KSS TEST WORK REPORT

CARTIER RESOURCES

ORE SORTING TEST WORK

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EXECUTIVE SUMMARY

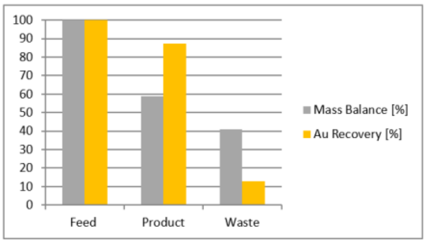
Cartier…

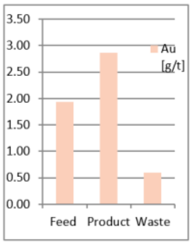
Headquartered in Val-d'Or, Quebec, Cartier is a Canadian gold exploration company. Cartier is active in several projects around Quebec. At this time Cartier is mainly in exploration phases on several properties, as well as continued exploration at Chimo Mine Project. Cartier provided four samples from their projects for this ore sorting test campaign. The test work was conducted at Steinert US in Walton, KY. The objective of the test work is to prove that sensor based sorting can be effective in removal of waste rock and upgrade and recovery of precious and non-precious metals.

Ore Sorting…

X-ray sorting technology has experienced rapid advancements in mineral beneficiation applications over the last decade with Steinert being on the forefront of developing sensor based sorting equipment. XRT image processing evaluates each particle's X-ray attenuation of each particle which has a direct correlation on the mineral composition. Steinert also uses a multi-sensor technique to optimize sorting results in one sorting step. In the case of the Cartier Resources sample laser brightness reflection was used to detect and recover gold bearing quartz and XRT was utilized as a second and third step to recover gold-bearing sulphides (aresenopyrite). The graph below shows the combined recovery of the more responsive fourth sample (TR317). At this setting in one pass the Steinert KSS can capture quartz at a low mass pull that can then increase to capturing 87.2% of gold with the addition of a single XRT sensitivity. By rejecting 41% of the volume of waste, increasing the ore content from 1.9 g/t Au to 2.9 g/t Au, a 34% increase in gold content.

Opportunity No.: 15975	Lab: 922			
Customer: Cartier Resources	Steps 1 & 2			
	Mass kg	Mass Balance [%]	Au Recovery [%]	Au [g/t]
Feed	70.4	100.0	100.0	1.94
Product	41.5	58.9	87.2	2.86
Waste	28.9	41.1	12.8	0.60





1. INTRODUCTION

Cartier has approached Steinert US to conduct ore sorting test work on drill-core material from the Chimo Mine property. Four gold bearing quartz/sulphide samples were provided from Cartier. Each sample weighing in under 100kg.

The objective of the test work is to show that the sample can be upgraded and waste eliminated using sensor based sorting. Different sensors at different sensitivity settings resulting in different mass pulls to product will be tested with different grades and recoveries. The test work was conducted at the Steinert US test centre in Walton, KY.

2. SENSOR SORTING TECHNOLOGIES

Sorting technology has experienced rapid advancements over the last decade. The Steinert technology now offers the mining industry a variety of sensors that can be utilized individually or in combination to ensure efficient sorting of minerals.

The dual energy X-ray system allows for approximation of atomic number ranges, which are used to evaluate mineral and maceral content. These include shale, rock and pyrites in a coal stockpile or deposit. This process is not sensitive to surface conditions (e.g. presence of dust) and can therefore be utilized completely dry. Relative atomic numbers form the basis of separation thus allowing this technology to be utilized in applications where other mineral processing techniques have been deemed unfeasible.

Steinert is continuously finding and developing new sensor based sorting applications in minerals and coal where conventional processes have failed, have specific limitations, or where additional value can be attained. Figure 1 shows that XRT sorting utilizes the high energy level low wave-length x-ray section of the Electromagnetic Spectrum

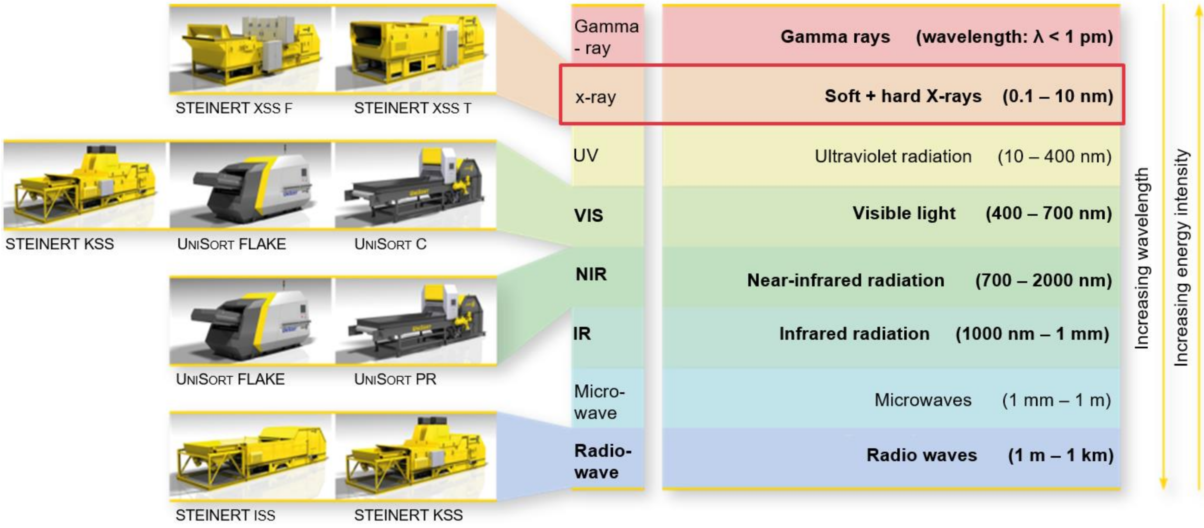


Figure 1: XRT sorting utilizes the high energy level low wave-length x-ray section of the Electromagnetic Spectrum

The Table 1 indicates the different Steinert sensor sorters available within the electromagnetic spectrum.

