

**DEVELOPMENT OF PROCESSING ALTERNATIVES FOR FRANKFIELD EAST DEPOSIT
USING SELECTIVE ARSENOPYRITE-PYRITE FLOTATION**

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ABSTRACT

Gowest Gold Ltd. is in the process of developing the Frankfield East gold deposit located along the largely undeveloped Pipestone fault northeast of Timmins, Ontario. In addition to resource development and environmental permitting work the company has had an ongoing program of metallurgical and engineering studies aimed at evaluating options for processing the Frankfield East ore.

Mineralization at the Frankfield project contains arsenopyrite and pyrite as the major sulphide minerals. Bulk flotation of all sulphides results in extremely high gold recovery. However, the gold is almost entirely associated with the arsenopyrite fraction of the ore and is refractory in nature requiring preoxidation treatment. Selective flotation was investigated to recover a gold-arsenopyrite concentrate thereby reducing the mass which would be subjected to further gold processing. As part of this work, a pyrite concentrate low in arsenic content was also recovered that would be suitable as a source of sulphur for a smelter (or other pyrometallurgical facility). Production of separate arsenopyrite and pyrite concentrates is frequently examined but rarely adopted due to the distribution of gold between the two products or the inability to achieve adequate separation. Several flowsheet options were investigated in the study. The best results were achieved following a sequential flotation flowsheet. The flowsheet configuration was key to meeting the targets for the two products. In this paper, the various options investigated are reviewed and the results of the final flowsheet are presented.

The overall plan by Gowest was to evaluate all process options to bring the Frankfield East deposit into production. The ability to effectively separate the arsenopyrite and pyrite components in the ore provides Gowest with added opportunities to pursue both short and long term production scenarios.

INTRODUCTION

The project and deposit are located in an area where there has been extensive gold mining over the past 100 years, with strong and vibrant plans for future infrastructure and capital projects in the works for many companies in and near the City of Timmins.

Project History

The Kidd Creek (Xstrata) base metal discovery in 1964 sparked an exploration rush focussed on locating additional base metals deposits in the areas north of Timmins. Airborne EM surveys and subsequent drill testing of conductors led to the discovery of several gold occurrences, proximal to graphitic conductors. These include the Frankfield East and Texmont zones (now part of Gowest Gold's North Timmins Project). However, the presence of significant quantities of water and glacial till over most of the area made exploration difficult.

In the 2000's Gowest continued to advance the geological model for the area utilizing updated government geophysical survey data. A significant shear structure (Pipestone fault) occurring along a mafic-ultramafic rock contact was identified as the primary target for gold mineralisation. Drilling intersects gold mineralization on the Frankfield zone for approximately 450 metres along strike and at a vertical depth of 600 metres establishing depth potential. In 2006, an inferred mineral resource of 510,000 oz (2.4 million tonnes @ 6.5 g/t Au) was estimated at the Frankfield East deposit, strengthening the confidence in the geological model.

Recent Work and New Resource 2008-2011

Gowest acquired 100% of the Frankfield East deposit in 2008 along with a series of adjacent claims. Through the use of modern geophysical (3D magnetic inversions) and geochemical (soil gas hydrocarbons) techniques, the geological model for the area was further advanced. A major drilling program of over 30,000 m demonstrated the size potential of the Frankfield East deposit by extending it along strike (+800 m) and at depth (+900 m). Post drilling, an updated 43-101 compliant resource estimate was completed in June 2011 which outlined 1.2 million ounces of indicated/inferred gold resources (approx. 6 million tonnes @ 6-7 g/t Au using a 3 g/t cut-off grade). Recent drilling continues to expand the known areas of mineralization along strike and has demonstrated continuity of the gold horizon from surface to a vertical depth in excess of 1000 metres.

Early after the consolidation of the Frankfield Project area, the company initiated an aggressive development program based on the assumption that the known resource area would be significantly expanded. Included in this program were First Nations consultations and the initiation of a comprehensive environmental baseline study. Detailed mineralogical evaluations, metallurgical testwork and engineering studies also commenced with the goal of ensuring that viable project development alternatives would be available immediately upon the demonstration of an economically viable resource.



Figure 1 - Map of site

PROJECT DESCRIPTION

The Frankfield East deposit is part of a significant and growing regional gold system (North Timmins Gold project) that now includes more than 60 square kilometres along the Pipestone fault system. A recent NI 43-101 compliant resource estimate identified 1.2 million ounces of indicated/inferred gold resources (approx. 6 million tonnes @ 6-7 g/t gold at a cut-off grade of 3 g/t). The expansion of the known resource combined with the potential for further exploration gains confirmed Gowest Gold's decision to proceed with engineering work to examine the economic feasibility of constructing a mining operation in the North Timmins project area. In order to identify viable processing alternatives an intensive program of mineralogical and metallurgical testwork was undertaken in a collective effort between Gowest and SGS Canada Inc. in Lakefield.

