

APPENDIX A METHODS OF ORE PREPARATION

1 Ore sampling

The Merensky ore was collected from the belt feeder to the mills at Impala Platinum (Rustenburg). The wet sample should ideally be air dried, but due to the wet weather the sample was dried on trays in ovens at 30°C. The sample was dried for 6 days. The ore contained lots of fines.

2 Ore preparation

2.1 Crushing

The dry ore was jaw crushed and screened to -6mm. The jaw crushers cause fracture by compression, since this is the most practical method of applying a fracture force to the large particles.

The second stage of the crushing was with the conetype gyratory and then screened to -3mm.

2.2 Splitter

The splitter has eight buckets. The buckets are stationary on a rotating wheel and the sample is fed into the buckets with a vibrating feeder. The first step of the splitting procedure is to mix the ore and this was done by putting the whole sample through the splitter two or three times. It is then split into the 1kg bags to give a representative size distribution of the Merensky sample. The procedure is as follow:

The 150kg sample is split into eight bags. Each bag weighs about 18.4 kg. The eight bags is then split into one kilogram bags. The eight kilograms is split into two halves. Each halve is then split into eight. Use seven of the eight beakers and then split again into eight. The samples are then weighed into bags of exactly one kilogram.

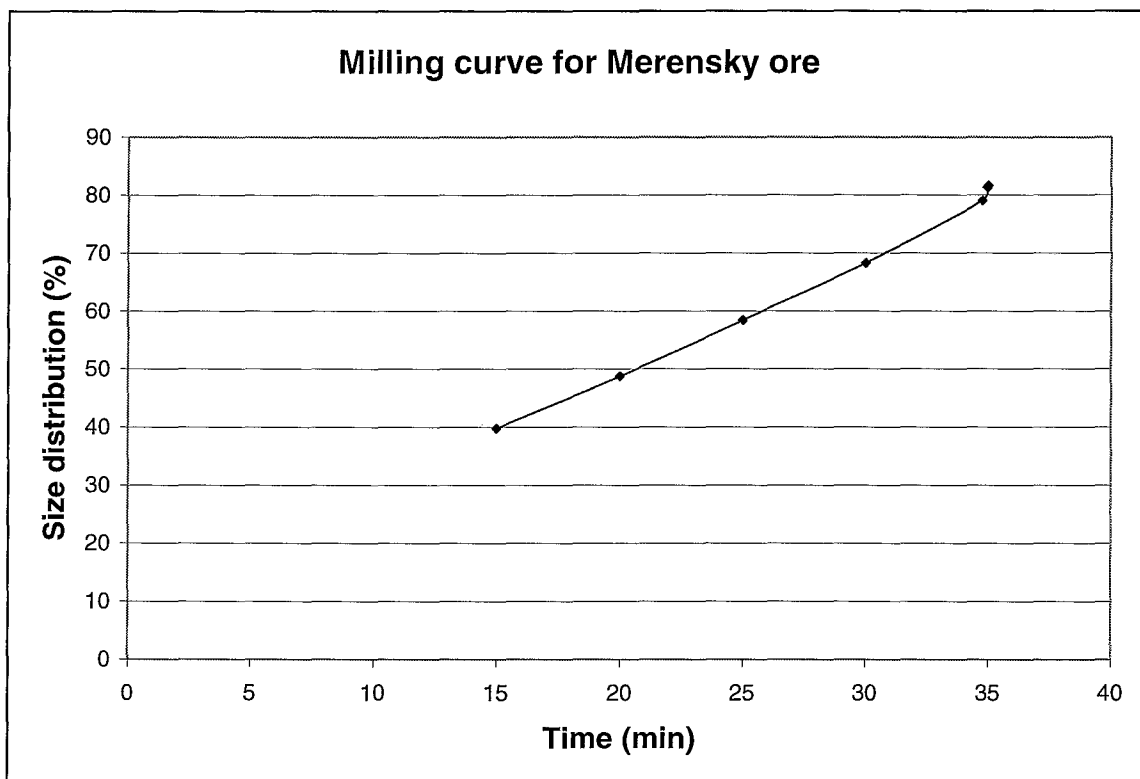
2.3 Milling

The standard size laboratory mill (Yamfo) is used to mill the ore to 80% -75 μ m. A new set of rods was made for the project, which consists of 35 rods. The diameter of the rods is 6, 8, 10, 12, 15, 20, 25 mm (five rods of each size). The one kilogram samples is milled for different times to get a milling curve to determine the exact time for 80% - 75 μ m. The water solid mass ratio in the mill is 1:1. The milled product is filtered and dried in the ovens overnight. The dried sample is then split to 200 g and is then wet screened (75 μ m) to get the fines out of the sample. It is dried again and then screened again for 20 minutes on the sieve shaker with the 300, 212,150, 106 and 75 μ m sieves. The size distributions are then determined by weighing the masses of the different sieves.

Table A1 Calculating the milling time for Merensky ore

Test no.	Time (min)	Wet screened (+ 75 μ m)	Dry screened (% -75 μ m)
1	20	110.52	48.755
2	25	92.29	58.48
3	15	123.66	39.78
4	30	66.32	68.27
5	35	49.98	81.665
6	34:58	51.57	81.31
7	34:45	63.5	79.055

These results are plotted and the total milling time to get 80% -75 μ m is 34 minutes and 52 seconds.

**Figure A1 Milling curve**

Appendix B Multiple collector addition in batch cells

Table B1 PGM results for multiple collector addition at BPR

Collector	Mass conc 1	Grade	Recovery	Mass Conc 2	Grade	Recovery	Mass Tails	Grade	Total Recovery
	(g)	(ppm)	(%)	(g)	(ppm)	(%)	(g)	(ppm)	(%)
STD (0.25)	74.76	39.75	50.78	48.73	51.65	87.36	877.39	0.42	93.78
STD (0.5)	79.15	37.25	61.75	40.66	36.80	81.91	881.03	0.38	93.08
STD (0.75)	92.52	45.75	79.74	34.23	19.30	61.42	873.47	0.48	92.18
iC ₃ -TTC (0.25)	78.92	40.25	59.06	35.96	40.40	65.98	886.49	0.85	86.07
iC ₃ -TTC (0.5)	79.94	48.25	62.06	36.41	51.30	79.19	884.27	0.56	92.10
iC ₃ -TTC (0.75)	86.12	48.80	74.54	34.38	24.40	58.44	883.80	0.68	89.42
C ₁₂ -TTC (0.25)	87.26	47.60	60.12	36.77	63.50	84.72	877.02	0.48	93.91
C ₁₂ -TTC (0.5)	86.46	45.55	73.88	40.00	24.30	69.80	875.94	0.48	92.11
C ₁₂ -TTC (0.75)	97.76	41.25	76.69	35.30	24.40	70.26	867.80	0.42	93.07

Table B2 Copper results for multiple collector addition at BPR

Collector	Mass conc 1	Grade	Recovery	Mass Conc 2	Grade	Recovery	Mass Tails	Grade	Total Recovery
	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)
STD (0.25)	74.76	1.00	90.36	48.73	0.05	28.43	877.39	0.01	93.10
STD (0.5)	79.15	0.96	89.68	40.66	0.05	24.06	881.03	0.01	92.16
STD (0.75)	92.52	0.79	90.26	34.23	0.05	22.88	873.47	0.01	92.49
iC ₃ -TTC (0.25)	78.92	0.91	86.28	35.96	0.06	18.17	886.49	0.01	88.77
iC ₃ -TTC (0.5)	79.94	0.93	89.19	36.41	0.05	21.75	884.27	0.01	91.54
iC ₃ -TTC (0.75)	86.12	0.84	89.35	34.38	0.06	23.28	883.80	0.01	91.83
C ₁₂ -TTC (0.25)	87.26	0.85	89.07	36.77	0.06	23.15	877.02	0.01	91.60
C ₁₂ -TTC (0.5)	86.46	0.83	87.62	40.00	0.04	17.46	875.94	0.01	89.78
C ₁₂ -TTC (0.75)	97.76	0.76	87.74	35.30	0.05	16.19	867.80	0.01	89.72

Table B3 Nickel results for multiple collector addition at BPR

Collector	Mass conc 1	Grade	Recovery	Mass Conc 2	Grade	Recovery	Mass Tails	Grade	Total Recovery
	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)
STD (0.25)	74.76	1.59	63.41	48.73	0.35	24.94	877.39	0.06	72.53
STD (0.5)	79.15	1.56	63.47	40.66	0.34	19.77	881.03	0.06	70.69
STD (0.75)	92.52	1.36	67.73	34.23	0.30	16.93	873.47	0.06	73.20
iC ₃ -TTC (0.25)	78.92	1.50	62.17	35.96	0.43	21.59	886.49	0.06	70.34
iC ₃ -TTC (0.5)	79.94	1.58	63.97	36.41	0.41	21.08	884.27	0.06	71.56
iC ₃ -TTC (0.75)	86.12	1.44	63.67	34.38	0.39	18.80	883.80	0.07	70.50
C ₁₂ -TTC (0.25)	87.26	1.48	66.59	36.77	0.44	25.28	877.02	0.06	75.04
C ₁₂ -TTC (0.5)	86.46	1.44	62.95	40.00	0.41	22.30	875.94	0.07	71.21
C ₁₂ -TTC (0.75)	97.76	1.34	66.27	35.30	0.38	19.96	867.80	0.06	73.00