Table 1: Sensors used in Steinert Sorting Systems

Sensor	Material Property	Mineral Application
X-ray Transmission	Atomic density	Coal, diamonds, base metals, precious metals, poly-metallic ores
Energy Dispersive XRF	Elemental composition	Manganese/Iron ore
NIR	Reflection/absorption of NIR radiation	Base metals, industrial minerals
Laser	Shape and Brightness	Precious metals, industrial minerals
VIS	Reflection/absorption of visible radiation	Metals, industrial minerals, gem stones
Induction	Conductive/magnetic	Magnetite, gold nuggets, nickel ore

Steinert US have commissioned a test plant to conduct test work for many different mining and recycling applications. Full scale production test sorting equipment at the Steinert US facilities at Walton, KY includes, X-Ray Transmission (XRT), a multi sensor unit incorporating combined Color and Laser (KSS), Induction or electromagnetic sensors (ISS), X-ray Fluorescence (XRF) and Near Infrared (NIR) and various other magnetic separation technologies. Additional sorting test equipment is available at Steinert in Cologne, Germany.

3. STEINERT'S MULTI-SENSOR SORTER - KSS FLIXT

The proposed test work scope is to determine the sorting efficiency of a STEINERT Combined Sensor (KSS FLI XT) as shown in Figure 2 on the ore samples provided. This sorter comprises the following sensors: dual-energy X-ray transmission sensors (XRT), Color camera (F), 3-D Laser (L) and induction (I). XRT sorting is the preferred technology for mining applications since the detection is based on the x-ray absorption which determines the atomic density of the entire particle. The advantage is that the particles do not need to be clean/washed which would be necessary for surface detection sensors such as color camera and laser. XRT is thus truly a dry beneficiation process.

Figure 2: STEINERT Combination Sorting System (KSS F XT L I)

3.1 *KSS FLI XRT – TECHNICAL DESCRIPTION*

The x-ray sorting tests were conducted using the following Steinert KSS FLI XT machine:

• Model:	KSS 100 520 FLI XT
• Current Consumption :	Max. 35 A
• Power Consumption:	Max. 12 kVA
• Compressed Air Operating Pressure:	6.5 bar
• Auxiliary Pressure:	approx. 1.5 bar
• Approx. Compressor Power:	45 - 75 kW
• Detection system	XRT, Color, Laser, Induction

The sorting system consists of the following components:

3.1.1 SENSORS

A particle passing through the sensor area of the KSS sorter can be detected by 4 different sensors as shown in Figure 3.

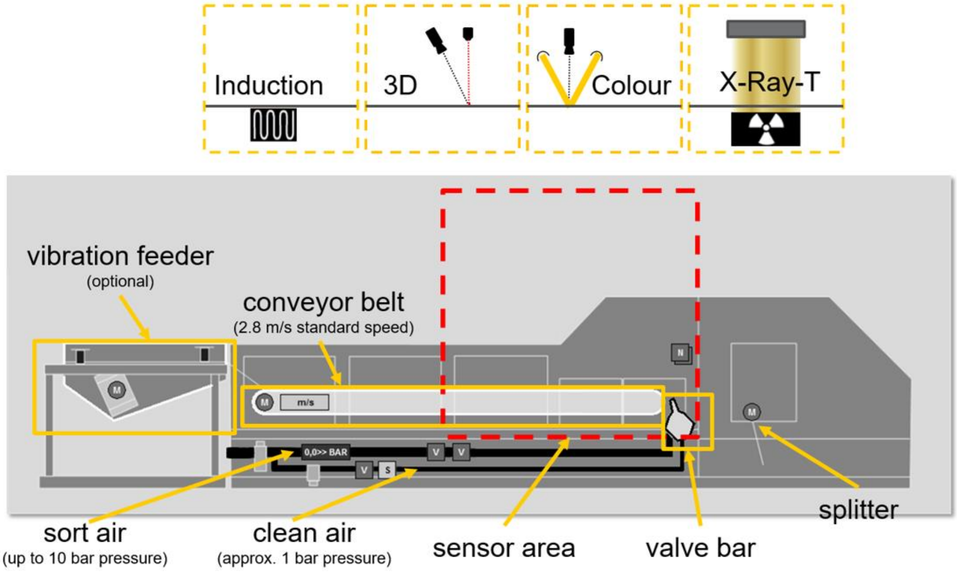


Figure 3: STEINERT Combination Sensor Sorters

XRT Sensor

X-ray sensitive line-scan sensors provides high resolution x-ray absorption images. An X-ray scintillation crystal sensor can capture up to 2500 lines per second.

Induction Sensor

Two active coils with a surrounding magnetic field are used to detect conductive objects. The main application is the separation of all electrical conductive components (metals). In the case of the Cartier material a tertiary filter was added to eliminate potential contaminants identified by Cartier as problematic, these were identified as potential pyrrhotite and graphite. Figure 4 below shows a selection of the reference material, where the multicolour piece was identified as granite.