Mineralogy

Early on in the exploration process it was determined that the mineralogy at Frankfield East was unlike many of the more "conventional" gold deposits in the Timmins area. Although highly silicified, the mineralized zones are largely absent of large structures of white quartz and visible gold. Instead, the brecciated and altered host rock is filled with fine sulphides that comprise anywhere from a few percent to in excess of 30% of the overall rock matrix. Historically, the zones were further subdivided into "main zone" material located close to the contact between the mafic and ultramafic rock units and a series of sub-parallel "hanging wall" zones that were more distal to the contact and somewhat different visually with more apparent bleaching and quartz veining.

Prior to the initiation of the full metallurgical testwork program a series of rock samples from different zones within the deposit were subjected to a program of QEMSCAN™ and XRD analysis to identify the type and nature of the mineral species present in the deposit. The results of this program provided valuable insights into the physical characteristics of the deposit. This included:

- Arsenopyrite and pyrite were the primary carriers of gold with the fine gold grains (submicron to 10 microns in size) being largely attached to or locked within the sulphides.
- Sulphide minerals were comprised almost exclusively of pyrite and arsenopyrite with variations in the ratio of these species in the different mineral zones.
- Sulphide grain sizes were very similar in the different ore zones (main vs. hanging wall) with >80% liberation at a particle size of 20-30 microns.
- The non-sulphide minerals in the different ore zones were relatively similar with the exception of a quantity of micas/clays in the hanging wall areas that was largely absent in the main zone.

Overall, the QEMSCAN™ and XRD data confirmed that differences between the mineralization present in the historically identified main and hanging wall zones were in fact minimal and both areas should respond similarly to metallurgical treatments. A gold deportment study using Dynamic SIMS analysis quantified the sub-microscopic gold content in pyrite and arsenopyrite mineral grains. This study confirmed the fact that the majority of the gold content was in sub-micron form. One other interesting finding from this work was that the gold was almost exclusively associated with the arsenopyrite (see Figure 2). Gold content in the arsenopyrite grains ranged from 130 g/t to +200 g/t while that in the pyrite grains was generally on the order of a few g/t or less.

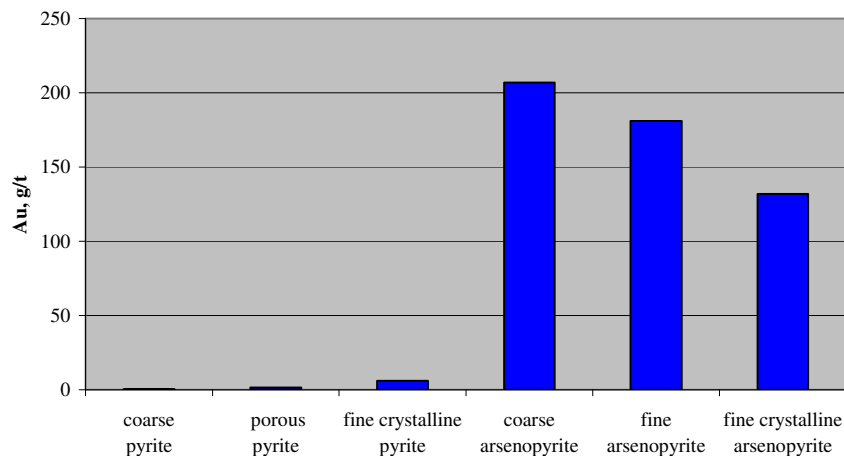


Figure 2 - Comparison by mineral type of the measured mean values of gold concentration.

Mineral Processing

Early attempts at whole ore cyanide leaching confirmed the expected difficulties in extracting gold from the sulphide minerals present in the Frankfield East deposit. With gold prices rising to unprecedented levels the company considered alternative options for bringing the Frankfield deposit into production using known oxidation techniques (bacterial and pressure). Due to the intimate association between the gold and the sulphide mineralization, flotation was identified early on as a method to produce a high grade/low volume gold-bearing concentrate that would reduce the scope of downstream processing operations. The remainder of this summary focuses on the development of this portion of the process flowsheet, and more specifically, options to tailor the technique to the unique mineralogical properties of the Frankfield East deposit. The metallurgical work was completed at SGS Canada Inc. in Lakefield from 2009 through 2011 as part of a larger ongoing process development program.