Table B4 Chromate results for multiple collector addition at BPR

Collector	Mass conc 1	Grade	Recovery	Mass Conc 2	Grade	Recovery	Mass Tails	Grade	Total Recovery
	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)
STD (0.25)	74.76	0.59	1.67	48.73	0.85	1.58	877.39	2.93	3.22
STD (0.5)	79.15	0.59	1.70	40.66	0.83	1.25	881.03	3.03	2.92
STD (0.75)	92.52	0.65	2.28	34.23	0.86	1.15	873.47	2.91	3.41
iC ₃ -TTC (0.25)	78.92	0.61	1.83	35.96	0.91	1.27	886.49	2.88	3.08
iC ₃ -TTC (0.5)	79.94	0.61	1.80	36.41	0.91	1.25	884.27	2.97	3.03
iC ₃ -TTC (0.75)	86.12	0.62	2.05	34.38	0.91	1.22	883.80	2.87	3.25
C ₁₂ -TTC (0.25)	87.26	0.64	2.12	36.77	1.04	1.49	877.02	2.87	3.58
C ₁₂ -TTC (0.5)	86.46	0.64	2.25	40.00	0.99	1.64	875.94	2.72	3.85
C ₁₂ -TTC (0.75)	97.76	0.67	2.58	35.30	0.96	1.38	867.80	2.80	3.93