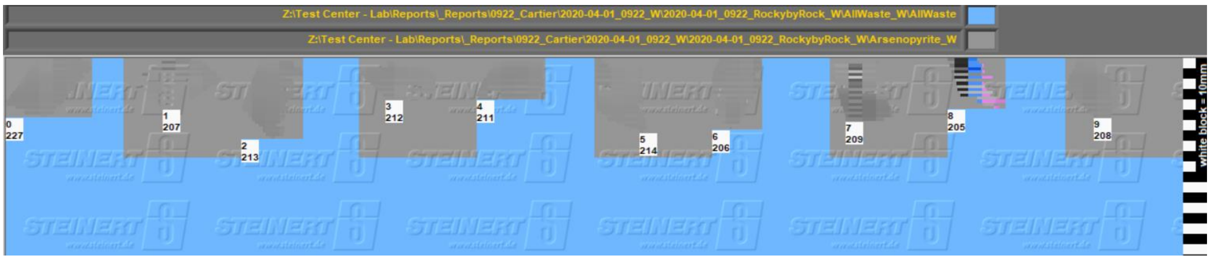


Figure 4: ARGOS induction readings mosaic view

Laser + 3D Camera

The laser sensor can be used for shape and size detection of the objects on the sorter belt which is used in combination with other sensors to determine the exact position of the particle for accurate ejection. A further use of the laser is brightness detection to differentiate between dark and light-colored particles.

Color Camera

Some mineral processing applications require color detection by camera.

3.1.2 PROCESSING SYSTEM

Image information is processed and analysed by the sorting PC. The prescribed algorithm is then applied to the particle to determine if it must be rejected or accepted. The position and size of the particle to be rejected is determined and the control system controls the ejection of material by activating the number of valves to ensure ejection.

3.1.3 EJECTION SYSTEM

This system utilizes pneumatic valves and consists of an array of air jets that are capable of rapid ejection of particles. The system allows for selective ejection of individual particles.

4. KSS SORTING TEST WORK

4.1 *TEST MATERIAL*

As previously stated Cartier provided 4 samples of varying compositions. Each of these compositions was examined, as well as 15 single rock reference samples provided by Cartier for further calibration.

4.1.1 DETERMINE ORE CLASSES

The reference single rock samples which were scanned separately to define the sensors reaction to each rock type. These were very finely detailed rock specimens covering most geology found on site. All high grade product rock-type samples were scanned separately as shown in Figure 5.

4.2 *XRT SCANNING*

The rock type samples were scanned to obtain the x-ray image for the relative x-ray representation and information. Each rock-type sample was scanned 5 times to obtain enough measured points to generate a reliable and representative scatter-plot for each rock-type. The x-ray image of dense ore samples are shown in Figure 5.

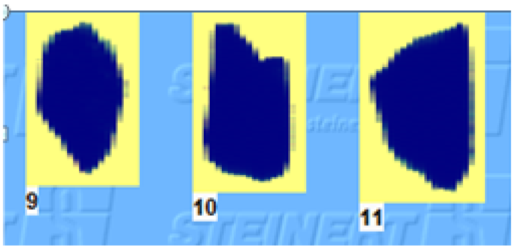


Figure 5: Scanned XRT raw image of dense ore

Figure 6 shows images of typical waste-rock samples. The lower density material is represented by the lighter blue color.

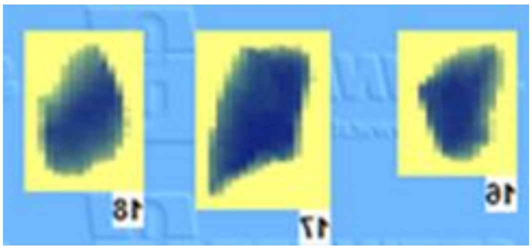


Figure 6: Scanned raw image of less-dense waste rock

The raw XRT scans are plotted on the dual-energy x-ray diagram shown in Figure 7.

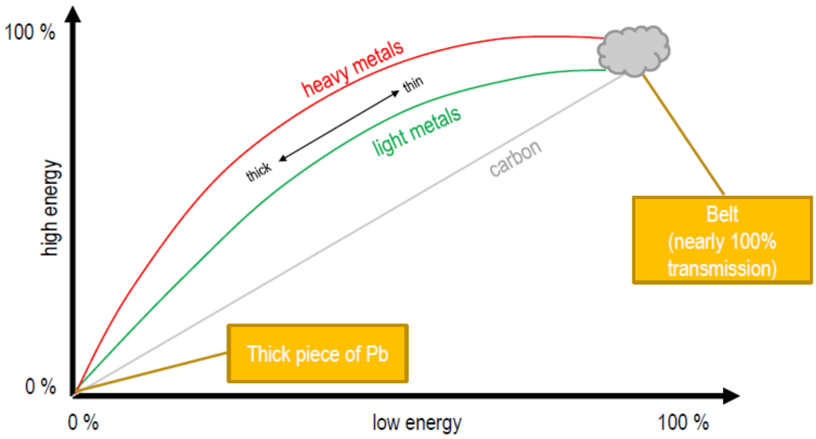


Figure 7: Dual-energy x-ray diagram

This information is then combined, and a mosaic view generated. A selection of scanned material from the Cartier reference samples is shown below in this combination in Figure 8.

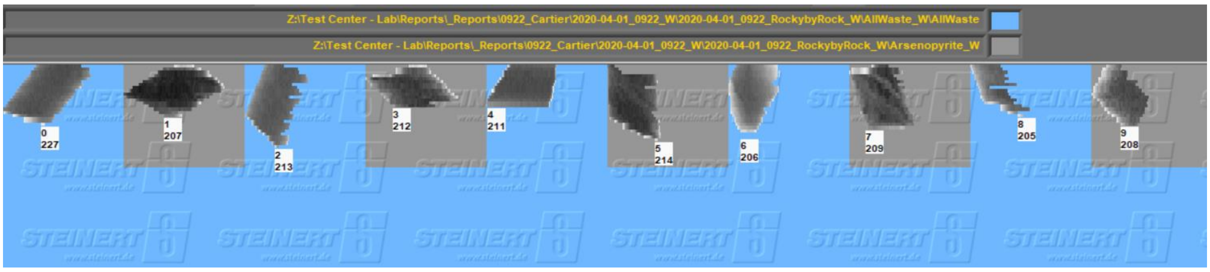


Figure 8: Grey-scale X-ray absorption images, aresenopyrite vs. waste

As you can see, the denser, product material shows as darker pixels, while the lighter waste material is grey. This is particularly evident in the Cartier material when looking at arsenopyrite in comparison to the waste. The waste is still quite dark, indicating some x-ray absorption, however the arsenopyrite pieces show up as near black in comparison, indicating a high level of absorption and therefore dense material.