Metallurgical Testwork Sample

The complete development phase of the metallurgical testwork as proposed in 2009 required approximately 500-600 kg of representative feed material. Due to the relative consistency of the mineralogy throughout the deposit, a composite was prepared by drilling 17 large diameter (HQ size) metallurgical holes in a vertical fan pattern (70 m to 130 m vertical depth) at two locations in the centre of the deposit approximately 100 m apart. Whole drill core samples were shipped to SGS in Lakefield in 1 m intervals which were coarse crushed and individually assayed for gold. Core section samples assaying greater than 2 g/t Au were then combined to form two Master Composite samples (MC1 and MC2) assaying 5.95 g/t Au and 6.75 g/t Au respectively (Table 1).

Table 1 - Head analyses of master composites

Element		Master Comp 1	Master Comp 2
Gold	g/t Au	5.95	6.75
Sulphur	% S	3.43	2.79
Sulphide Sulphur	% S ⁻	3.30	NA
Arsenic	% As	2.19	1.81
Iron	% Fe	9.30	NA

DEVELOPMENT OF PROCESSING OPTIONS

The objective of the Frankfield East flotation testwork was to recover the majority of the gold contained in the composite material into a gold-bearing sulphide concentrate thereby allowing for a significant reduction in the quantity of material requiring downstream processing. In addition to the production of a bulk sulphide concentrate, the unique characteristics of the Frankfield mineralization and the possibility of treating the concentrate at a third party location also brought forward the idea to produce two products from the Frankfield ore: Firstly, a high grade arsenopyrite/gold concentrate which would be less affected economically by longer shipping distances to a final off-site processing facility, and secondly, a pyrite concentrate for potential sale to a smelter for fuel with trace quantities of arsenic and payable gold or for disposal.

Bulk Sulphide Flotation

Bulk sulphide flotation resulted in high gold recoveries. With staged additions of sodium hydrosulphide and potassium amyl xanthate, 96% of the gold was recovered in a concentrate containing 25% of the mass and assaying 21 g/t Au, 12% S and 7.4% As.

In some of the earlier bulk flotation tests, it was possible to lower the mass pull of the concentrate material to less than 16% by adding sulphide cleaners after the rougher circuit. Only batch test data is available but the results suggest a potential gold recovery of ~96% with middling recirculation.

Table 2 - Bulk Cleaner Flotation Test Results

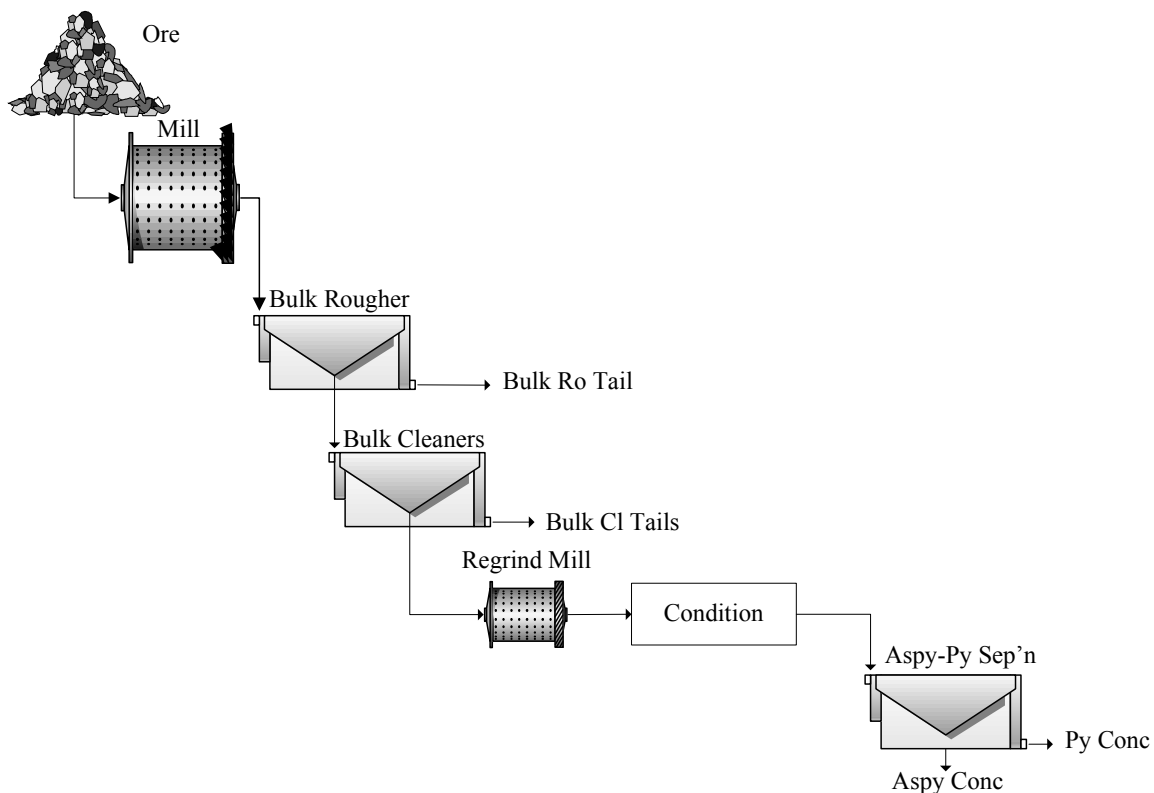
Product	Wt %	Assays, g/t, %			% Distribution		
		Au	S	As	Au	S	As
2 nd Cl Concentrate	15.5	36.1	21.0	12.7	93.2	93.1	92.2
1 st Cl + Cl Scav Conc	23.7	24.5	14.3	8.64	96.4	96.6	95.8
Rougher Concentrate	33.7	17.4	10.1	6.15	97.7	97.5	97.2
Rougher Tailing	66.3	0.21	0.13	0.091	2.3	2.5	2.8
Head (calc)	100.0	6.00	3.49	2.13	100.0	100.0	100.0

