-conc.	61.3	50.2	3.79	65.6
Sorter waste	26.0	21.3	1.64	12.0
< $\frac{3}{4}$ " fraction	34.9	28.6	2.27	22.4
TOTAL	122.2	100.0	2.90	100
Total Conc (Sorter pre-conc + <$\frac{3}{4}$" fraction)	96.2	78.7	3.24	88.0

3.1.5 Chemical analyses comparison

The gold grades determined by Corem's analytical services laboratory and those provided by Cartier Resources Inc. are presented in Table 9. The results of the independent student t-test are reported in Table 10. The results show that the t-test statistic value is much lower than the critical value, and thus the differences between the two data sets are not significant.

Table 9. Comparison of the chemical assays produced by Corem with those provided by Cartier Resources Inc.

	Sample	COREM analyses	Cartier Resources Inc. analyses	
		Au Grade (g/t)	Au Grade (g/t)	Weight (g)
1	61529	1.81	0.98	1765
2	61531	0.10	0.10	1806
3	61533	1.06	0.55	1581
4	61534	3.63	4.19	1630
5	61535	7.25	4.35	1593
6	61536	1.50	2.18	1520
7	61539	4.36	9.76	1505
8	61548	8.26	7.11	1227
9	61851	15.00	5.55	1440
10	52501	5.52	10.12	1607
11	62506 and 63687	11.2	14.18	2973
	Mean	5.426	5.370	
	Standard deviation	4.6545	4.5321	

Table 10. Independent student t-test results

Degree of freedom	t-test value	critical value	p-value
20	0.0288	2.086	0.9773

The “one-to-one” relation between the Corem and Cartier Resources analyses is given in Figure 9. The linearity is however not perfect and might come from three operations: division of the material prior sending it to each laboratory, sample preparation prior the analyses and gold grade determination. To eliminate the divergences related to the two first operations, the gold grade determination should be performed on the same leachate.

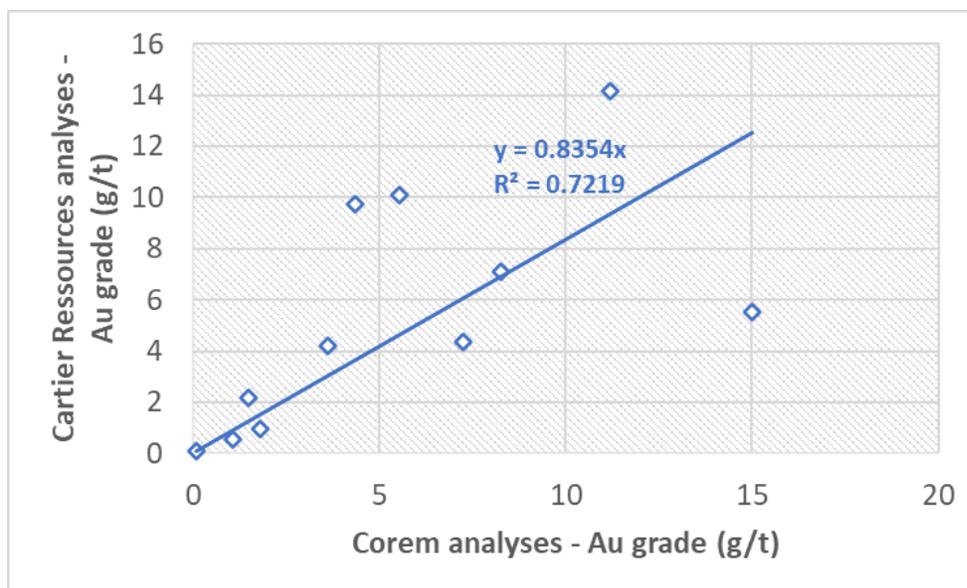


Figure 9. Chemical assays produced by Cartier Resources as a function of chemical assays produced by Corem

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the work conducted in this project, it can be concluded that:

- A combination of the optical and XRT sensors is suitable to sort the gold-bearing core fragments from the Chimo Gold Mine Project;
- The synthetic sample showed almost perfect pre-concentration amenability;
- The processing of sample 2 showed very good amenability for ore sorting;
- The overall performance for sample 2 (crushing/screening + sorting) showed that it is possible to discard waste directly at the mine to reduce the OPEX of the downstream processes (transportation, grinding, reagent and disposal costs).