4.2.1 GENERATE XRT SORTING ALGORITHM

The density scans of the mineralized and waste samples were loaded into the Steinert software. Figure 9 shows scatterplots on the dual-energy XRT diagram for the mineralised rock-types (green) and waste rock (red). These x-ray absorption plots indicate that there are good differences in to separate the denser mineralised ore from the less-dense barren waste rock types.

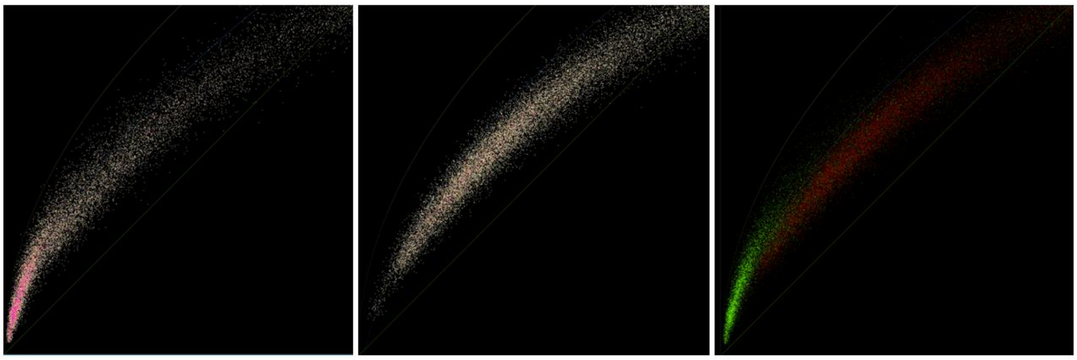


Figure 9: XRT diagrams showing scatter plots of poly-metallic sulphide rock types (left) and waste rock types (middle), combined scatterplots (right)

The basis of the separating algorithm is the defined area of the scatter plot graph which can identify one specific rock type. In the Steinert software this area is called a MAT table. The first approach was to isolate the waste rock types. This area was defined in the black area plot shown below in Figure 10.

Figure 10: Area defined for mineralized rocks (MAT 1)

The data of these scatter-plot areas are then entered into the Steinert software to generate a separation curve called MD curve as shown in Figure 11 below. The green curve and the area to the left represent product rock types. The red curve and the area to the right represent waste particles. The blue lines represent the sorter setting for the test run showing good separation criteria. For the test runs we have used first the blue line (step 1) to produce a high grade concentrate. As a second stage we examined sorting at Step 2, then Step 3. We also examined potential for further steps. With each stage more mass will report to the product fraction.

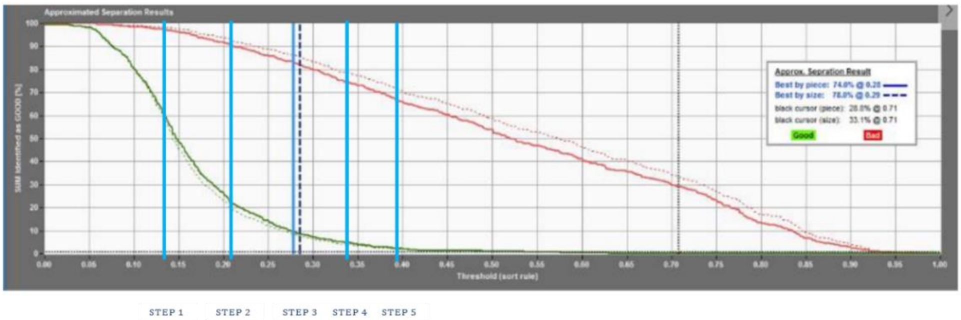


Figure 11: MD curves for separation

In this case the decision was made to combine sensor readings and use a combination of laser, XRT, and inductive sensors, but utilizing three steps, in part due to limited sample mass.

4.2.2 PARTICLE SIZE AND DENSITY DISTRIBUTION

This method we have tested is a new approach using a combination of particle size and density absorption. The height of the particle is measured by a 3D laser sensor and the density by the x-ray absorption energy levels of the X-ray sensor. 3 different density cut curves were tested in a 3-step approach resulting in increasing mass-pull to product, higher recovery of ore and decreasing product grade with each progressive sorting step.

4.3 *COLOR CAMERA SCANNING*

Some ore types and material require color camera scanning. This is not the case with the Cartier samples as Steinert's laser sensor can identify the lighter quartz on its own.

4.4 *TEST RUNS*

Figure 12 below displays the flowsheet used for all samples.