Selective Arsenopyrite-Pyrite Flotation

Bulk sulphide flotation is an obvious method to recover the gold into a concentrate for further processing and obtain the highest possible recoveries. The gold grade was increased from an average of 6 g/t in the ore to >30 g/t using bulk flotation methods.

It was not clear which methods for separation would work best or even if the two predominant sulphide minerals (pyrite/arsenopyrite) were separable. In order to reduce the amount of material being shipped and/or processed and therefore to reduce overall processing costs, selective arsenopyrite-pyrite flotation was investigated. With the strong association of gold and arsenopyrite, high gold recoveries were expected as long as high arsenopyrite recovery was maintained. In addition, the secondary goal of producing a pyrite concentrate low in arsenic/gold content that could be disposed of or sold as a source of sulphur was introduced. This led to the study of selective arsenopyrite-pyrite flotation. Three flowsheets were examined: bulk flotation followed by arsenopyrite-pyrite separation, sequential pyrite-arsenopyrite flotation, and sequential arsenopyrite-pyrite flotation. The flowsheets are shown in Figures 3-5.

Figure 3 – Bulk flotation followed by separation flowsheet



Bulk flotation had previously demonstrated the ability for high gold recoveries. Using the flowsheet illustrated in Figure 3, the bulk rougher concentrate was cleaned prior to arsenopyrite-pyrite separation. The bulk cleaner concentrate was reground then conditioned at 60°C and pH 12 to deactivate the sulphides and depress the pyrite. Small additions of copper sulphate and a more selective thionocarbamate collector were applied to recover the arsenopyrite and leave the pyrite in the separation tailing. Although some success was realized using this flowsheet, the arsenic content of the pyrite concentrate could not be reduced below 5.5% and the sulphur grade of the pyrite concentrate was limited to 24%. Gold recovery in the arsenopyrite concentrate was limited to 60%.