Further investigation is recommended as follows: Repeat the test work on larger samples coming directly from a blast. Processing a blasted sample would allow to validate the following:

- Analyze the Au content of the fine fraction (<math>< \frac{3}{4}"</math>) produced by blasting and transported to the mine (potentially enriched in Au);
- Perform tests with different types of crushers and settings, to minimize the production of fine particles not suited for sorting;

- Analyze the Au content of the fine fraction ($<3/4''$) produced by different types of crushers and settings, to check for any detrimental effect on grade;
- Optimize the overall ore sorting results with respect to different types of crushing.

5. REFERENCES

1. <http://www.sthda.com/english/wiki/t-test-formula#independent-t-test-formula>

APPENDIX 1:
Summary of the chemical analysis method used for the Au assays

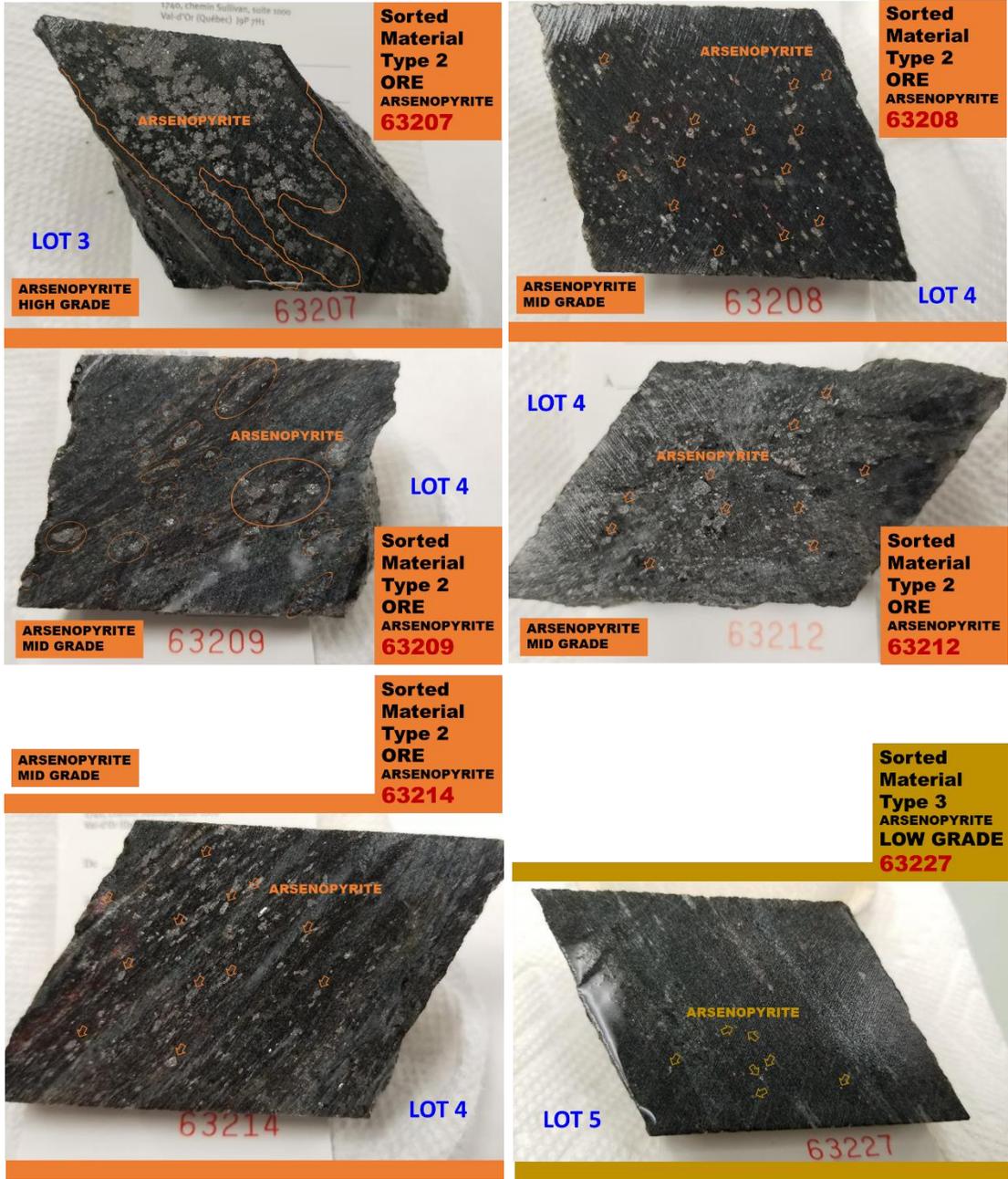
RÉSUMÉ DE MÉTHODE / METHOD SUMMARY

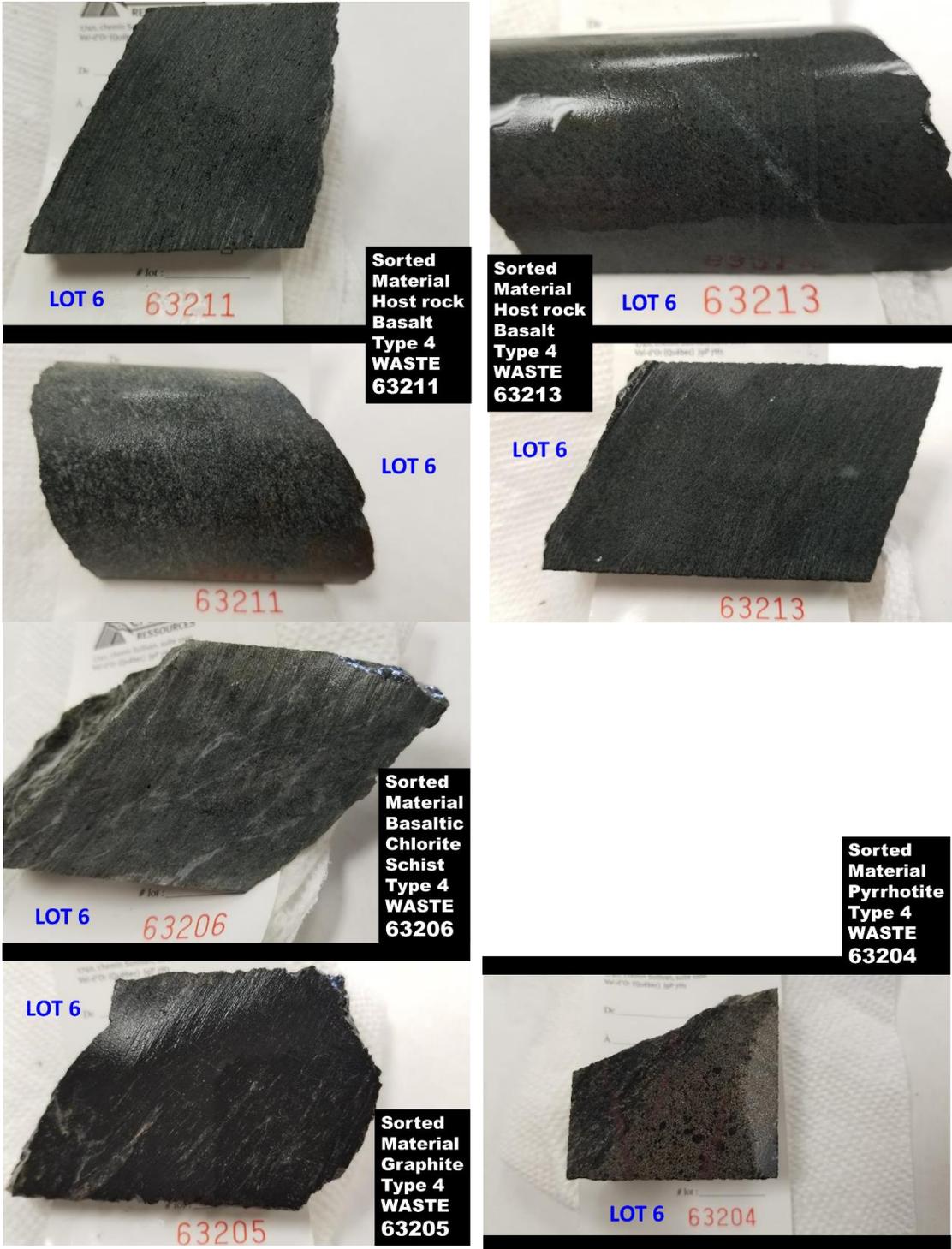
Titre / Title	Détermination de l'or (Au) dans diverses substances minérales par pyroanalyse et analyse par ICP-MS ou par ICP-OES																
	Determination of Gold in Various Mineral Matrices Using ICP-MS or ICP-OES Following Fire Assay																
Code interne / Internal code	LSA-M-AU																
Date d'émission / Issue date	2013-07-03																
Date de révision / Revision date	2020-07-23																
Champ d'application / Scope	<p>Cette méthode s'applique aux échantillons qui contiennent environ 0,005 g/t ou plus d'or (Au) et environ 0,3 g/t ou plus d'argent.