Appendix C Results of batch floats conducted at UCT

1 Metallurgical results - Graphics

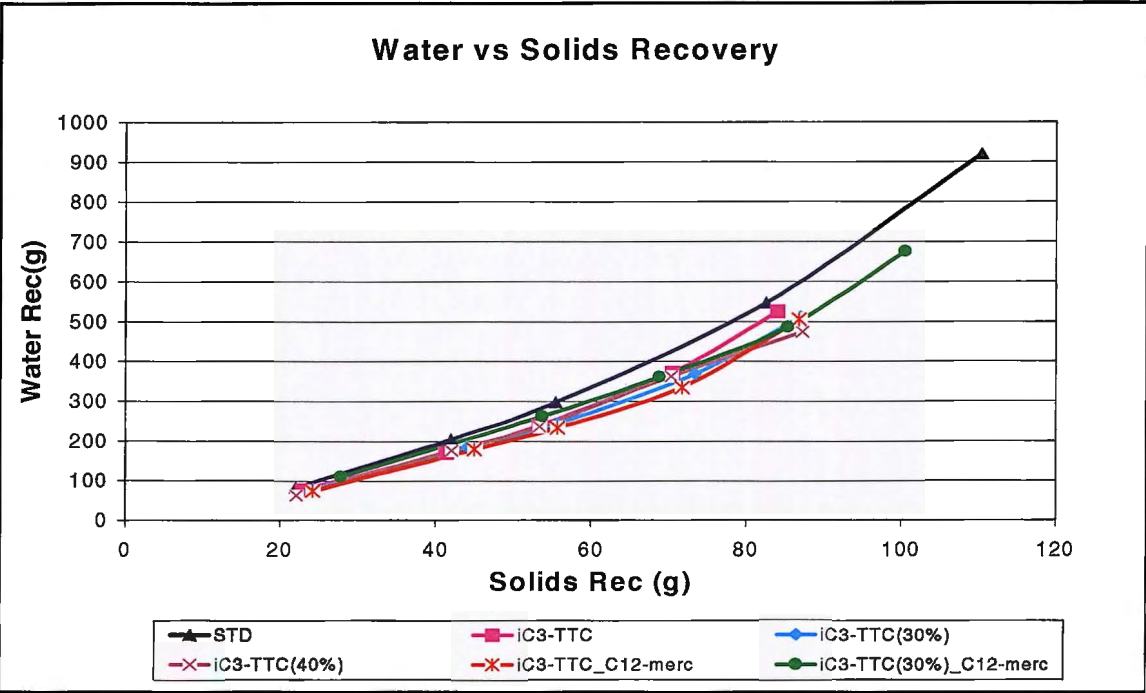


Figure C1.1 Water recovery vs solids recovery

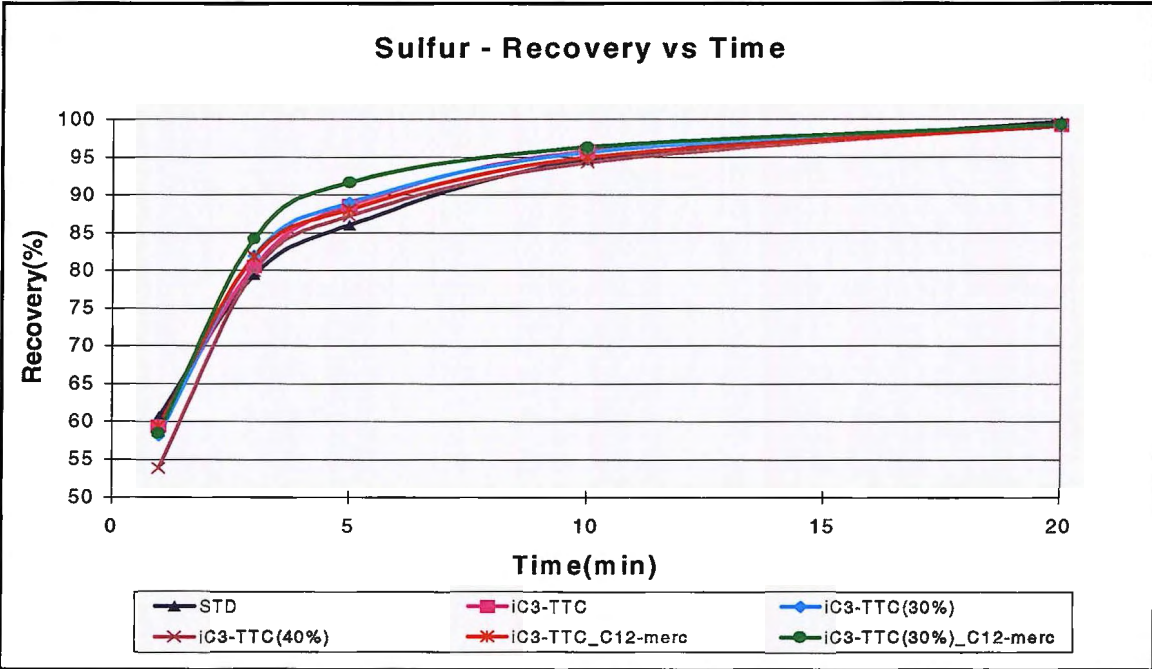


Figure C1.2 Sulphur recovery vs time

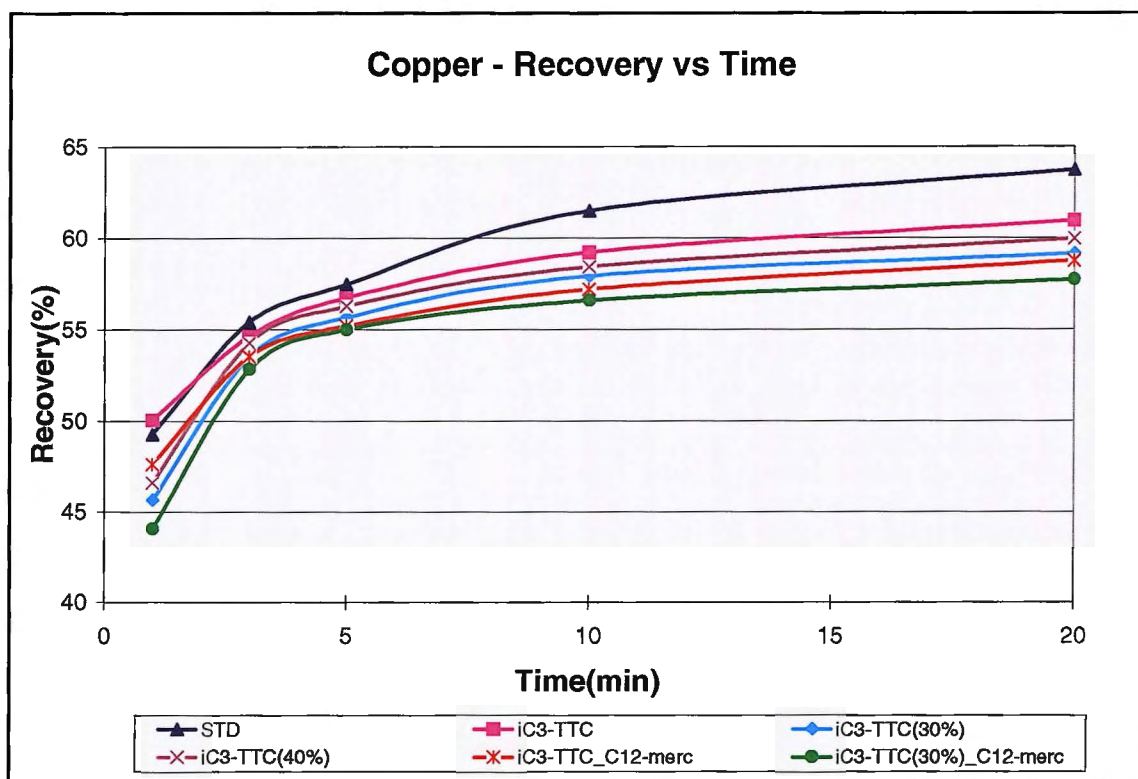


Figure C1.3 Copper recovery vs time

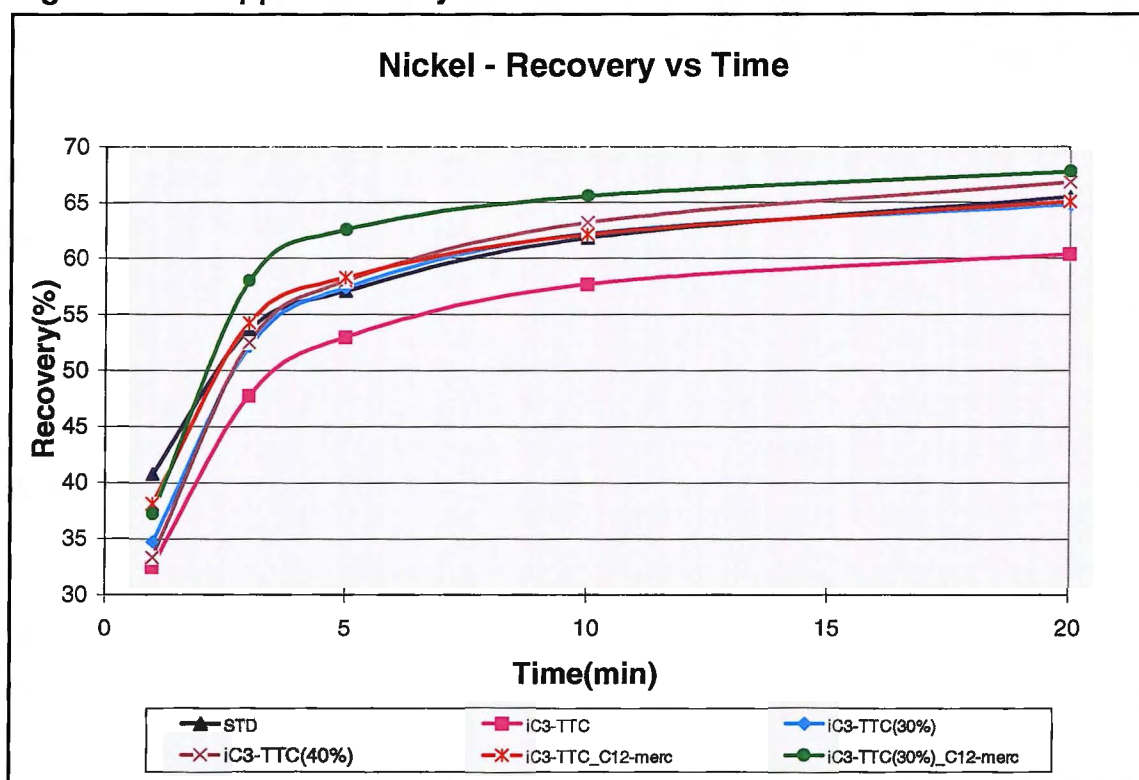


Figure C1.4 Nickel recovery vs time

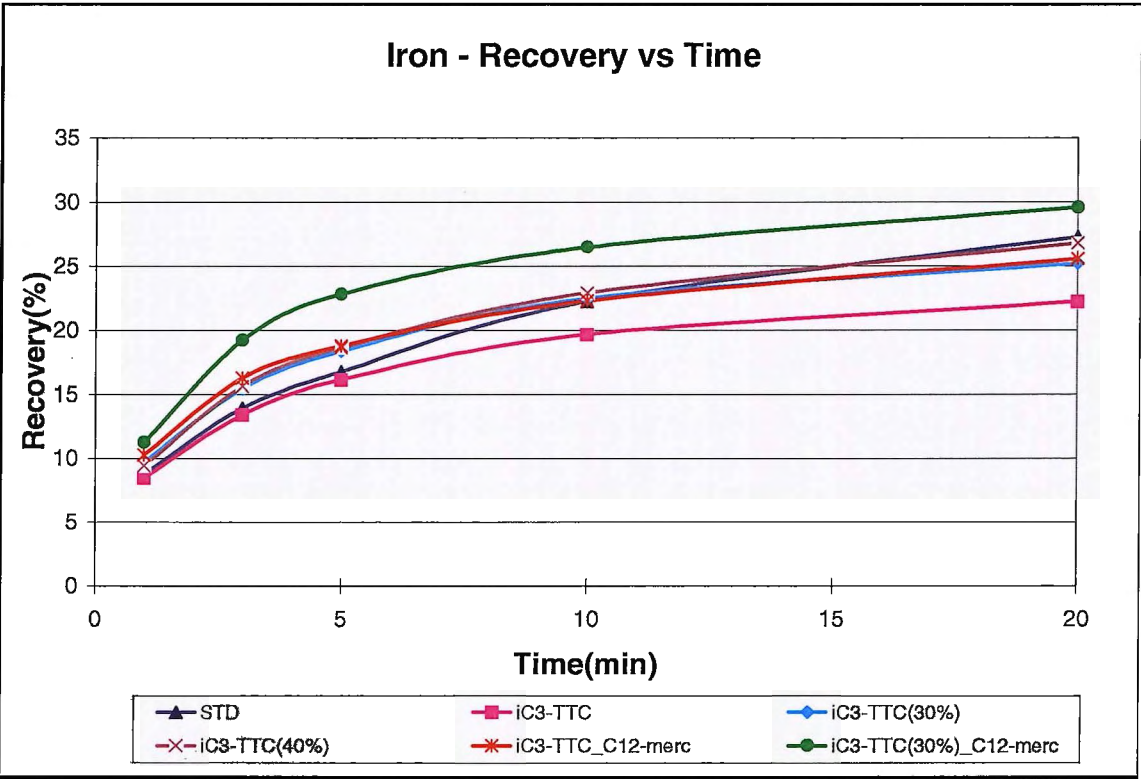


Figure C1.5 Iron recovery vs time

2 Metallurgical results - Tables

Table C1. Sulphur results of batch floats at UCT

Sulphur					
Collector	Mass	Recovery	Rate	Grade	Water
	(g)	(%)	(/min)	(%)	(g)
STD	110.32	99.70	2.05	3.51	919.59
iC ₃ -TTC	84.00	99.17	2.10	4.55	524.93
iC ₃ -TTC(30%)	86.87	99.05	2.02	4.44	510.45
iC ₃ -TTC(40%)	87.16	99.33	2.04	4.44	473.75
iC ₃ -TTC_C ₁₂ -merc	86.71	99.15	2.11	4.37	504.95
iC ₃ -TTC(30%)_C ₁₂ -merc	100.37	99.28	2.04	3.76	673.99

Table C2. Copper results of batch floats at UCT

Copper					
Collector	Mass	Recovery	Rate	Grade	Water
	(g)	(%)	(/min)	(%)	(g)
STD	110.32	63.72	4.43	0.67	919.59
iC ₃ -TTC	84.00	60.95	5.75	0.83	524.93
iC ₃ -TTC(30%)	86.87	59.15	4.26	0.79	510.45
iC ₃ -TTC(40%)	87.16	59.95	3.37	0.83	473.75
iC ₃ -TTC_C ₁₂ -merc	86.71	58.77	5.28	0.79	504.95
iC ₃ -TTC(30%)_C ₁₂ -merc	100.37	57.73	4.03	0.68	673.99

Table C3. Iron results of batch floats at UCT

	Iron				
Collector	Mass	Recovery	Rate	Grade	Water
	(g)	(%)	(/min)	(%)	(g)
STD	110.32	27.27	0.49	8.75	919.59
IC ₃ -TTC	84.00	22.24	0.78	9.40	524.93
IC ₃ -TTC(30%)	86.87	25.19	0.80	10.06	510.45
IC ₃ -TTC(40%)	87.16	26.78	0.84	10.13	473.75
IC ₃ -TTC_C ₁₂ -merc	86.71	25.56	0.90	9.80	504.95
IC ₃ -TTC(30%)_C ₁₂ -merc	100.37	29.55	0.88	9.43	673.99

Table C4. Nickel results of batch floats at UCT

	Nickel				
Collector	Mass	Recovery	Rate	Grade	Water
	(g)	(%)	(/min)	(%)	(g)
STD	110.32	65.44	2.34	1.23	919.59
iC ₃ -TTC	84.00	60.37	1.71	1.41	524.93
iC ₃ -TTC(30%)	86.87	64.76	1.71	1.60	510.45
iC ₃ -TTC(40%)	87.16	66.78	1.92	1.62	473.75
iC ₃ -TTC_C ₁₂ -merc	86.71	65.06	2.04	1.63	504.95
iC ₃ -TTC(30%)_C ₁₂ -merc	100.37	67.74	1.82	1.41	673.99

Appendix D Operating procedure of continuous 60 liter cell

1. Open valve at inlet to tank (above conical section).
2. Close valve under conical section.
3. Open valve at cyclone overflow 8 half turns.
4. Allow all water in pipe to flow back to surge tank.
5. Open valve under conical section slightly.
6. Start CuSO₄ pump.
7. Take feed sample from under conical section and measure SG.
8. Adjust CuSO₄ dosage according to graphs to match SG.
9. Once tank is full enough, switch on impeller motor.
10. When tank 1 overflows into tank 2, start SIBX pump.
11. Continue with tank 2 and tank 3 as with tank 1 from 8 to 10.
12. Begin pumping from tank 3 to float cell when level in tank 3 gets to 100 liter.
13. Control level in tank 3 by opening and closing valve under conical section to keep flow through circuit at 10l per minute.
14. Continuously monitor flow into third tank to ensure that flow through circuit is constant at 10l per minute.

15. Allow circuit to run in this manner for at least 60 minutes. If it appears that a steady state has not been achieved yet, continue until the circuit is running steadily.
 16. Begin sampling concentrates and tails of 60 liter cell. Take a sample at approximately 3 minute intervals for at least 30 minutes or until sufficient sample has been gathered.
 17. Take sample of head with all reagents in (if it is desired to perform batch flotation tests on the samples in the laboratory).
 18. Switch off the air to the cell.
 19. Close the valve under the conical section.
 20. Pump slurry out of tanks 2 and 3, moving the pump hose further and further into the tank and switching off the stirrer when the level is sufficiently low.
 21. Move the pump and empty tank 1 in a similar fashion.
 22. Close cyclone overflow valve and wait for the line to drain slightly.
 23. Move connection to water line and flush feed pipe immediately.
 24. Once all slurry has been cleaned from the line, open valve under conical section again and allow tank to fill slightly with water. Pump the water out to clean pump.
 25. Take samples of concentrate, tails and feed to laboratory.
 26. If no batch flotation is desired, weigh, filter, and dry samples and send to Rustenburg laboratory for PGM, Cr_2O_3 , Ni and Cu.
- If batch flotation is required, continue with sample as per standard batch flotation procedure in 3l Leeds cell or 8l Denver cell.