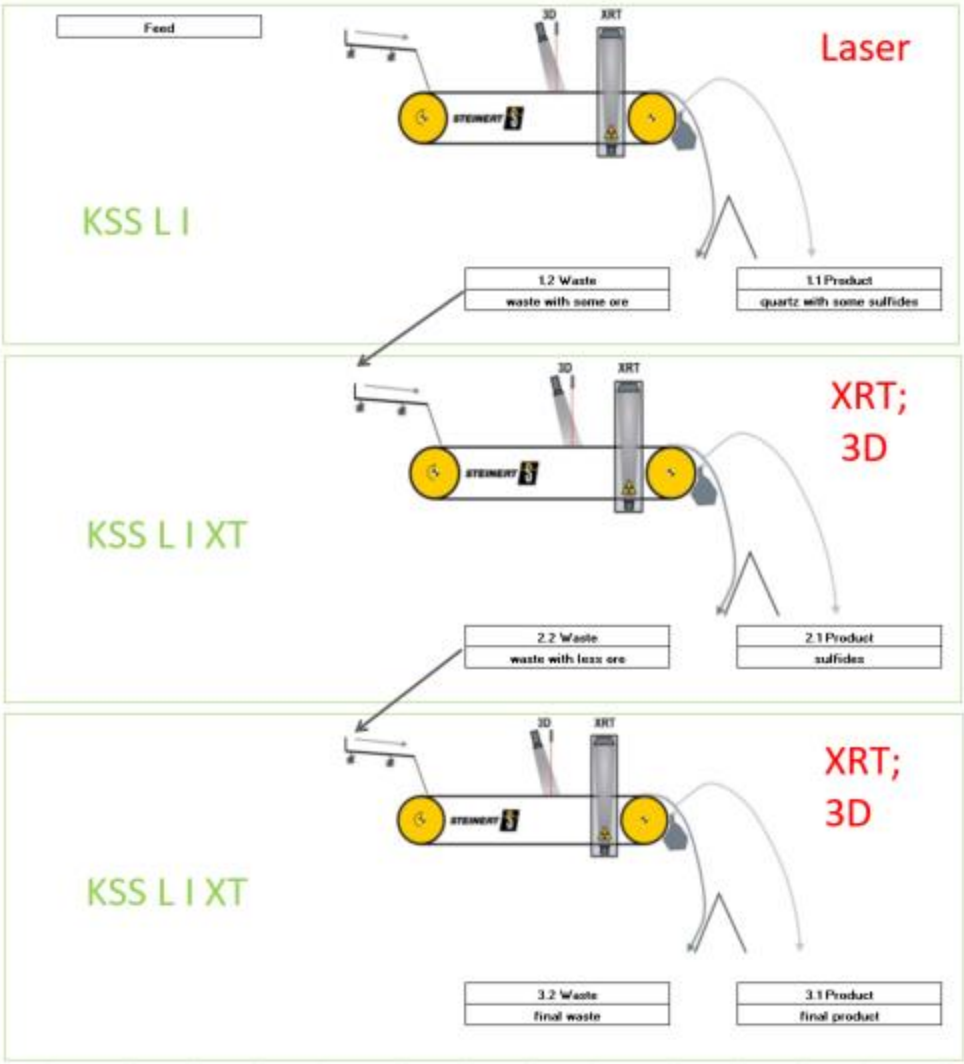


Figure 12: 3 step test run flowsheet

After establishing the best settings for each sample in the simulation test the sorter was set-up for the actual sorting test runs. Mass balance of the sorting runs for the sample are shown in Table 2.

Table 2: Mass balances of sorting test runs

Test Run	Sample Name	Fraction	Sensors	Steps	Total Sample (kg)	Eject Sample No.	Ejects (kg)	Eject Mass (%)	Drops Sample No.	Drops (kg)	Drops Rejection (%)	Cum. Mass Pull (%)	Cum. Waste Reject (%)
TR-0314	Blue Sample	-60+20 mm	MLW 1.6 to inf	1	18.3	314.1.1	4.5	24.59	314.1.2	13.8	75.41	24.59	75.41
TR-0314	Blue Sample	-60+20 mm	3D; Inductive; XSS-T;s1	2	13.9	314.2.1	1.9	13.67	314.2.2	12	86.33	38.26	61.74
TR-0314	Blue Sample	-60+20 mm	3D; Inductive; XSS-T;s2	3	11.6	314.3.1	5.5	47.41	314.3.2	6.1	52.59	47.41	52.59
TR-0315	Pink Sample	-60+20 mm	MLW 1.6 to inf	1	38.8	315.1.1	12.6	32.47	315.1.2	26.2	67.53	32.47	67.53
TR-0315	Pink Sample	-60+20 mm	3D; Inductive; XSS-T;s1	2	26.1	315.2.1	4.5	17.24	315.2.2	21.6	82.76	49.72	50.28
TR-0315	Pink Sample	-60+20 mm	3D; Inductive; XSS-T;s2	3	21.1	315.3.1	11.6	54.98	315.3.2	9.5	45.02	54.98	45.02
TR-0316	Yellow Sample	-60+20 mm	MLW 1.6 to inf	1	33	316.1.1	9.9	30.00	316.1.2	23.1	70.00	30.00	70.00
TR-0316	Yellow Sample	-60+20 mm	3D; Inductive; XSS-T;s1	2	22.2	316.2.1	3.3	14.86	316.2.2	18.9	85.14	44.86	55.14
TR-0316	Yellow Sample	-60+20 mm	3D; Inductive; XSS-T;s2	3	18.1	316.3.1	7.9	43.65	316.3.2	10.2	56.35	43.65	56.35
TR-0317	Orange Sample	-60+20 mm	MLW 1.6 to inf	1	71.6	317.1.1	33.4	46.65	317.1.2	38.2	53.35	46.65	53.35
TR-0317	Orange Sample	-60+20 mm	3D; Inductive; XSS-T;s1	2	37.8	317.2.1	8.1	21.43	317.2.2	29.7	78.57	68.08	31.92
TR-0317	Orange Sample	-60+20 mm	3D; Inductive; XSS-T;s2	3	28.9	317.3.1	17.5	60.55	317.3.2	11.4	39.45	60.55	39.45

The product and waste fractions of the test runs 1 to 3 of the TR314 Cartier sample are shown in Figure 13 below.