Figure 4 - Sequential pyrite-arsenopyrite flotation flowsheet

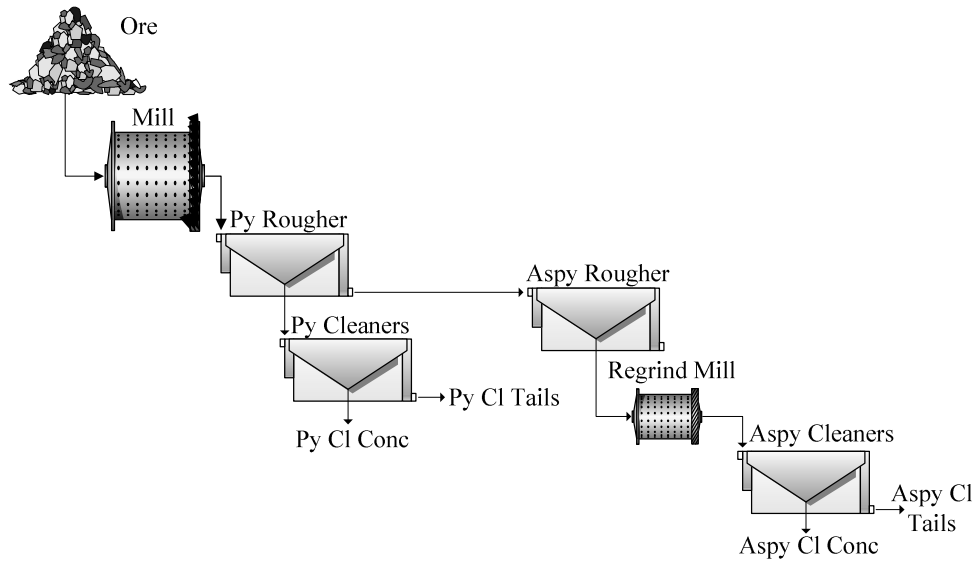
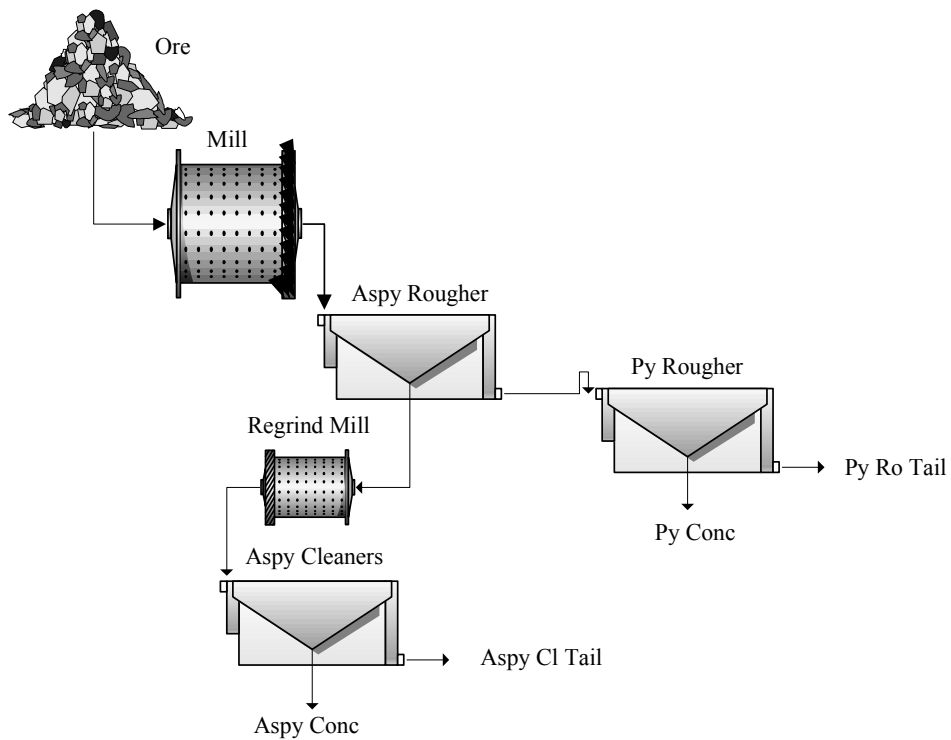


Figure 5 – Sequential arsenopyrite-pyrite flotation flowsheet



In the sequential flotation of pyrite followed by arsenopyrite (Figure 4), aeration and potassium permanganate were applied to oxidize and depress the arsenopyrite during pyrite flotation. The arsenopyrite was then activated with copper sulphate and recovered. Overall, selectivity was poor with 51% of the arsenopyrite and 52% of the gold reporting to the pyrite rougher concentrate.

The best overall separation efficiencies were achieved following a sequential arsenopyrite-pyrite flowsheet (Figure 5). The ore was ground with lime and conditioned at pH 11 in order to depress pyrite flotation. Stage additions of CMC for gangue depression, copper sulphate for arsenopyrite activation and a thionocarbamate as collector were made to selectively recover an arsenopyrite rougher concentrate containing 92% of the gold, 18% of the pyrite and 90% of the arsenopyrite. This was reground with lime and cleaned twice at pH 11. The arsenopyrite rougher tailing was conditioned with acid to reduce the pH to 9. Sodium hydrosulphide and potassium amyl xanthate were applied to recover a pyrite concentrate. The results of the best batch test are shown in Table 3.

A significant portion of the gold and arsenic were distributed through the arsenopyrite cleaner circuit products. Pyrite flotation kinetics after the pH adjustment and addition of NaHS and collector were very fast.