</p> <p>Voici les codes de dosage LIMS utilisés :</p> <table border="1"> <thead> <tr> <th>Code de dosage</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>B30-ICP</td> <td>Or par ICP-MS</td> </tr> <tr> <td>B104-ICP / B104-OE</td> <td>Or (assay to extinction) par ICP-MS ou ICP-OES</td> </tr> <tr> <td>B31-ICP / B31-OE</td> <td>Or « Metallic sieve » par ICP-MS ou ICP-OES</td> </tr> <tr> <td>AU-OE-S</td> <td>Or par ICP-OES</td> </tr> <tr> <td>B135 *</td> <td>Or et Argent par ICP-OES</td> </tr> <tr> <td>B137</td> <td>Or par ICP-OES (basse limite)</td> </tr> <tr> <td>B32-OE *</td> <td>Or et Argent « Metallic sieve » par ICP-OES</td> </tr> </tbody> </table>	Code de dosage	Description	B30-ICP	Or par ICP-MS	B104-ICP / B104-OE	Or (assay to extinction) par ICP-MS ou ICP-OES	B31-ICP / B31-OE	Or « Metallic sieve » par ICP-MS ou ICP-OES	AU-OE-S	Or par ICP-OES	B135 *	Or et Argent par ICP-OES	B137	Or par ICP-OES (basse limite)	B32-OE *	Or et Argent « Metallic sieve » par ICP-OES
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B32-OE *	Or et Argent « Metallic sieve » par ICP-OES																
<p><i>This method is performed for the determination of gold (Au) in samples that contain about 0.005 g/t or more and for the determination of silver (Ag) in samples that contain about 0.3 g/t or more.</i></p> <p><i>Here are the test codes used:</i></p> <table border="1"> <thead> <tr> <th>Test code</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>B30-ICP</td> <td>Gold finished by ICP-MS</td> </tr> <tr> <td>B104-ICP / B104-OE</td> <td>Gold (assay to extinction) finished by ICP-MS or ICP-OES</td> </tr> <tr> <td>B31-ICP / B31-OE</td> <td>Gold (Metallic sieve) finished by ICP-MS or ICP-OES</td> </tr> <tr> <td>AU-OE-S</td> <td>Gold finished by ICP-OES</td> </tr> <tr> <td>B135 *</td> <td>Gold and Silver finished by ICP-OES</td> </tr> <tr> <td>B137</td> <td>Gold finished by ICP-OES (low limit)</td> </tr> <tr> <td>B32-OE *</td> <td>Gold and Silver (Metallic sieve) finished by