Figure 13: TR314 steps 1-3 product & waste fractions

The product and waste fractions of the test runs 1 to 3 of the TR315 Cartier sample are shown in Figure 14 below.

Figure 14: TR315 steps 1 - 3 - product & waste fractions

Next, Figure 15 below shows photographs from TR 316.

Figure 15: TR316 steps 1 – 3 – product & waste fractions

Finally Figure 16 below shows the final test run, TR 317.

Figure 16: TR317 steps 1 – 3 – product & waste fractions

5. RESULTS AND INTERPRETATION

The samples were weighed, bagged and labelled before they were shipped for sampling and assay.

5.1 *RESULTS: CARTIER ASSAY RESULTS*

The assay results are shown in Table 3

Table 3: Cartier Assay Results

Eject ORE Sample No.	ORE TYPES	Assay Sample (g/t)	Assay Sample (kg)
314,1.1	QUARTZ ORE	2.1	4.72
314,2.1	ARSENOPYRITE HIGH GRADE ORE	3.9	2.76
314,3.1	ARSENOPYRITE MID GRADE ORE	4.98	5.8
314,3.2	WASTE	1.7	6.26
315,1.1	QUARTZ ORE	2.61	12.88
315,2.1	ARSENOPYRITE HIGH GRADE ORE	6.48	5.96
315,3.1	ARSENOPYRITE MID GRADE ORE	3.63	12.04
315,3.2	WASTE	1.92	9.85
316,1.1	QUARTZ ORE	5.07	10.21
316,2.1	ARSENOPYRITE HIGH GRADE ORE	2.71	5.07
316,3.1	ARSENOPYRITE MID GRADE ORE	1.58	8.84
316,3.2	WASTE	1.47	10.42
317,1.1	QUARTZ ORE	3.06	33.81
317,2.1	ARSENOPYRITE HIGH GRADE ORE	2.06	17.17
317,3.1	ARSENOPYRITE MID GRADE ORE	0.65	17.87
317,3.2	WASTE	0.53	11.84

5.1.1 CARTIER TEST RUN 314 RESULTS

The grade-recovery-curve for gold for the first sample is shown in Figure 17 below.

Opportunity No.:	15975				Lab: 922				
Customer:	Cartier Resources								
-60 +20mm			Date:	6/30/2020					
Test No.	Setting	Total Sample kg	Feed Au (g/t)	Product kg	Mass Recovery %	Product Au (g/t)	Au Recovery %	Waste kg	Waste Au (g/t)
314.1	Step 1	18.0	3.0	4.5	25.0%	2.1	17.3%	13.5	3.3
314.2	Step 2	18.0	3.0	6.4	35.6%	2.6	30.9%	11.6	3.3
314.3	Step 3	18.0	3.0	11.9	66.1%	3.7	81.0%	6.1	1.7

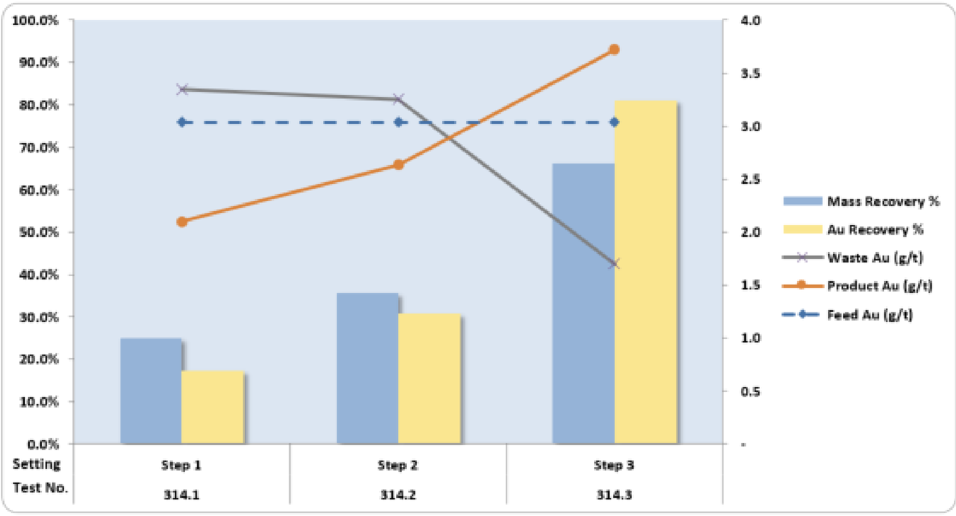


Figure 17: TR 314 – Cartier runs 1-3 gold grade-recovery curve.

Again, the first step in this test protocol was utilizing laser to remove quartz content immediately. Step 1 achieved a gold grade of 2.1 g/t Au at a recovery of 17.3%. The successive 2 steps added XRT, these removed the sulfide material, increasing recovery to 81% at a grade of 3.7 g/t.

5.1.2 CARTIER TEST RUN 315 RESULTS

The 3 additional samples were tested in the same way, beginning with a single laser pass to identify and capture quartz, then again 2 XRT steps to capture gold bearing sulfides. The grade-recovery-curve for gold TR315 is shown in Figure 18 below.