Appendix E Viscosity of TTC suspension

Various concentrations of iC₃-TTC powder in the solvent were made up, and their viscosities were measured. Selection of dosing equipment, especially pumps could be assisted with viscosity shear relationships.

1. Materials and methods

The Brookfield viscometer was used to measure the viscosity's of different concentrations of SX12-emulsion/ TTC mixtures at 25 C. The aim was to measure their viscosities at different spindle speeds to determine the properties of the emulsion.

Standard procedure is to record torsion readings at different spindle speeds. At 4RPM it usually takes 20-30 seconds to stabilise, and at lower speeds it takes one revolution of the dial. The viscosity of the material can then be obtained from the Factor Finder supplied with the meter. The temperature was controlled in a water bath.

2. Results

The different viscosities of the emulsions at 3 RPM gave the best results for low shear rate values. The viscosity of the emulsions at 3 RPM is reported in Table E1 and figure E1.

Table E1 Viscosity at different TTC concentrations

TTC powder in emulsion	Viscosity
%	cP
0	3280
10	3000
20	3600
30	5600
35	8640
40	13880
45	23200
50	36600

A viscosity increase occurred with increasing solids in emulsion up to 50% solids. Beyond 35% solids the material was not readily pumpable in a piston pump.

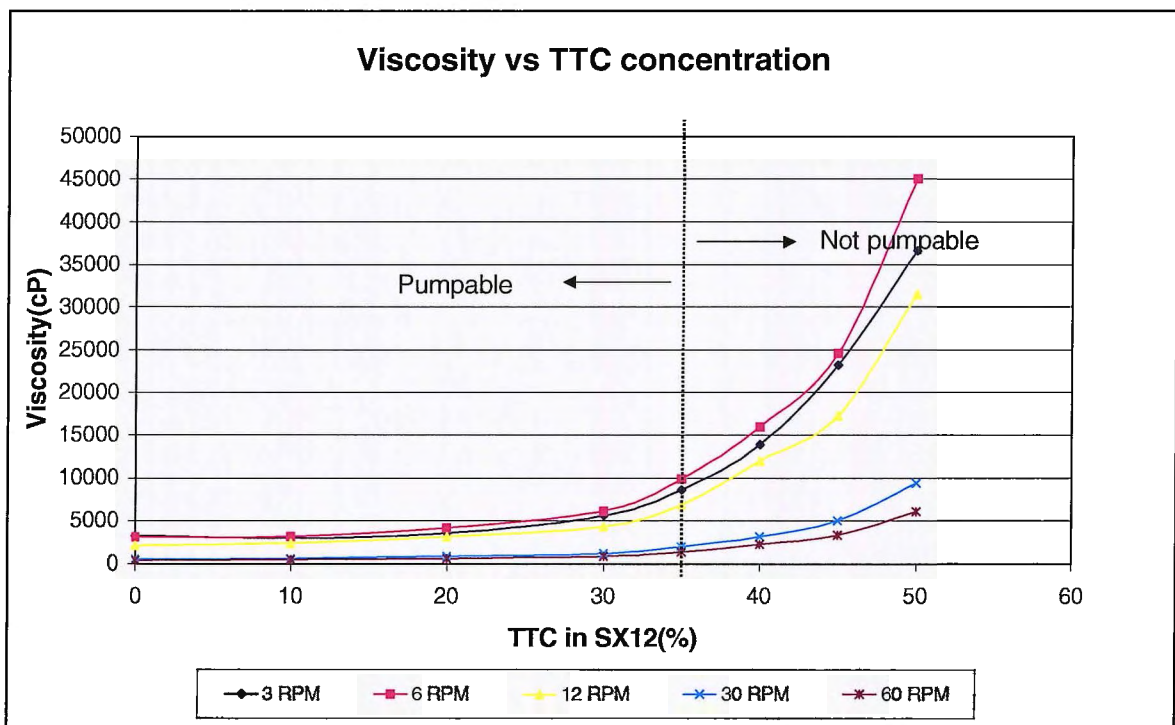


Figure E1 Viscosity vs. TTC % for various speed levels

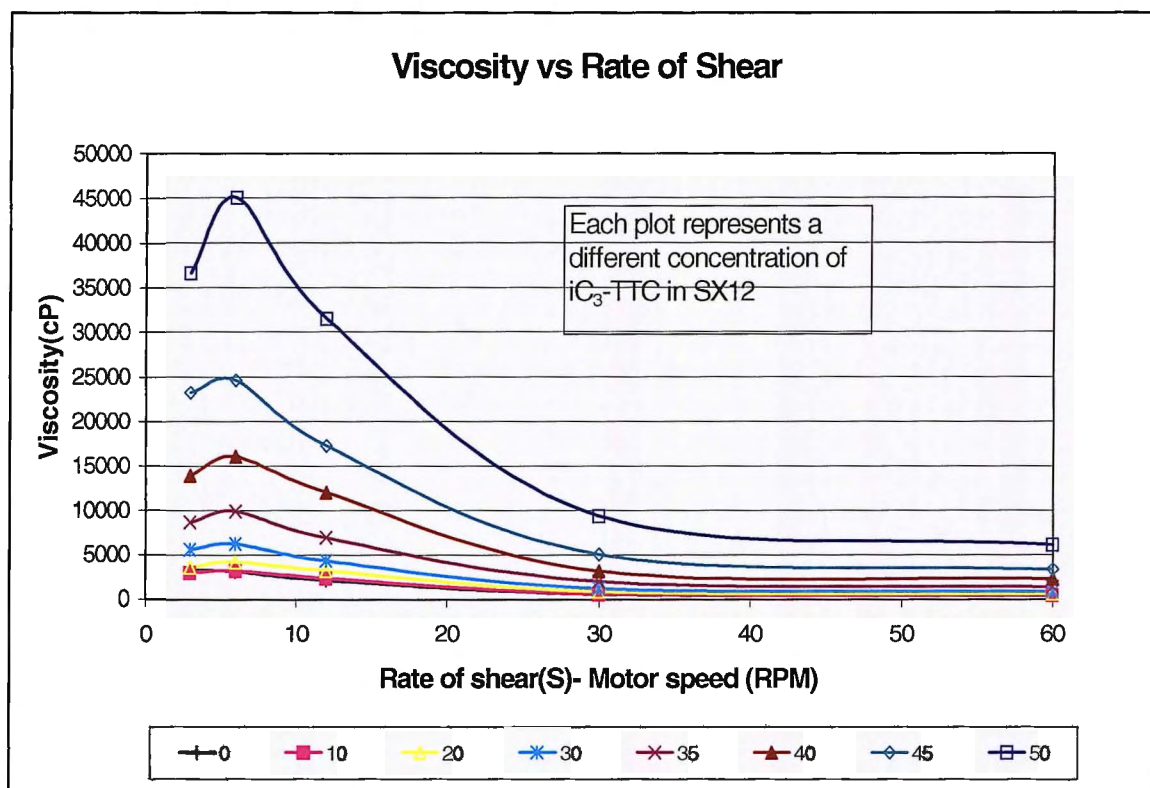


Figure E2 Viscosity vs. rate of shear

If one assumes that rate of shear and RPM is the same we can plot viscosity versus rate of Shear (S). From this we can determine the group of liquid to which this emulsion belongs. The emulsion has typical pseudo-plastic properties.

The effect of shear rate on viscosity is more pronounced the higher the solids content. At 35% solids as much as a threefold decrease in viscosity is noted as shear rate increases. This would be useful in pump and transfer selection.

Appendix F Decomposition of collectors

From the odour observations, hydrolysis of iC_3 -TTC is believed to be fast and the sodium-salt among others decomposes to the reagents (caustic soda, CS_2 and mercaptan) used. Decomposition tests to determine the half-life times of these collectors are therefore needed. These results could also help identify the decomposition products of the different chemicals.

The project goal was to investigate the decomposition of some sulphydryl collectors by measuring half-life times. Decomposition products and solubilities of salts were determined, to evaluate the stability of the collectors in solution and at the mineral surface. A principal objective here was to determine whether the different TTC collectors would be safe to use in the flotation circuits. Particular emphasis was on hazardous gases such as H_2S and CS_2 as possible decomposition products at alkaline and mild acid concentrations.

1 Materials and methods

An ultraviolet spectrophotometer was used to measure the absorbency of the collector in water at different times to establish comparative rates of decomposition at $25^\circ C$.

2 Experimental

The collectors were prepared in buffer solutions at pH values of six and nine. Their decomposition was measured in nitrogen and air saturated solutions. The solutions were kept at a constant temperature of 25°C in a water bath, which could be controlled to within 0.5°C. The buffer solutions were made up of analytical reagents and distilled water. Borax and hydrochloric acid were used to attain the different pH values.

For decomposition tests in nitrogen, 200ml aliquots of each solution (5ppm) were transferred to a 250ml Pyrex bottle, which was placed in the water bath. Nitrogen, saturated with water vapour was bubbled through the solution for one minute to remove the oxygen. According to Harris (1998) this would be sufficient to remove the oxygen and therefore no measurements were made. A by-pass valve was then opened to maintain a nitrogen blanket. Figure F.1 shows the apparatus used for decomposition work.

Absorbency was monitored by extracting a 5 ml sample of solution and then analysing in the UV spectrophotometer. The concentration of the collector remaining in solution was determined from absorbance peakheights (Harris, 1984), measured at different wavelengths for the different collectors.

