METHODOLOGY

A brief schematic diagram for the project test work is presented in Figure 1 and comprises the following main steps: sample collection, sample preparation, chemical characterization, grinding tests and flotation experiments

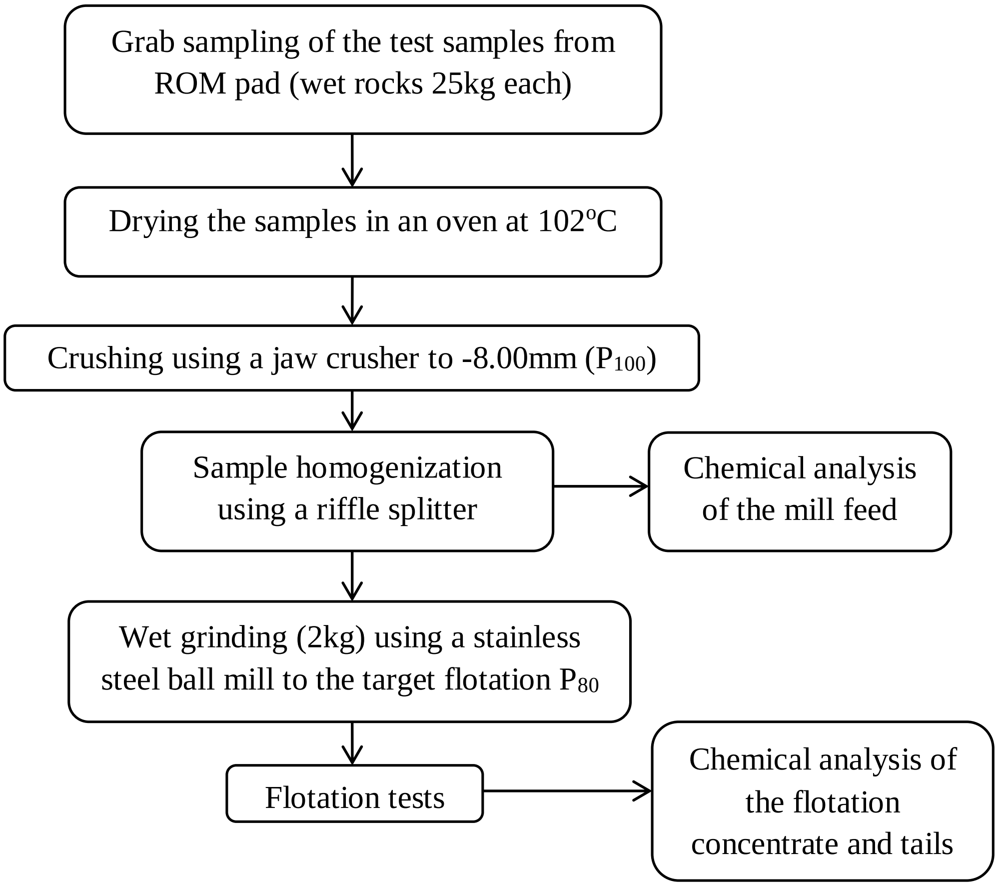

Figure 1: Schematic block-diagram of the project test work

The experimental procedures are described below:

- Grab sampling from the Lower Mine and Upper East ore stockpiles was done at the ROM pad. 25kg samples per each rock sample (wet) were collected into samples buckets.
- The samples were dried in an electric powered oven in the laboratory at a temperature of 105°C so as to avoid decomposing/altering the physical and chemical properties of the ores.
- The ore samples were then crushed to -8.00mm P_{100} in a laboratory jaw crusher.

- Then the samples were homogenized by means of a riffle splitter, and the samples reduced to 2kg which was the mill feed. The mill feed samples were taken for chemical analysis at the SGS laboratory.

- Wet grinding of the ore samples, individually, was then done in a laboratory stainless steel ball mill using steel balls of about 8mm in size at a speed of 15rpm for 20, 60 and 85 minutes respectively so as to establish the grinding time giving -75µm P_{80}. The dilution water used was 1 litre of process water fetched from the flotation plant.

- Thereafter kinetic flotation tests were done on the test samples, as well as the flotation feed in situ, for 30 minutes using a Denver flotation machine. The rotor speed was 1200rpm and airflow rate 5L/min. The pH condition was the natural ore pH, ranging from 8-9. The reagents dosages in the tests was as shown in Table 1. Optimization tests for PAX dosage were also done for the flotation feed at a flotation time of 30 minutes. The PAX dosages were 225g/t, 300g/t, 375g/t and 450g/t. Chemical analysis of the concentrate and tailing products was then done at the SGS laboratory for the analysis of gold, copper and silver by atomic absorption spectrum (AAS) and fire assay (FAA) methods.