Opportunity No.:	15975				Lab: 922				
Customer:	Cartier Resources								
-60 +20mm			Date:	6/30/2020					
Test No.	Setting	Total Sample kg	Feed Au (g/t)	Product kg	Mass Recovery %	Product Au (g/t)	Au Recovery %	Waste kg	Waste Au (g/t)
315.1	Step 1	38.5	3.1	12.9	33.5%	2.6	27.8%	25.6	3.4
315.2	Step 2	38.5	3.1	17.4	45.2%	3.6	51.9%	21.1	2.8
315.3	Step 3	38.5	3.1	29.0	75.3%	3.6	86.7%	9.5	1.7

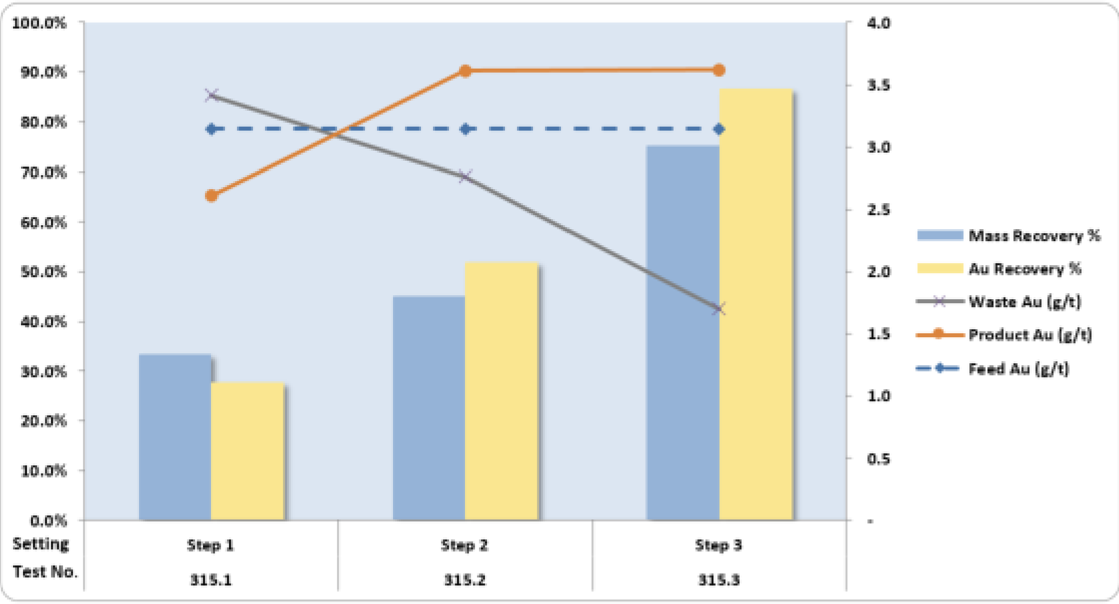


Figure 18: TR 315 – Cartier runs 1-3 gold grade-recovery curve.

With each step (sensitivity setting) the gold recovery rate steadily increases to 86.7% gold recovery at step 3 at a grade of 3.6 g/t of gold. Quartz recovery alone recovered nearly 28% of gold content at a grade of 2.6 g/t.

5.1.3 CARTIER TEST RUN 316 RESULTS

The grade-recovery-curve for gold for the third Cartier sample is shown in Figure 19 below.

Opportunity No.:	15975				Lab: 922				
Customer:	Cartier Resources								
-60 +20mm			Date: 6/30/2020						
Test No.	Setting	Total Sample kg	Feed Au (g/t)	Product kg	Mass Recovery %	Product Au (g/t)	Au Recovery %	Waste kg	Waste Au (g/t)
316.1	Step 1	31.3	2.8	9.9	31.6%	5.1	58.0%	21.4	1.7
316.2	Step 2	31.3	2.8	13.2	42.2%	4.5	68.3%	18.1	1.5
316.3	Step 3	31.3	2.8	21.1	67.4%	3.4	82.7%	10.2	1.5

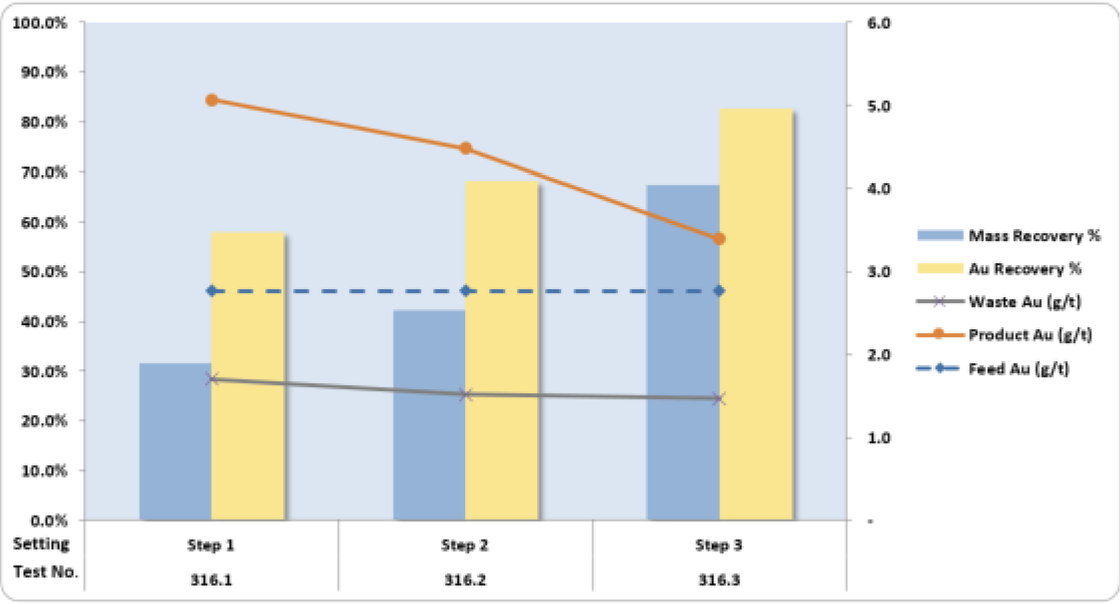


Figure 19: TR 316 – Cartier runs 1-3 gold grade-recovery curve.