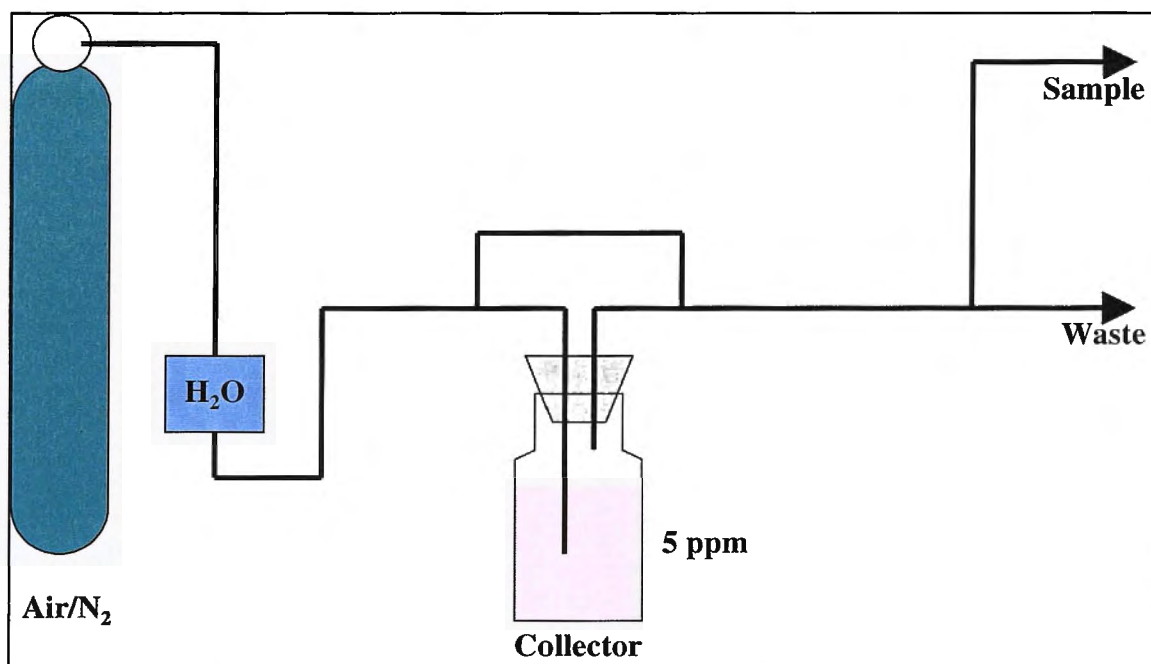


Figure F.1 Decomposition and solubility product apparatus

The absorbance peak was measured after 0,5,10, 30, 60, 120, 180 minutes. These measurements took 4 minutes for each sample and this was included in the sampling times. The time needed to reach half the original peak height at a fixed wavelength was used as the half-life time of the collectors.

3 Results and discussion

3.1 Half-life times

The absolute values for the C₁₂-Mercaptan and covalent collector (iC₃/iC₄-TTC) peaks fluctuated. This could have resulted from their low solubility in water.

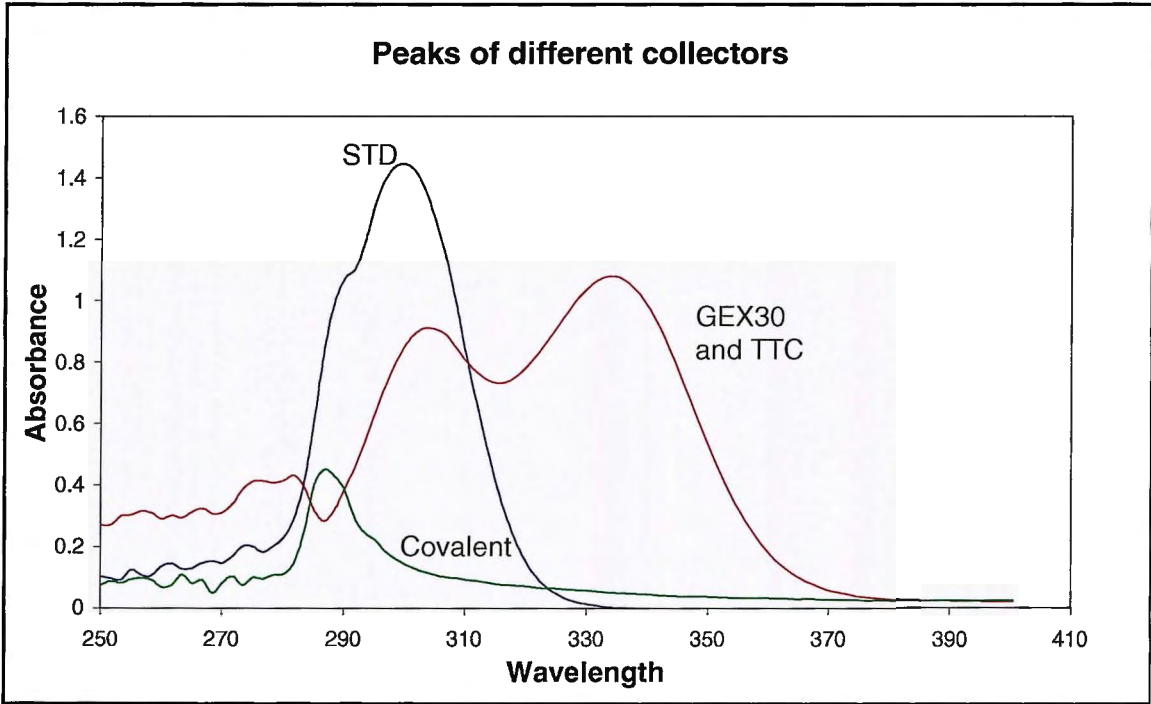


Figure F.2 Absorbance peaks of collectors

The half-life time for SIBX varied form 63 to 1173 hours at pH levels of nine to six at 25°C. The results for the SIBX were extrapolated to longer times since the longest tests were run for 24 hours, which was not sufficient to measure the half-lives of the standard collector directly. The half-life of isobutyl xanthate varies from 0.9 - 1187 min at pH levels of 4 to 9 respectively at 25°C (Harris, 1984).

Table F.1 Half-life times for different pH and gases.

Collector	Half life time (min)			
	pH 6		pH 9	
	N ₂	Air	N ₂	Air
SIBX	81.5hr	63.2hr	1172hr	1193hr
iC ₃ -TTC	25	36	40	63
GEX30	52	40	58	40

The half-life time of TTC is a lot lower than that of the Xanthates. From Table F.1 one can see that for all conditions the TTC half-life times at this dilution and pH are between 30 and 60 minutes. The TTC is more stable in air and higher pH levels. SIBX is more sensitive to pH differences than the TTC's. The medium used for these tests does not have a great effect on the standard collector at pH 9, which was not true for the lower pH level. Comparison between the TTC collector as a salt or dosed in an emulsion suggests that the emulsion protected the collector ions in solutions. The pH levels did not change the properties of the emulsion. It is important to note that these tests were conducted at low concentrations (5ppm), and according to Harris (1984) this could have an effect on these results.

3.2 Toxic gases

Previous work by Harris (1984) showed that CS_2 gas is a common decomposition product of most collectors and is very toxic and odourless. With the decomposition of xanthates, the product, an alcohol has no smell, but with TTC's the mercaptan is readily detected without any instrumentation.

H_2S levels were measured for all the decomposition tests by taking gas samples above the reactor. Every five minutes a gas sample was extracted from the decomposition experiments and analysed for H_2S levels with unknown apparatus. No H_2S traces were found at these pH levels. The conclusion is that TTC collectors will not be more dangerous than the other chemicals used and could also help as warning sign of CS_2 generation.

Appendix G Electrochemical measurements

Mineral potential measurements during the conditioning times of each flotation test may help to describe the mechanism of the different collectors reacting with each mineral.

No data on TTC electrochemical reaction is available in the literature. Although it was not possible to analyse any reaction products, changes in potentials during collector adsorption onto pyrrhotite, pentlandite, chalcopyrite and pyrite against a Ag/AgCl reference electrode were measured. In addition to the specially prepared mineral electrodes the potential of a platinum electrode was also logged.

Reactions occurring at the mineral/solution interface are controlled by the potential across this interface. In flotation environments non-equilibrium conditions exist and as such a mixed potential is set up at the interface. At the mixed potential the total current due to oxidation equals that due to reduction.

Due to thermodynamic considerations the mixed potential of the mineral/solution interface will control what reactions are possible at the interface. For instance the oxidation of a specific ion is not possible below the equilibrium potential for this reaction. Thus a knowledge of the mixed potential of the various minerals during flotation gives an important indication of what reactions are possible and what the stable species will be on the surface of the mineral.

Trithiocarbonates (TTC's) are novel flotation collectors with a molecular structure similar to classical thiol collectors except that the oxygen in the thiol molecule is replaced with sulphur. It is indicated that this should result in stronger adsorption of the TTC molecule to the mineral surface than the classical thiol molecule. It is not known whether any

mechanistic studies have been conducted on TTC's. Due to the similarities of the TTC molecule with thiols an electrochemical mechanism may still be relevant. It was decided to measure the mixed potential of the minerals in aqueous solution and during flotation as an initial step in probing the mechanism of TTC adsorption.

1 Buffered aqueous solutions

1.1 Materials and methods

Three collectors, iC_3 -TTC, iC_3 - iC_4 -ester and SIBX (standard) were compared in aqueous solutions under nitrogen and air.

0.05 Mole disodium tetraborate (borax) was added to water to buffer the solution at pH 9. The mineral probes were placed in the buffered solutions and collectors were added after 100 seconds. The collectors were dosed to be equimolar (60g/ton SIBX). The potentials of all electrodes were logged during the experiments to a PC via an Adam-4017 8-channel analog to digital converter module and an Adam-4520 RS-232 to RS-422/485 module. Computer code was written in Basic to control the modules, which operates on a simple command set via the RS 232 port (COM1). The 8 channels were sampled every two seconds and the data stored in a ASCII text file.