Subsequently, locked cycle tests were conducted to investigate the effect of recirculating middling streams on the sequential arsenopyrite-pyrite flotation process. Recirculation of the arsenopyrite cleaner scavenger tailing to the pyrite circuit would increase the arsenic content of the pyrite above acceptable levels. To maximize gold recovery and maintain a low-arsenic pyrite concentrate, a sulphide scavenger circuit was added. The feed to this circuit was the pyrite rougher tailing and the arsenopyrite 1st cleaner scavenger tailing. The sulphide scavenger concentrate was combined with the arsenopyrite concentrate for regrinding and cleaning in test LCT2. In test LCT3 a third cleaning stage was added. The flowsheet is shown in Figure 6 and the projected results from these cycle tests are presented in Table 4.

Figure 6 - Final locked cycle test flowsheet

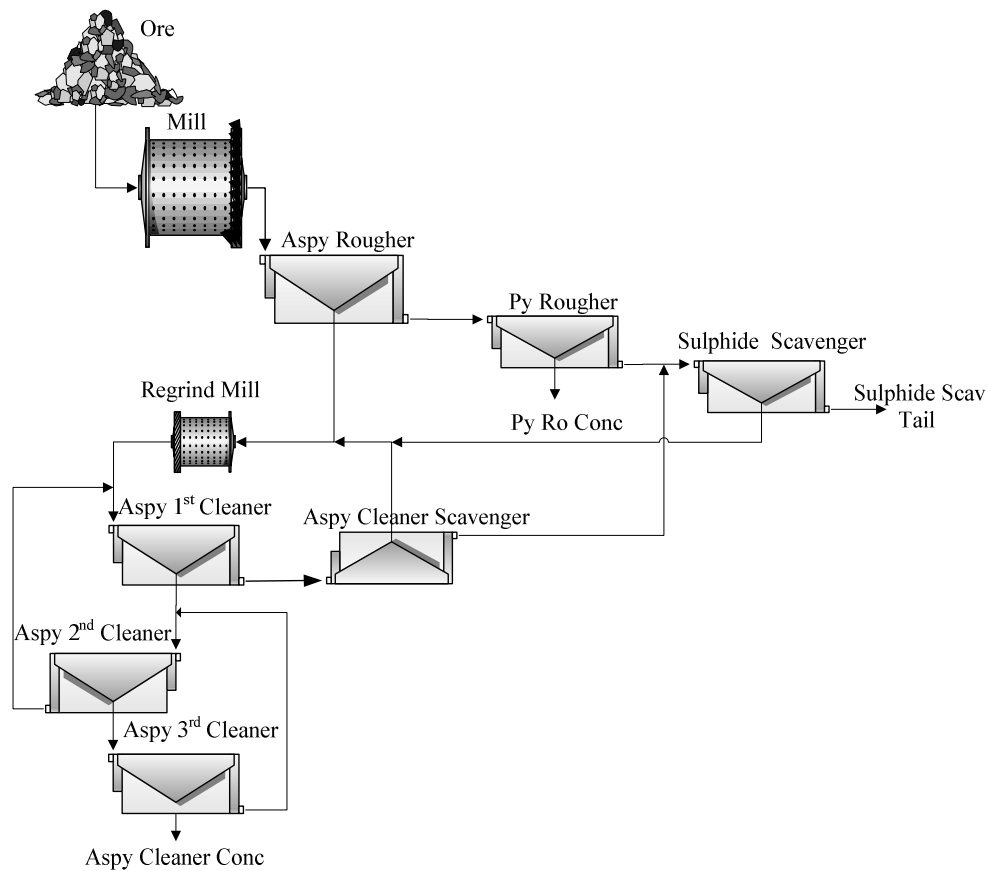


Table 3 – Results of batch sequential arsenopyrite-pyrite flotation test

Product	Wt %	Assays, g/t, %					Distribution, %				
		Au	S	As	Py*	Aspy*	Au	S	As	Py*	Aspy*
Aspy 2 nd Cl Conc	4.1	95.3	20.1	33.4	10.9	72.6	63.5	24.2	61.1	9.7	61.1
Aspy Ro Conc	10.8	52.3	12.0	18.7	7.5	40.6	92.2	38.3	90.3	17.9	90.3
Py Ro Conc 1	5.7	3.77	32.7	1.61	59.9	3.5	3.5	55.4	4.1	75.6	4.1
Py Ro Conc 1+2	8.0	3.72	24.7	1.63	44.8	3.5	4.9	58.4	5.9	78.9	5.9
Aspy + Py Ro Conc	18.8	31.6	17.4	11.4	23.4	24.8	97.1	96.6	96.2	96.8	96.2
Rougher Tailing	81.2	0.22	0.14	0.11	0.2	0.2	2.9	3.4	3.8	3.2	3.8
Head (calc)	100.0	6.11	3.38	2.23	4.5	4.8	100.0	100.0	100.0	100.0	100.0