Table 1: Table showing the reagent dosages in the flotation tests

Product	**PAX (g/t)**	**Aerophine (g/t)**	**Frother (g/t)**
Flotation feed	300	22	27
Lower Mine Ore	300	22	27
Upper East Ore	600	50	27

RESULTS AND DISCUSSION

The flotation test work for the Lower Mine ore, Upper East ore and flotation (feed in situ) showed that the flotation rate for gold and copper in the first 5 to 10 minutes was fast for both the ores (and flotation feed) giving recoveries of at least 70%. Thereafter the flotation rate decreased to an optimal recoveries of gold around 90%, 88% and 80% for Lower Mine ore, Upper East ore and flotation feed respectively (Figure 2). The recoveries for copper were around 92% and 90% for the Lower Mine ore and the flotation feed respectively (Figure 3). The copper recovery for Upper east ore rose up 87%.

The gold and copper recoveries for Lower Mine ore was high compared to the Upper East ore since the earlier had a high head grade for both gold and copper. Although having a relatively higher grade than the Upper east ore, the composite flotation feed gave a lower gold recovery. This was because the reagent dosages for Upper East ore flotation tests was high (Table 1). This can be attributed to the fact that the Upper East ore contains constituent minerals other than chalcopyrite and pyrite that are high consumers of reagents, such as carbonaceous materials or siliceous gangue minerals like talc.

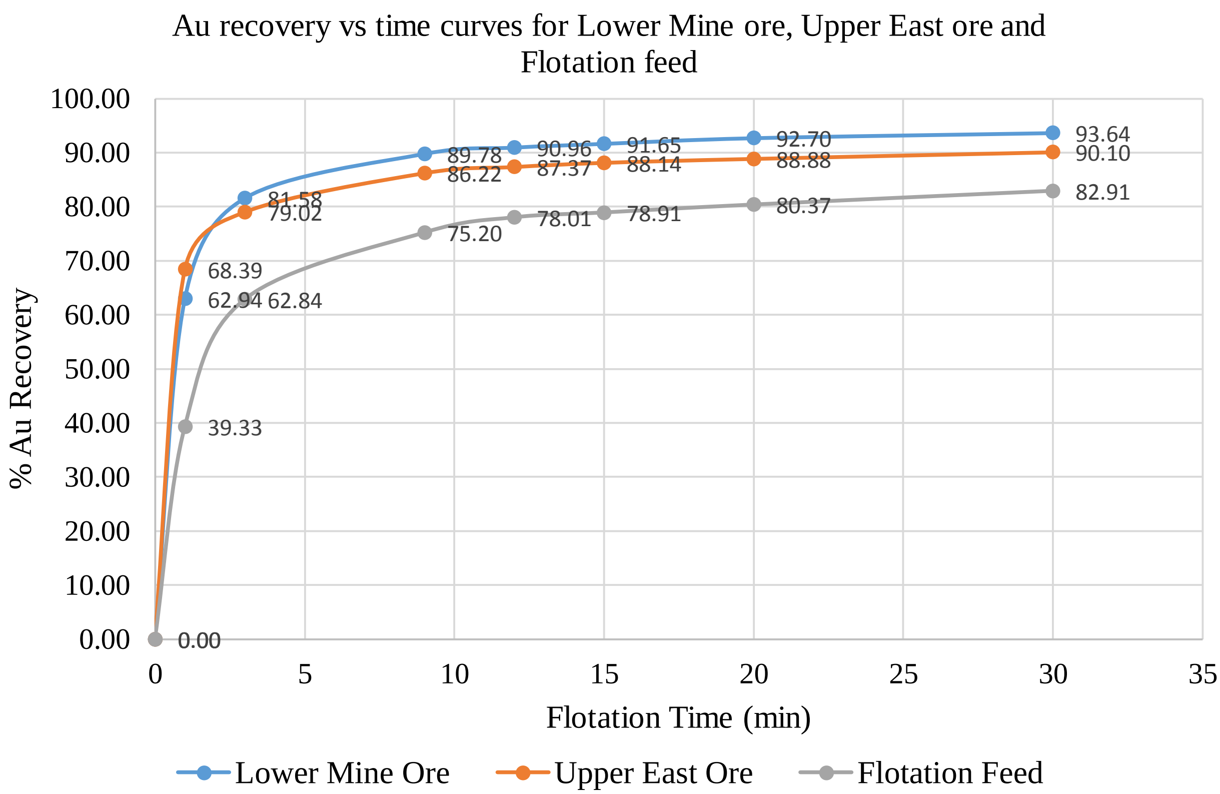

Figure 2: Au Recovery-time curves for lower mine ore, upper east ore and flotation feed