A TPS meter was used to log temperature, dissolved oxygen, pH and redox potential (Eh). The redox potential was measured with a Metrohm platinum electrode against a Metrohm silver/silver chloride reference electrode. Four probes were simultaneously immersed into the liquid. Collector was added and potentials were then logged. Figure F4 shows the experimental set-up. Before each test it is necessary to grind the surface of the mineral probes in order to expose a non-oxidised surface. This was done by

rubbing the mineral surface on 600 μ m emery paper and washing the paper with distilled water.

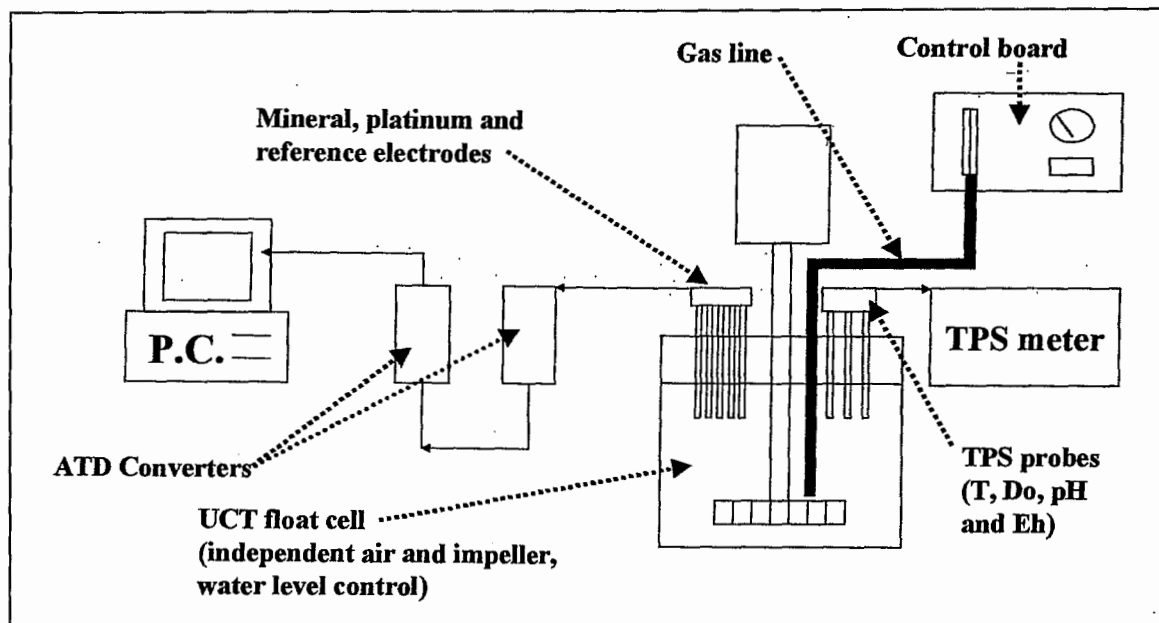


Figure G.1. Schematic of experimental set-up (Buswell, 1998)

1.2 Results and discussion

1.2.1 Ionic collectors in solution

1.2.1.1 Pyrrhotite probe

Potential versus time curves for pyrrhotite in the presence of nitrogen and air are given in figure F.4. Buswell (1998) reported that to convert the reference electrode to the standard hydrogen scale one must add 0.207V to the measured results. The standard that is used in this section is SIBX collector.

Xanthates need oxygen to form dixanthogen, but it is not known what happens with the TTC's when they interact with the different mineral surfaces. The initial potentials in air

were higher than in nitrogen and this probably is due to surface oxidation. Oxygen reduction means higher potentials.

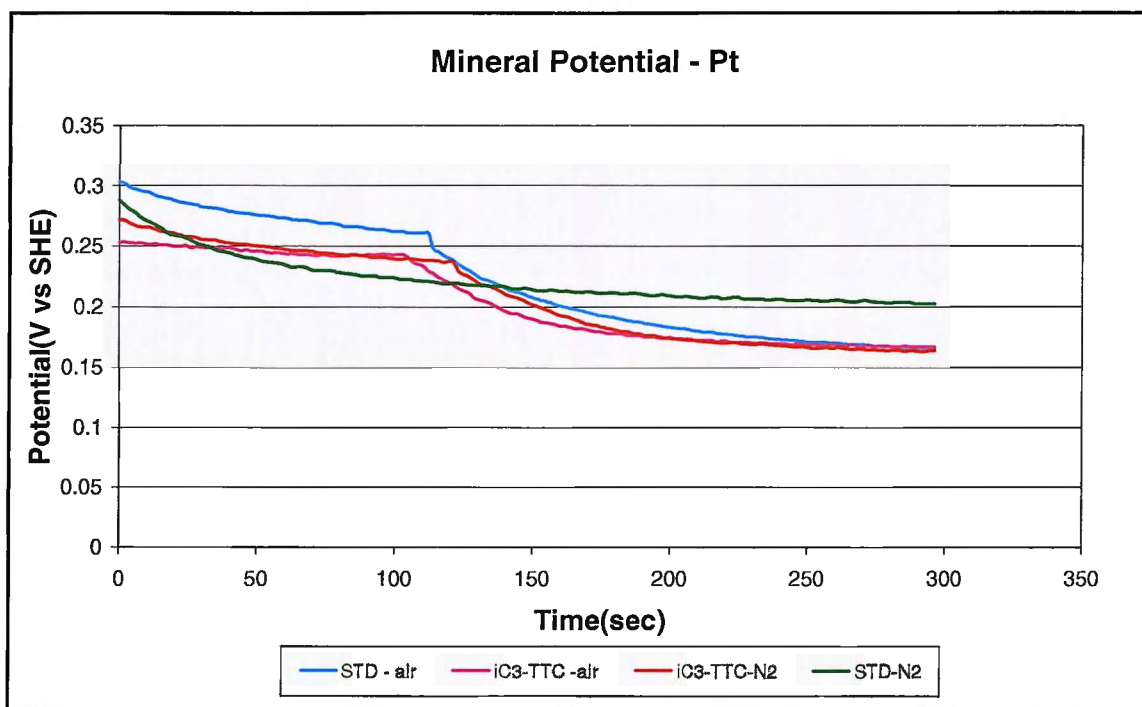


Figure G.2. Mineral potentials of platinum in aqueous solution

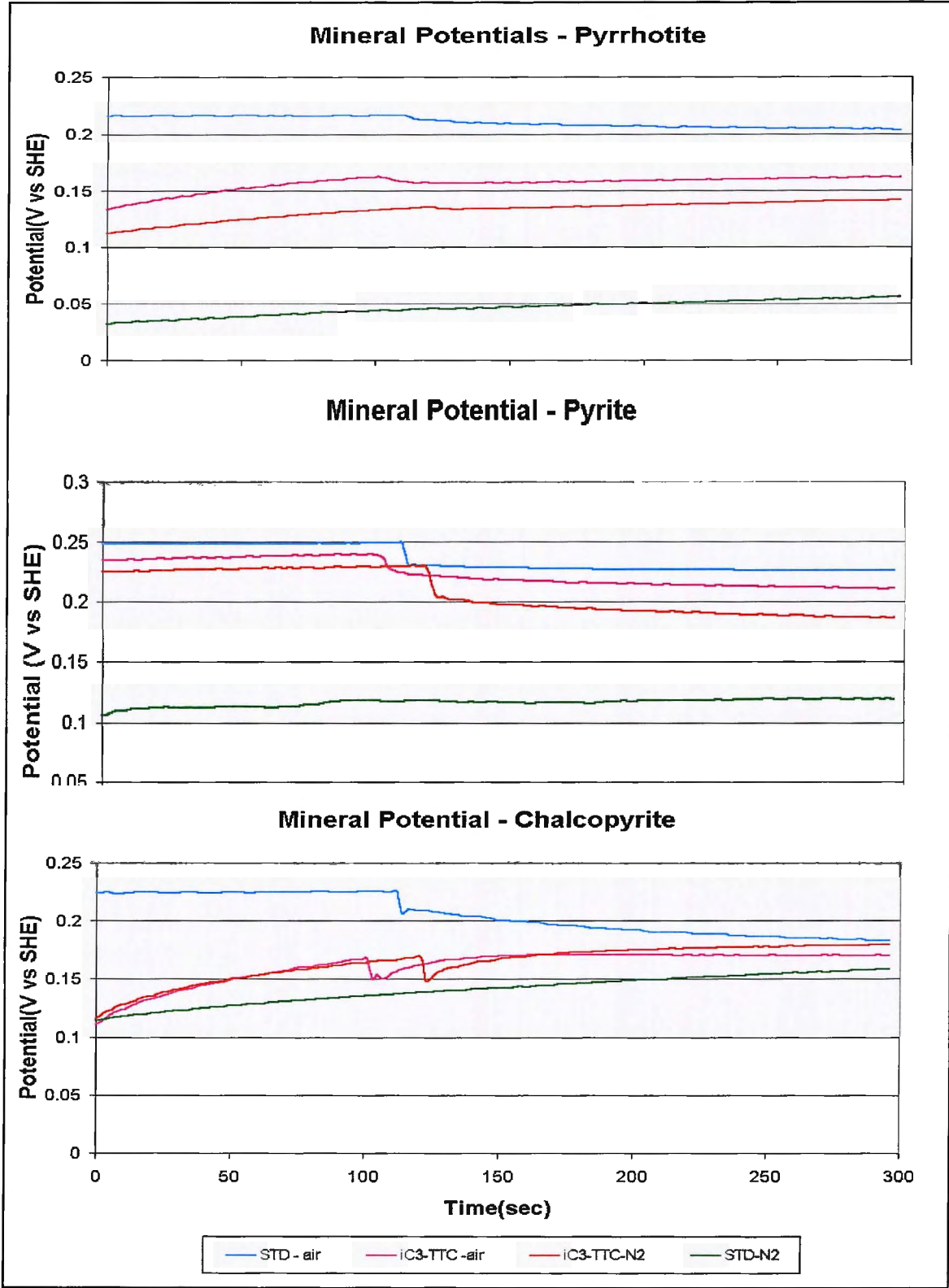


Figure G.3 Mineral potentials for different minerals in aqueous solution

1.2.1.2 Pyrite probe

The data in figure F.4 for the pyrite system is similar to that of pyrrhotite, the only exception being that the TTC interaction with the mineral probe resulted in a much more distinct and significant potential drop.