With each step (sensitivity setting) the gold recovery rate steadily increases to 82.7% gold recovery at step 3 at a grade of 3.4 g/t of gold. The highest grade is achieved at step 1 of 5.1 g/t Au at a recovery of 58.0% Au.

5.1.4 CARTIER TEST RUN 317 RESULTS

The grade-recovery-curve for gold for the final Cartier sample is shown in Figure 20 below.

Opportunity No.:	15975			Lab: 922					
Customer:	Cartier Resources								
-60 +20mm			Date: 6/30/2020						
Test No.	Setting	Total Sample kg	Feed Au (g/t)	Product kg	Mass Recovery %	Product Au (g/t)	Au Recovery %	Waste kg	Waste Au (g/t)
317.1	Step 1	70.4	1.9	33.4	47.4%	3.1	75.0%	37.0	0.9
317.2	Step 2	70.4	1.9	41.5	58.9%	2.9	87.2%	28.9	0.6
317.3	Step 3	70.4	1.9	59.0	83.8%	2.2	95.6%	11.4	0.5

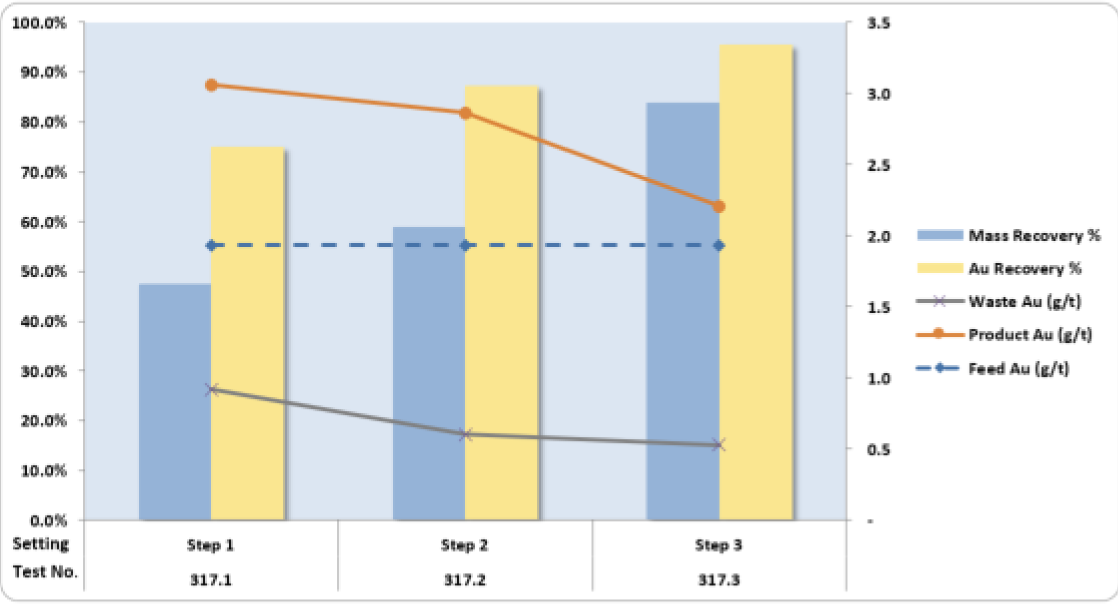


Figure 20: TR 317 – Cartier runs 1-3 gold grade-recovery curve.

With each step (sensitivity setting) the gold recovery rate steadily increases to 95.6% gold recovery at step 3 at a grade of 2.2 g/t of gold. The highest grade is achieved at step 1 of 3.1 g/t Au at a recovery of 75.0% Au.

6. CONCLUSION

The ore sorting test work on Cartier's material has shown the following:

- The samples had varying levels of amenability to ore sorting, with the fourth sample clearly showing the most 'normal' correlation, but all showed good opportunity to capture both quartz and sulfide material.
- The varied grade-recovery curves are affected largely by the first step, which was designated as the quartz capture step. Some samples results indicated that those samples contained significant gold in the quartz, and less so in the sulfide material, while some other samples showed the opposite of this.
- The first sample, TR314, indicates that the quartz contains some gold, but overall the gold recovery on step 1 is only 17.3% at a grade of 2.1 g/t. This seems to indicate that there is more free gold, or gold that follows the sulfide material. Steps 2 and 3 show that we start gaining back that sulfide material, especially in the third step where grades increase to 3.7 g/t Au at a recovery of 81.0%, while leaving 1.7 g/t Au in the waste.
- The second sample, TR315, shows a very similar trend, with step recovering 27.8% of the gold, at a grade of 2.6 g/t. However in steps 2 and 3 the gold is capture more quickly indicating perhaps more gold in this sample being associated with the dense sulfide material.
- The third sample, TR316, is the first sample where the first step captures a large amount of gold, at 58% recovery at a grade of 5.1 g/t. The difference in this case is that there does seem to be less gold associated with the dense material, as the subsequent XRT steps increase the recovery to only 82.7% at a grade of 3.4 g/t.
- Finally, TR317 seems to show an even stronger correlation between gold and quartz, while still capturing some gold that goes with the dense material. The step 1 laser only step captures 75% of gold at a grade of 3.1 g/t. This recovery increases to 95.6% at a grade of 2.2 g/t, while only leaving 0.5 g/t of gold in the waste.
- Overall the fourth sample (TR317) in particular showed itself to be very responsive to sensor sorting, but this is of course dependent upon sample makeup and quartz content. Steinert recommends detailed a further set of test work, with more material to both verify results, and potentially examine more options in the sensor settings to improve results.