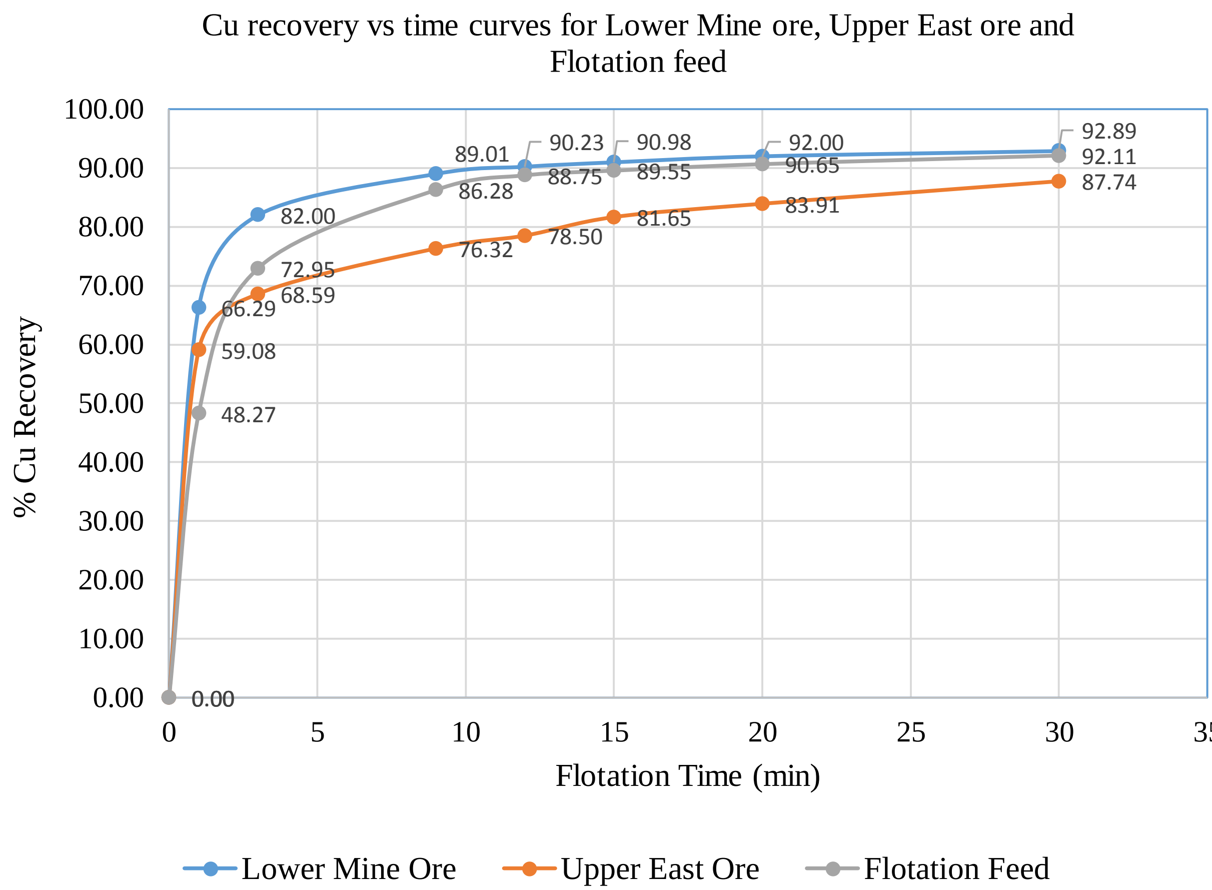

Figure 3: Cu Recovery-time curves for lower mine ore, upper east ore and flotation feed

- Furthermore, the optimization tests for PAX on the flotation feed showed a gradual increase in the recovery of gold, with the subsequent decrease in concentrate grade. The recovery and grade values at 300g/t PAX were 81% and 25 g/t respectively. The recovery for copper was however optimal throughout the whole range (225, 300, 375 and 450 g/t PAX) giving a recovery of about 95% and concentrate grade around 3% (Table 2).

Table 2: Results for PAX optimization test work

PAX Dosage (g/t)	**Aerophine Dosage (g/t)**	**Frother Dosage (g/t)**	**Grade**		**Recovery (%)**	
			Au (g/t)	**Cu (%)**	**Au**	**Cu**
225	22	27	28.80	3.365	76.35	94.88
300	22	27	25.55	4.245	81.47	95.89
375	22	27	25.98	2.838	85.28	95.05
450	22	27	24.67	3.644	85.33	96.13

CONCLUSION AND RECOMMENDATIONS

From the results, it can be seen that the flotability of gold and copper bearing minerals in both types of ores is relatively fast. At least 70% of these minerals can be recovered in the first 10 minutes of flotation after which the rate of flotation starts to decrease. The gold recoveries for Lower Mine, Upper East and flotation feed were 93.64%, 90.10% and 82.91% with concentrate grades of 10.69, 15.42 and 11.19 g/t respectively while the copper recoveries were 92.89%, 87.74% and 92.11% respectively, all with a similar concentrate grade of about 1.10%

The PAX dosage optimization tests for the flotation feed showed in increase in gold recovery with increasing PAX concentration rom 225, 300, 375 and 450 g/t. The recovery keeps increasing past 300 g/t PAX giving recovery of about 81% and a concentrate grade of 25 g/t. However, the optimization recovery curve of PAX optimization for copper seems to flatten at around 300 g/t PAX with a recovery of about 95% and concentrate grade around 3%.