1.2.1.3 Chalcopyrite probe

From figure F.4 one has to conclude that again the interactions are the same and the total absence of potential drop of DTC's in nitrogen is observed.

1.2.2 Covalent collector

The covalent iC_3/iC_4 -TTC is an oxidised form of ionic iC_3 -TTC and iC_4 -TTC. Any adsorption onto a surface would entail physical bonding only.

In figure F.5 the potential time curves also show no potential drop after the addition of the collector.

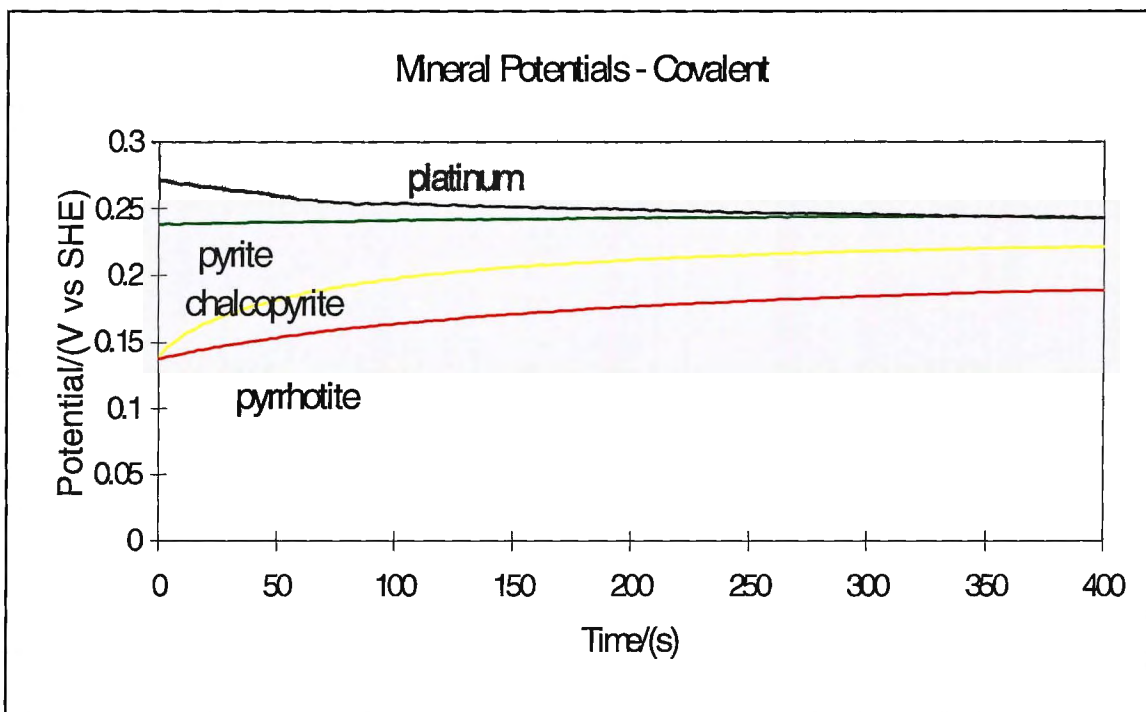


Figure G.4 Mineral potentials of covalent collectors

2 Mineral Potentials in batch floats

2.1 Materials and methods

The mineral potential measurements were done during the conditioning time of the floatation experiments. The same experimental procedure was used as discussed in section 3.1.

Six collectors were chosen for evaluation on Merensky ore. The new solvent with iC_3 -TTC suspended was used to dose the chemical as an emulsion. Two concentrations of 30 and 40% emulsions were used. Combinations of covalent collectors, long chain mercaptans and iC_3 -TTC were compared to the standard collector suite (SIBX/DTP). The collector suites were tested in duplicate. The mineral potentials were measured

during the conditioning time of the float tests and the mineral probes were then removed for the scraping of the froth.

The method was to place the respective probes in the pulp used for batch flotation. After conditioning for 120 seconds, copper sulphate (60g/ton) was added. The potential change was recorded continuously. After a further 300 seconds the collector (equimolar to 60g/ton iC_3 -TTC) was added.

2.3 Results and discussion

Copper sulphate addition invariably resulted in an increase in the electrochemical potential. This can be expected for divalent cation adsorption, which would increase the surface potential when the positive surface charge density is increased.

After addition of collectors a potential drop was always observed. However, with TTC's on pyrrhotite, pentlandite and chalcopyrite there was always a two-step drop in potential, irrespective of whether the solvent was present or not. No explanation for this is offered other than the possibility of secondary adsorption of possible reaction products formed during primary adsorption.

An exception to the double step with TTC's is when a C_{12} -mercaptan is present. In these cases it appears that a secondary surface reaction is absent. Perhaps the mercaptan is strongly adsorbed and competes for adsorption sites that may have interacted with reaction products of the TTC's when mercaptan was absent. However, no clear explanation can be forwarded at this point.