ICP-OES</td> </tr> </tbody> </table>	Test code	Description	B30-ICP	Gold finished by ICP-MS	B104-ICP / B104-OE	Gold (assay to extinction) finished by ICP-MS or ICP-OES	B31-ICP / B31-OE	Gold (Metallic sieve) finished by ICP-MS or ICP-OES	AU-OE-S	Gold finished by ICP-OES	B135 *	Gold and Silver finished by ICP-OES	B137	Gold finished by ICP-OES (low limit)	B32-OE *	Gold and Silver (Metallic sieve) finished by ICP-OES	
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<p>Principe / Principle</p>	<p>La pyroanalyse est utilisée depuis très longtemps pour doser l'or dans diverses substances.</p> <p>L'avantage de cette technique pour la détermination des métaux précieux est qu'elle utilise une assez grande quantité d'échantillons (~15 g ou plus) à partir de laquelle il est possible de concentrer ces métaux en éliminant pratiquement toute la gangue qui y est généralement associée.</p> <p>Cette concentration se fait en mélangeant l'échantillon* avec un fondant dont la composition dépend de la matrice de l'échantillon. La propriété du fondant est d'abaisser le point de fusion de la gangue et de la séparer de l'échantillon. Dans le cas des roches et des minerais silicatés, un fondant de base est recommandé et ce dernier peut être modifié en fonction des divers types d'échantillons. Le plomb contenu dans le fondant agit comme collecteur pour les métaux précieux. Par élimination subséquente du plomb, ces métaux sont récupérés et dosés par ICP-OES ou par ICP-MS.</p> <p>* Les échantillons doivent respecter les deux critères granulométriques suivants : de 98 % à 100 % passant 106 µm et 85 % passant 75 µm.</p> <hr/> <p><i>Fire assay has been used for a very long time to assay gold in various substances.