Due to the findings discussed above I therefore recommend the following:

- Mineralogical analysis of the flotation feed should be done so as to enable a better understanding of the flotation feed ores.
- The amount of Upper East ore in the composite flotation feed should be decreased, or the flotation feed should only be the Lower Mine ore alone since the mineralogical nature of the Upper East ore is so reagent consuming and causes trouble at the flotation stages.
- Further tests should be done by a proper design of experiment so as to determine the interaction of the reagents on the response (recovery or concentrate grade).

The project is commendable because it would help to alleviate additional costs incurred due to usage of excessive reagents to treat the troublesome ore feed. Furthermore, the project would help to optimize the flotation feed treatment, thereby improving the flotation circuit recovery (and concentrate grade).

APPENDIX A: HEAD ASSAY RESULTS

Table 3: Table showing head assays of the test samples

Product	Au (ppm)	Au(r) (ppm)	Au (avg) (ppm)	Cu (%)	Cu(r) (%)	Cu (avg) (%)
Lower Mine Ore Samples						
Sample 1	16.88	15.69	16.28	0.48	0.48	0.48
Sample 2	6.71	6.09	6.40	0.50	0.51	0.50
Sample 3	9.54	8.73	9.13	0.51	0.51	0.51
Average	11.04	10.17	10.60	0.50	0.50	0.50
Upper East Ore Samples						
Sample 1	2.77	2.30	2.53	0.19	0.19	0.19
Sample 2	3.51	3.10	3.31	0.24	0.24	0.24
Sample 3	4.31	3.80	4.05	0.25	0.25	0.25
Sample 4	4.75	5.97	5.36	0.22	0.22	0.22
Average	3.84	3.79	3.81	0.22	0.23	0.23

APPENDIX B: EXPERIMENTAL RAW DATA

Table 4: Kinetic flotation test results for flotation feed

Product	Flotation time (min)	Au Cumulative grade (g/t)	Au Cumulative recovery (%)	Cu Cumulative grade (%)	Cu Cumulative recovery (%)
Feed	0		0.00		0.00
Conc. 1	1	43.42	68.39	3.51	59.08
Conc. 2	3	34.31	79.02	2.51	68.59
Conc. 3	9	27.69	86.22	1.91	76.32
Conc. 4	12	25.36	87.37	1.74	78.50
Conc. 5	15	22.44	88.14	1.58	81.65
Conc. 6	20	20.07	88.88	1.43	83.91
Conc. 7	30	15.47	90.10	1.16	87.74
Total Concentrate					
Tails		0.42		0.25	

Table 5: Kinetic flotation test results for Upper East ore

Product	Flotation time (min)	Au Cumulative grade (g/t)	Au Cumulative recovery (%)	Cu Cumulative grade (%)	Cu Cumulative recovery (%)
Feed	0		0.00		0.00
Conc. 1	1	32.96	62.94	3.73	66.29
Conc. 2	3	22.52	81.58	2.41	82.00
Conc. 3	9	17.01	89.78	1.77	89.01
Conc. 4	12	15.33	90.96	1.59	90.23
Conc. 5	15	14.05	91.65	1.46	90.98
Conc. 6	20	12.34	92.70	1.28	92.00
Conc. 7	30	10.69	93.64	1.10	92.89
Total Concentrate					
Tails		0.34		0.38	

Table 6: Kinetic flotation test results for Lower Mine ore

Product	Flotation time (min)	Au Cumulative grade (g/t)	Au Cumulative recovery (%)	Cu Cumulative grade (%)	Cu Cumulative recovery (%)
Feed	0		0.00		0.00
Conc. 1	1	34.18	39.33	3.81	48.27
Conc. 2	3	26.65	62.84	2.85	72.95
Conc. 3	9	20.49	75.20	2.18	86.28
Conc. 4	12	18.08	78.01	1.91	88.75
Conc. 5	15	16.65	78.91	1.75	89.55
Conc. 6	20	14.46	80.37	1.51	90.65
Conc. 7	30	11.19	82.91	1.16	92.11
Total Concentrate					
Tails				0.52	