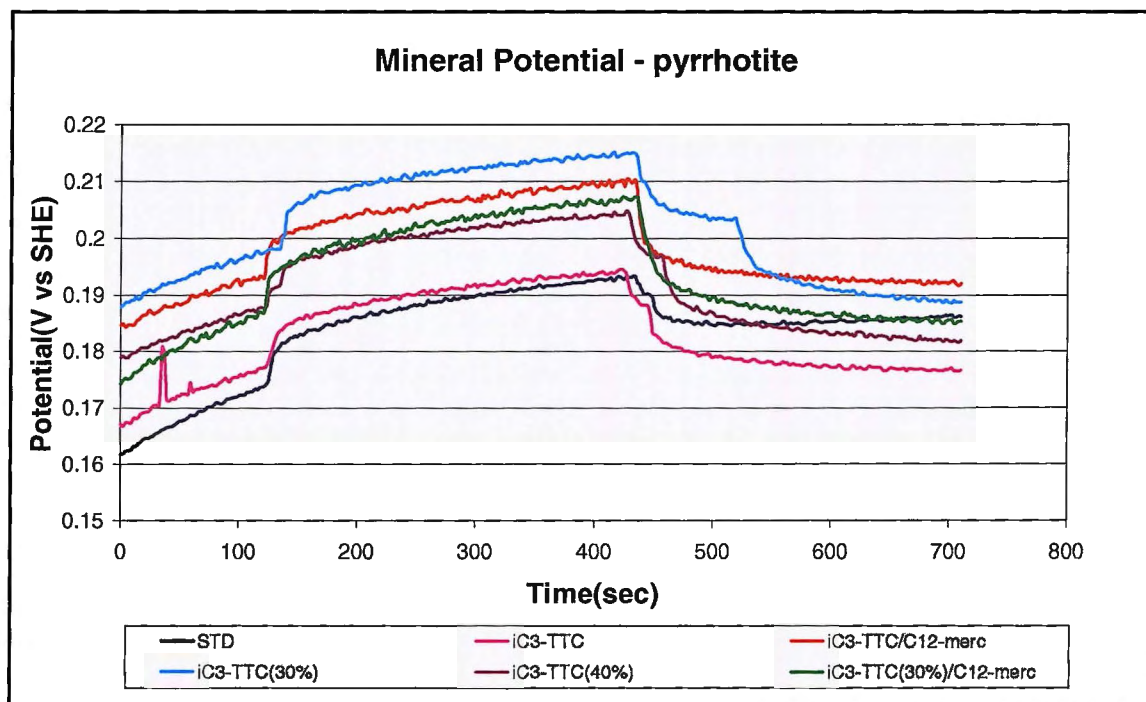


Figure G.5 Mineral potential of pyrrhotite in flotation system

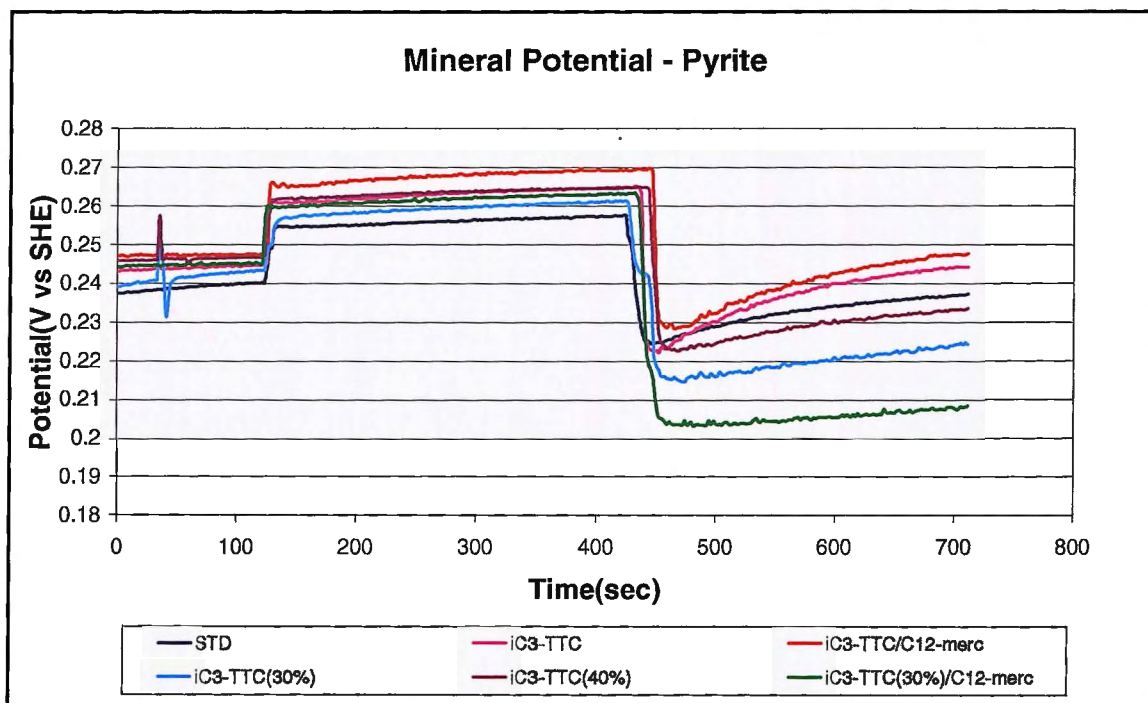


Figure G.6 Mineral potential of pyrite in flotation system

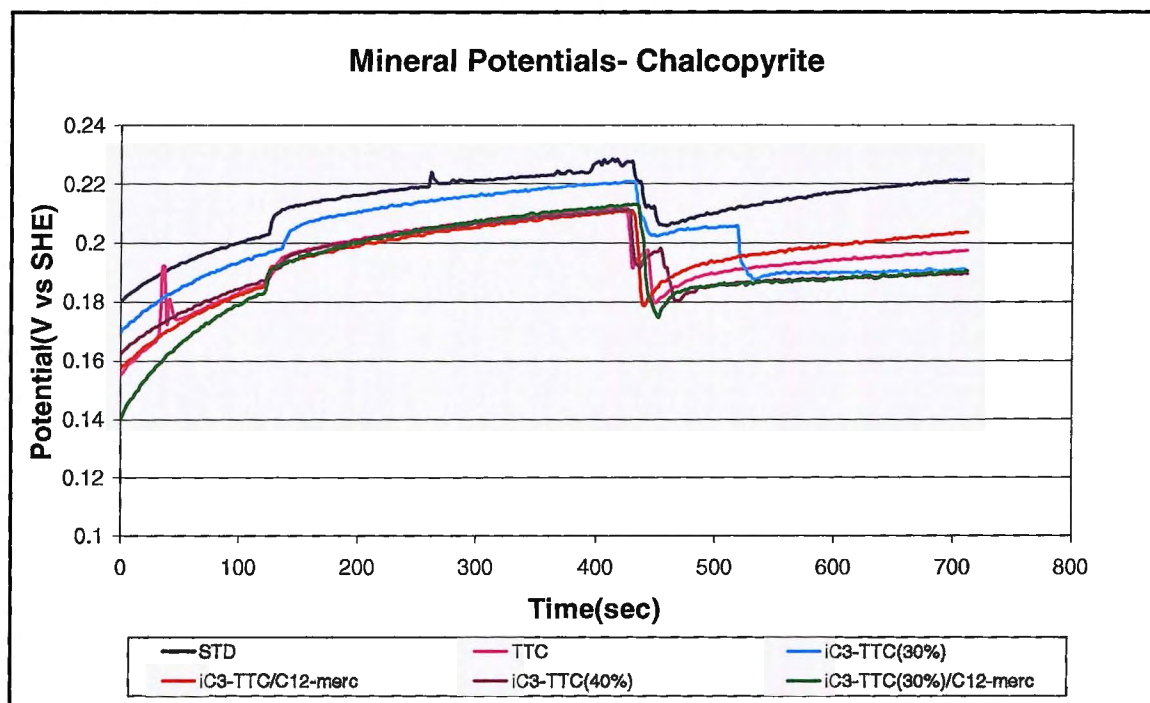


Figure G.7 Mineral potential of chalcopyrite in flotation system

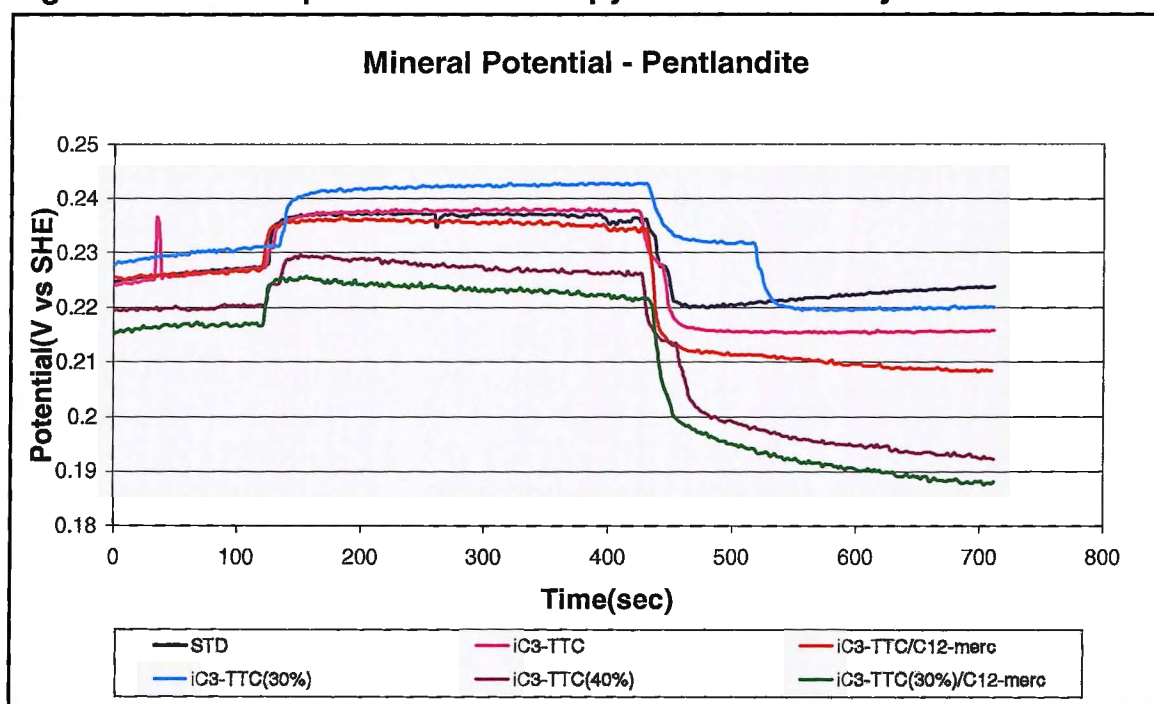


Figure G.8 Mineral potential of pentlandite in flotation system

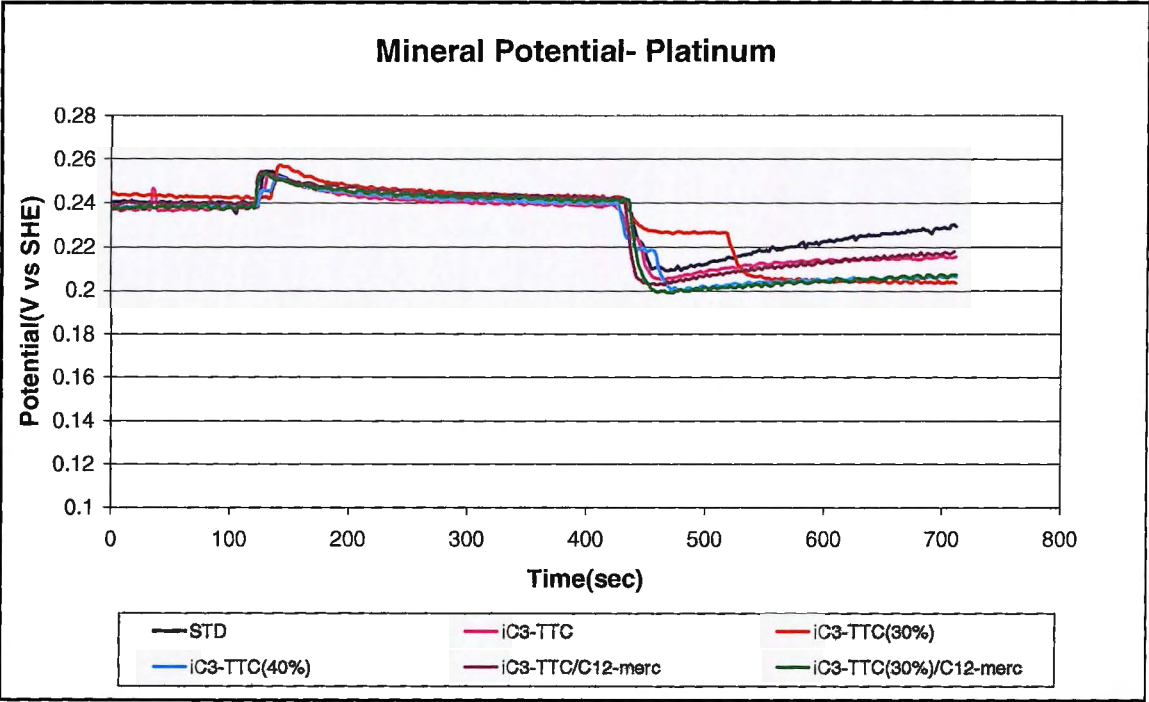


Figure G.9 Mineral potential of platinum as reference electrode in flotation system