
CHAPTER 3

MATERIALS AND METHODS

3.1 Materials**3.1.1 Ore**

The auriferous pyrite ore samples used in this study were collected from the feed stream to the flotation circuit at No. 2 Gold Plant at Vaal Reefs. The feed consists of a de-slimed mixture of cyanide leach tailings from two circuits, one treating reclaimed tailings from West Pay Dam and the other, run-of-mine ore from Kopanang Mine. The latter treats feed augmented with reclaimed dump material as well. After filtration and drying at 60°C, about 350kg of the bulk feed sample collected was screened through an 850µm screen; thoroughly mixed and divided first into 50kg batches, and then down to 2kg samples. To avoid dust losses, the cone and quartering technique was used throughout.

Typical mineralogical composition of the feed is shown in Table 3.1 and was determined using X-Ray Diffraction Spectrometry. The accompanying XRD pattern is shown in Figure 2.1

Table 3.1 *Typical minerals found in No. 2 Gold Plant Feed*

Mineral	Chemical Formula
Quartz	SiO ₂
Pyrophyllite	Al ₂ Si ₄ O ₁₀ (OH) ₂
Clinocllore	(Mg,Fe) ₆ (Si,Al) ₄ O ₁₀ (OH) ₈
Muscovite	(K,Na)(Al,Mg,Fe) ₂ (Si _{3.1} Al _{0.9})O ₁₀ (OH) ₂
Hematite	Fe ₂ O ₃
Pyrite (Cubic)	FeS ₂
Gypsum	CaSO ₄ .2H ₂ O

Typical chemical composition of the material is shown in Table 3.2. The gold content was assessed using fire assay while a sequential XRF spectrometer ARL 9400-241 XP+ was used for determining the concentrations of the other constituents. Particle size distribution (Figure 3.1) was determined using a Malvern Mastersizer 2000 instrument.

Table 3.2 Typical chemical composition of the bulk ore sample used in this study

	Composition								
	%					ppm			
Element	Si	Ca	Fe	S	Zr	Au	Pb	U ₃ O ₈	Zn
Content	39.62	0.46	3.06	1.03	0.03	0.4	109	140	213

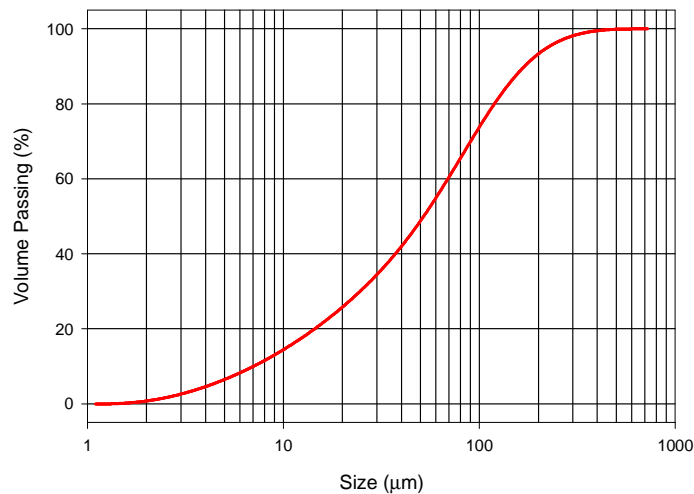


Figure 3.1 Typical particle size distribution of ore samples treated in this investigation.

3.1.2 Reagents

The pH was adjusted by adding either reagent grade sulphuric acid or analytical grade caustic soda. GEMPOLYM GM4, a guar based depressant was used for depressing pyrophyllite present in the feed and Dowfroth 200 was used as the frother. The three collectors (Table 3.3) tested in this work were sodium *iso*-butyl xanthate, C₁₀ and C₁₂ trithiocarbonate (TTC). Copper sulphate and lead nitrate and sodium cyanide were used as modifiers. All reagents were dosed from 1% wt solutions. Tap water was used in all the experiments.

Table 3.3 *Collectors used in the study*

Name	Abbreviation	Chemical Formula	Molecular Weight (a. m. u)
Sodium <i>iso</i> -butyl xanthate	SIBX	C ₄ H ₉ OCS ₂ Na	172
Sodium <i>n</i> -decyl trithiocarbonate	C ₁₀ TTC	C ₁₀ H ₂₁ SCS ₂ Na	272
Sodium <i>n</i> -dodecyl trithiocarbonate	C ₁₂ TTC	C ₁₂ H ₂₅ SCS ₂ Na	300

3.1.3 Apparatus

A Denver D12 flotation machine (Figure 3.2) fitted with either a 5L or 10L cell was used for all the batch flotation experiments. The machine was run at 1200rpm and 1500rpm for the 5L and 10L cells respectively. The pH was monitored using an Orion pH meter-model 420.