*calculation based on the assumption that all arsenic was present as arsenopyrite and the remaining sulphur was present as pyrite

Test No.	Product	Wt %	Assays, g/t, %					Distribution, %				
			Au	S	As	Py*	Aspy*	Au	S	As	Py*	Aspy*
LCT2	Aspy 2 nd Cl Conc	7.7	77.0	14.1	20.9	9.7	45.4	92.3	40.3	89.2	20.7	89.2
	Py Ro Conc	6.0	5.12	23.9	1.74	43.3	3.8	4.8	53.1	5.8	72.1	5.8
	Rougher Tailing	86.4	0.22	0.20	0.10	0.3	0.2	3.0	6.6	5.0	7.2	5.0
	Head (calc)	100.0	6.40	2.69	1.80	3.6	3.9	100.0	100.0	100.0	100.0	100.0
LCT3	Aspy 3 rd Cl Conc	6.4	93.7	16.2	24.3	10.8	52.9	92.7	40.3	90.2	20.2	90.2
	Py Ro Conc	4.8	4.64	28.6	1.54	52.3	3.4	3.5	54.1	4.3	74.3	4.3
	Rougher Tailing	88.8	0.27	0.16	0.11	0.2	0.2	3.8	5.5	5.5	5.5	5.5
	Head (calc)	100.0	6.44	2.56	1.72	3.4	3.7	100.0	100.0	100.0	100.0	100.0

*calculation based on the assumption that all arsenic was present as arsenopyrite and the remaining sulphur was present as pyrite.

Table 5 - Results of the sequential flotation test to produce concentrates

Product	Wt %	Assays, g/t, %					Distribution, %				
		Au	S	As	Py*	Aspy*	Au	S	As	Py*	Aspy*
Aspy 3rd Cl Conc	5.9	95.8	17.6	25.9	12.3	56.3	90.4	39.6	86.0	20.7	86.0
Aspy 3 rd Cl Tail	0.6	7.09	3.63	2.34	4.9	5.1	0.7	0.8	0.8	0.8	0.8
Aspy 2 nd Cl Tail	0.2	3.41	2.08	1.17	3.0	2.5	0.1	0.2	0.1	0.2	0.1
Aspy 1 st Cl Scav Conc.	0.2	3.41	2.24	1.15	3.3	2.5	0.1	0.1	0.1	0.1	0.1
Aspy 1 st Cl Scav Tail	0.4	0.81	0.93	0.31	1.5	0.7	0.1	0.1	0.1	0.2	0.1
Py Ro Conc 1	4.3	5.46	30.7	2.06	55.8	4.5	3.7	50.0	5.0	68.4	5.0
Py Ro Conc 2	1.2	6.07	8.25	3.64	12.5	7.9	1.2	3.8	2.5	4.4	2.5
Py Ro Conc 1 + 2 (calc)	5.5	5.60	25.7	2.42	46.1	5.3	4.9	53.9	7.5	72.8	7.5
Aspy + Py Conc (calc)	12.7	47.1	19.5	13.1	25.9	28.6	96.3	94.8	94.6	94.8	94.6
Rougher Tailing	87.3	0.27	0.16	0.11	0.2	0.2	3.7	5.2	5.4	5.2	5.4
Head (calc)	100.0	6.22	2.61	1.77	3.5	3.8	100.0	100.0	100.0	100.0	100.0

*calculation based on the assumption that all arsenic was present as arsenopyrite and the remaining sulphur was present as pyrite.

Overall, the locked cycle testwork program was able to recover 92-93% of the gold into an arsenopyrite cleaner concentrate with approximately 7% of the original ore mass. The grade of this concentrate was 94 g/t Au. In addition, a pyrite concentrate was recovered assaying <1.6% As.

In order to generate concentrates for downstream testing, 230 kg of Master Comp 2 were processed following the procedure of LCT3 using 10-kg charges. Two pyrite rougher concentrates were collected separately to investigate the recovery of a higher sulphur grade product. The results are shown in Table 5 and confirmed the results of the locked cycle tests. In addition, it demonstrated that a higher grade pyrite concentrate, analysing >30% S, could be produced. High sulphur pyrite concentrates have some value for sale to pyrometallurgical operations such as roasters and smelters for use as a heat source.

Overall the effectiveness of the selective flotation process at separating and concentrating the sulphide minerals is apparent when examining the final concentrates. The combined arsenopyrite + pyrite concentrate has the same overall gold recovery that was achieved in the prior bulk flotation testwork with only half of the concentrate weight.