</i></p> <p><i>The advantage of this technique for the determination of precious metals is that it uses a fairly large quantity of samples (~ 15 g or more) from which it is possible to concentrate these metals by eliminating almost all the gangue that there is usually associated.</i></p> <p><i>This concentration is done by mixing the sample* with a flux whose composition depends on the matrix of the sample. The property of the flux is to lower the melting point of the gangue and to separate it from the sample. In the case of silicate rocks and ores, a basic flux is recommended, and this may be modified for different types of samples. The lead contained in the flux acts as a collector for precious metals. By subsequent removal of lead, these metals are recovered and assayed by ICP-OES or by ICP-MS.</i></p> <p>*Samples must respect the two following size distribution criteria: 98% to 100% passing 106 µm and 85% passing 75 µm.</p>
<p>AQ-CQ / QA-QC</p>	<p>L'ICP-MS et l'ICP-OES sont étalonnés avant chaque série d'analyse. La courbe d'étalonnage est vérifiée avec un étalon d'une autre source que celle qui a servi à préparer les étalons.</p> <p>Pour chaque série de 20 échantillons, 1 blanc, 2 matériaux de référence certifiés (MRC) et un duplicata sont analysés.</p> <hr/> <p><i>The ICP-MS and ICP-OES are calibrated before each batch of samples. The calibration curve is checked with a standard prepared from a second source different than the source used for the standards.</i></p> <p><i>For every 20-sample batch, one blank, two certified reference material (CRM) and one duplicate are analyzed.</i></p>
<p>Références / References</p>	<p>INTERNATIONAL STANDARD. Concentrés de sulfure de cuivre, de plomb et de zinc - Dosage de l'or et de l'argent - Méthode gravimétrique par essai au feu et spectrométrie d'absorption atomique dans la flamme. ISO 10378 : 2016.</p>