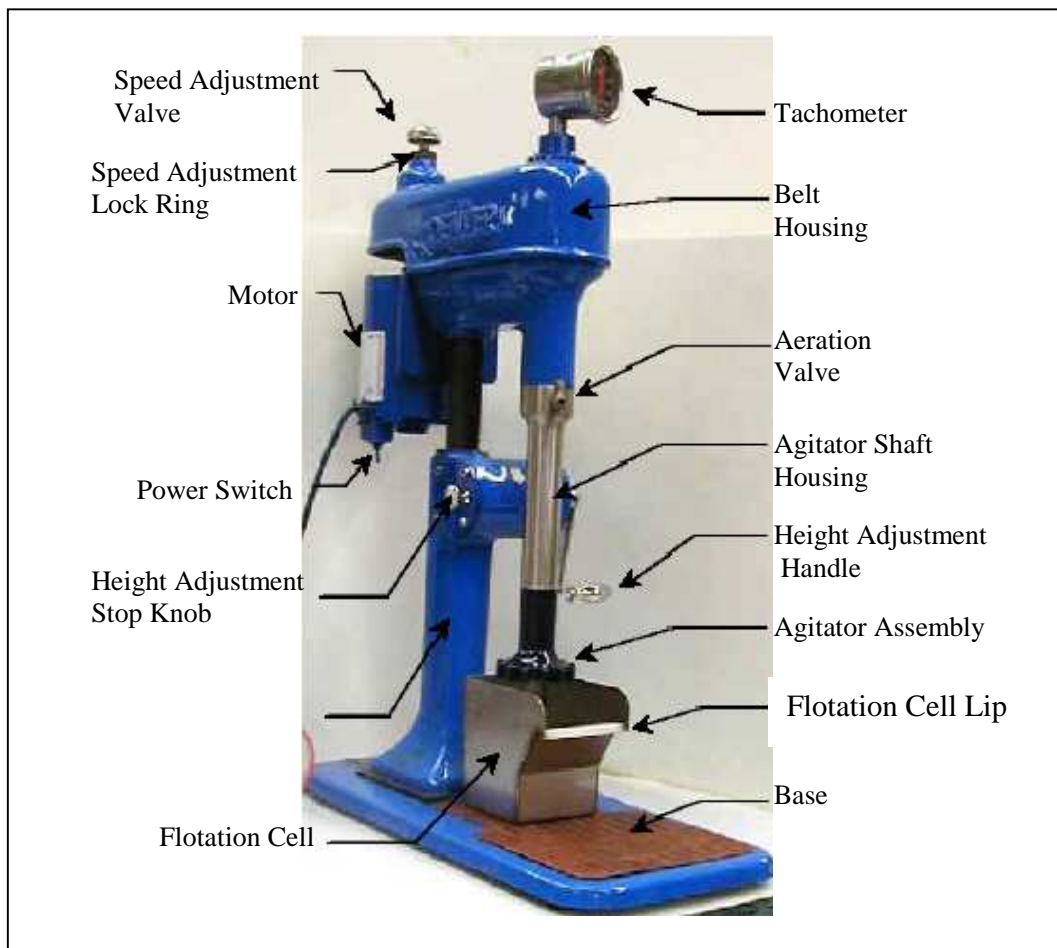


Figure 3.2 A Denver-D12 laboratory flotation machine fitted with a flotation cell

3.2 Methods

3.2.1 Single-Point Flotation Tests

Batch flotation tests were used to firstly establish the optimum SIBX dosage (called the standard) by studying the effect of SIBX dosage level; and to evaluate the effect of SIBX/TTC mixtures on gold, pyrite and uranium flotation.

A 2kg sample of dried plant feed was mixed with 3kg of water in a 5-litre flotation cell to give a pulp of 40% wt solids at a natural pH of 7.8. This was conditioned at 1200 rpm for 1 minute to ensure homogenous slurry before any reagents were added. Firstly copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) was dosed at 70g/t and the pulp conditioned for 5 minutes. This was followed by the collector (SIBX or a mixture of TTC and SIBX) and another 5 minutes of conditioning. The frother (16g/t Dow 200) and lastly the depressant (20g/t GEMPOLYM GM4) was added, each followed by 1 minute of conditioning. Thereafter, the pulp was aerated. Froth was allowed to build up, after which it was scrapped at 15 second intervals for 6 minutes. During the experiment, the pH of the pulp was maintained at 7.2 by adding either sulphuric acid or a caustic solution. Froth height was not controlled. All tests at a given set of conditions were repeated in triplicates.

Concentrates and tailings were filtered, dried at 70°C and weighed. Individual samples were then sent for chemical analysis. Sulphur content was determined using a 114 Series Leco Analyser located within The Department of Materials Science and Metallurgical Engineering at The University of Pretoria. Gold, lead and uranium were assayed by SGS Lakefield Research Africa (Pvt) Ltd in Johannesburg. Gold was analysed by fire assay while lead and uranium were done using XRF

3.2.2 Release Curve Measurements

Release curves were used to compare the standard and the optimum SIBX/TTC mixtures, the effect of acid conditioning prior to flotation and the effect of activating with copper sulphate or lead nitrate in the presence of sodium cyanide.

A dry 4kg ore sample was placed into a 10-litre flotation cell. It was then re-pulped with 6kg of tap water to give a pulp of 40% wt solids. 70g/t of the activator, copper sulphate, was added and conditioned for 5 minutes. From this point onwards, pH was maintained at 7.2 using either sulphuric acid or a caustic solution. The collector (SIBX or combinations with either C₁₀ or C₁₂ TTC) were added and the pulp conditioned for 5 minutes. This was followed by the frother (16g/t) and the depressant (20g/t), each accompanied by 1 minute of conditioning. Air was then introduced into the cell and scrapping of the froth was initiated every 15 seconds. Concentrates were collected after 1, 2, 4, 8 and 20 minutes of flotation. At the end of the each test, the concentrates and tailings were dried and analysed for sulphur, uranium and gold. Experiments were repeated to assure reproducibility and establish the magnitude of statistical error. All experimental data were fitted using empirical first order kinetics outlined by Cullinan et al. (1999) and Agar and Barrett (1983):

$$R = R_{\max} [1 - e^{-kt}] \quad [3.1]$$

Where R (%) is the recovery at time t (min), k (min^{-1}) is the initial rate and R_{\max} (%) is the final recovery. Sigma Plot 2001[®] was used for fitting experimental data and for determining the k and R_{\max} terms in equation 3.1. In the fitting of all the data into this first-order rate equation, an R-squared value was quoted. The closer the value is to 1, the better the data could be described in terms of the model.