Engineering Design

The overall development plan by Gowest for the Frankfield East deposit was to evaluate all processing options available to bring the deposit into production. The ability to effectively separate the arsenopyrite and pyrite components in the ore provides Gowest with added opportunities to pursue both short and long term production scenarios. A Preliminary Economic Assessment is currently being completed for the project to fully evaluate the economic parameters surrounding each scenario. A brief portion of this work is summarized below examining the operating cost trade-offs between processing a bulk sulphide concentrate versus a selective arsenopyrite concentrate via pressure oxidation

Assumptions

	Bulk Concentrate*	Selective Aspy Concentrate (LCT3)
Concentrate Feed Rate (tpd)	260	95
Concentrate Assays:		
Gold (g/t)	30	94
Arsenic (%)	10	24
Sulphur (%)	18	16
Gold Recovery to Concentrate (%)	96%	93%

*Numbers are estimates including recycle of middlings (see Table 2)

Impacts

For the purposes of this evaluation, only the impact of key consumables has been included. These include oxygen, limestone and lime. The elimination of the majority of the barren pyrite content in the ore via a selective arsenopyrite flotation process significantly reduces the quantity of oxygen required during oxidation to oxidize the iron and sulphur in the pyrite. In addition, limestone and lime savings are achieved subsequent to pressure oxidation as less sulphuric acid has been generated which must subsequently be neutralised. Obviously there are other minor changes in the operating costs (flotation reagents, etc.) but these have been excluded in the current summary.

Under the scenario being examined, the change to selective flotation results in operating cost savings of \$330 per hour at the expense of a reduction in overall gold recovery of ~3%. Assuming feed ore is processed at a rate of approximately 60 t/h this equates to a saving of \$5.50 per tonne of ore -- 0.14 g/t of gold at gold price of \$1200 per ounce.

	Bulk Concentrate	Selective Aspy Concentrate	Cost Differential
Oxygen	4.5 t/h	2.5 t/h	-200 \$/h
Limestone	5.7 t/h	3.3 t/h	-72 \$/h
Lime	1.0 t/h	0.6 t/h	-58 \$/h
Total			-330 \$/h

Ultimately, the decision on which processing route is most cost effective will depend on how the projected savings compare to the small loss in gold recovery going from a bulk concentrate process to that of selective flotation. At an average ore feed grade of 6.5 g/t Au the savings correspond to a 2.2% change in gold recovery. This is slightly less than the forecast ~3% loss predicted from metallurgical testwork and would indicate that the bulk concentrate route is preferable. However, the current evaluation excludes capital cost savings due to the reductions in plant equipment sizes achieved with the selective concentration route. Once these factors are included the two options are comparable.

It should also be noted that no allowances have been made for differences in shipping costs between the two processing alternatives (assumption that all processing takes place at a single site). Some of the scenarios that Gowest has identified as opportunities involve the construction of a concentrate oxidation facility at a second site that is some distance away from the primary concentrator facility. Including the additional shipping/handling costs for transporting the concentrate to the new facility would increase the savings associated with the selective flotation process and under certain scenarios, make it the preferred alternative.

DISCUSSION

For Gowest, the ability to effectively separate the arsenopyrite and pyrite components in the ore provides added opportunities to pursue both short and long term production scenarios. A carefully planned mineralogical analysis completed early on in the metallurgical program demonstrated that almost all of the gold in the Frankfield East ore was contained in the arsenopyrite, with only a small fraction associated with the pyrite. This feature of the deposit led to the development of an effective sequential flotation process that can offer significant benefits over bulk concentration methods. A number of production scenarios are currently being considered by the company and the ability to produce a low mass, high gold content concentrate with only minimal reductions in overall gold recoveries significantly expands the range of economically viable alternatives.

The flotation work conducted on composite ore samples by SGS using batch and locked-cycle techniques provided the critical data required to assess the trade-offs between the different flotation alternatives. A basic economic evaluation demonstrates the value of the selective flotation process in terms of reduced reagent consumptions and savings in downstream capital equipment requirements. Should an offsite processing facility be selected to handle the final processing of the gold concentrate product, additional savings would be realized due to significant reductions in concentrate shipping costs. In addition, the selective flotation process was able to generate a high sulphur, low arsenic pyrite concentrate that may have value as a heat source for sale to existing pyrometallurgical operations.

Gowest continues to aggressively expand and develop the Frankfield East deposit as part of its growing North Timmins project area. The improved understanding of the deposit's mineralogy and the ability to incorporate selective flotation into the processing options being evaluated has aided greatly with this process.