APPENDIX 2:
Photos of the 15 core fragments







APPENDIX 3:
Ore sorting tests with the lots

This appendix describes the work performed with the lots of the core fragments. The table below presents the number of core fragments per each lot.

Lot	Description	Number of core fragments
1	SiO ₂ – quartz	48
2	SiO ₂ – hydrothermal silica	37
3	Arsenopyrite – high grade	37
4	Arsenopyrite – medium grade	42
5	Arsenopyrite – low grade	39
6	Waste	33

The sorting tests were done in continuous mode; after each test the core fragments reported to the concentrate (ejected core fragments) and waste (non-ejected core fragments) products were counted and their proportions were calculated.

The first batch of tests was done using the optical (RGB) camera. For this test work only the quartz, hydrothermal silica and waste lots were employed. The aim of these tests was to validate that most of the core fragments of the lots 1 and 2 reported to concentrate as well as most of the waste core fragments reported to the waste product. From the results presented below it is showed that the optical camera allowed to recover most of the quartz and hydrothermal silica fragments. The same settings allowed to observe that only a few waste core fragments were recovered in the sorter concentrate.

Lot 1		Quartz	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	41	87.2	
Waste (non-ejected)	6	12.8	
Total core fragments	47	100.0	
Lot 2		Hydrothermal silica	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	35	94.6	
Waste (non-ejected)	2	5.4	
Total core fragments	37	100.0	

Lot 6		Waste	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	2	6.1	
Waste (non-ejected)	31	93.9	
Total core fragments	33	100.0	

The second batch of tests was performed using the XRT sensor. The main condition for this test was a relative absorption of 52 and the percentage area of the rock for the XRT setting was fixed at 20%. The aim of these tests was to assess the response of the lots to this setting. The results shown in the tables below showed that the response of the arsenopyrite-based core fragments were proportional to their content: thus, 100% of the core fragments of high grade arsenopyrite were captured in the concentrate, whereas the proportion of the low grade arsenopyrite was only 48.7%. Only 9.1% of the waste core fragments were captured in the concentrate. The silica-based core fragments proportions captured in the concentrate were low 12.5% and 27.0% respectively, due to the low density of silica-based core fragments.

Lot 1		Quartz	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	6	12.5	
Waste (non-ejected)	42	87.5	
Total core fragments	48	100.0	

Lot 2		Hydrothermal silica	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	10	27.0	
Waste (non-ejected)	27	73.0	
Total core fragments	37	100.0	

Lot 3		High grade	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	37	100.0	
Waste (non-ejected)	0	0.0	
Total core fragments	37	100.0	

Lot 4		Medium grade	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	30	71.4	
Waste (non-ejected)	12	28.6	
Total core fragments	42	100.0	
Lot 5		Low grade	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	19	48.7	
Waste (non-ejected)	20	51.3	
Total core fragments	39	100.0	
Lot 6		Waste	
	N° of core fragments	Percentage	
Pre-concentrate (ejected)	3	9.1	
Waste (non-ejected)	30	90.9	
Total core fragments	33	100.0	

The overall results considering the performances of all lots are in the table below; it is seen that 44.5% of the core fragments were captured in the sorter pre-concentrate.

Total Lots 1-6		
	N° of core fragments	Percentage
Pre-concentrate (ejected)	105	44.5
Waste (non-ejected)	131	55.5
Total core fragments	236	100.0

This proportion is however underestimated since for the silica-based core fragments the optical sensor is necessary to capture them in the pre-concentrate.

The pre-concentrate proportion calculated for the lots 3 to 6 (core fragments from lots amenable to sorting with the XRT sensor) was 58.9%, in line with the Client's expectations (see table below).

Total Lots 3-6		
	N° of core fragments	Percentage
Pre-concentrate (ejected)	89	58.9
Waste (non-ejected)	62	41.1
Total core fragments	151	100.0

From these results and discussions with Cartier Resources Inc., it was decided to move to the next step, select core fragments from each lot to make a synthetic sample.

The photos of the core fragments of each lot are presented below.

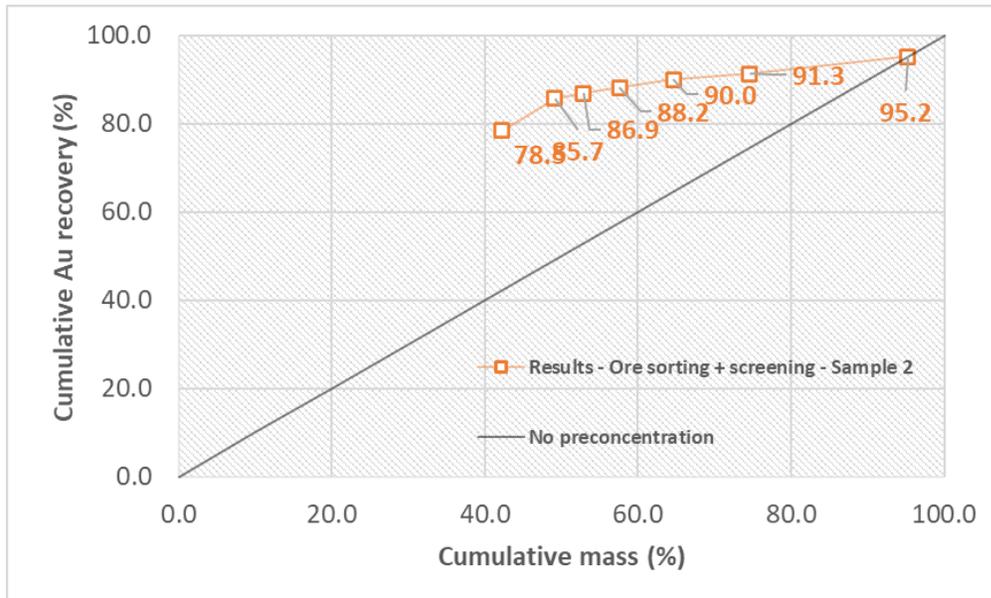


APPENDIX 4:
Repeatability tests with the synthetic sample

	Nb of core fragments					
	Initial	Sorter pre-concentrate				
		Test 1	Test 2	Test 3	Test 4	Test 5
Lot 1	3	3	3	3	3	3
Lot 2	6	6	6	5	5	5
Lot 3	3	3	3	3	3	2
Lot 4	6	5	6	6	6	5
Lot 5	9	6	3	6	4	6
Lot 6	27	6	7	5	5	6
TOTAL	54	29	28	28	26	27
Pre-concentrate proportion of core fragments		54%	52%	52%	48%	50%
Average	51%					
SD	0.02					

APPENDIX 5:
Sample 2: overall results combining crushing-screening and sorting

Results - Ore sorting + screening - Sample 2										
1 1/4" > Fraction > 3/4"										
Weight (kg)	Weight (%)	Conditions	Products	Weight (%)	Au Gr. (g/t)	Rec. Au (%)	Cumul wt.	Cumul Au	Cumul Au	
100.582	95.2	Optical	Prod. 1	42.3	3.45	78.5	42.3	3.45	78.5	
		Opt+XRT200	Prod. 2	6.8	1.98	7.3	49.1	3.24	85.7	
		Opt+XRT150	Prod. 3	3.7	0.55	1.1	52.8	3.05	86.9	
		Opt+XRT100	Prod. 4	4.7	0.52	1.3	57.6	2.85	88.2	
		Opt+XRT52	Prod. 5	7.0	0.49	1.9	64.6	2.59	90.0	
		Opt+XRT25	Prod. 6	10.0	0.23	1.2	74.6	2.27	91.3	
			Prod. 7	20.6	0.36	3.9	95.2	1.86	95.2	
				95.2	1.86	95.2				
Fraction < 3/4"										
Weight (kg)	Weight (%)			Au Gr. (g/t)		Rec. Au (%)				
5.08	4.8			8.07		4.8				
	100.0			2.16						



APPENDIX 6:

Sample 1: overall results combining crushing- and sorting

Results - Ore sorting + screening - Sample 1									
1 1/4" >Fraction >3/4"									
Weight (kg)	Weight (%)	Conditions	Products	Weight (%)	Au Gr. (g/t)	Rec. Au (%)	Cumul wt. (%)	Cumul Au Gr. (g/t)	Cumul Au Rec. (%)
87.256	71.4	Optical	Prod. 1	28.6	3.94	35.8	28.6	3.94	35.8
		Opt+XRT200	Prod. 2	8.7	5.12	14.2	37.3	4.22	50.0
		Opt+XRT150	Prod. 3	6.2	2.48	4.9	43.5	3.97	54.9
		Opt+XRT100	Prod. 4	6.7	2.61	5.5	50.2	3.79	60.4
		Opt+XRT52	Prod. 5	7.9	2.59	6.5	58.0	3.63	66.8
		Opt+XRT25	Prod. 6	8.5	1.32	3.5	66.5	3.33	70.4
			Prod. 7	4.9	0.67	1.0	71.4	3.15	71.4
				71.4	3.15	71.4			
Fraction <3/4"									
Weight (kg)	Weight (%)			Au Gr. (g/t)	Rec. Au (%)				
34.92	28.6			2.27	28.6	22.4			
	100.0			2.90					

