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MINING SERVICES
Geoanalytical Laboratory
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LABORATORY FROTH FLOTATION TESTWORK OF BIDJOVAGGE D-DYP ORE

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LABORATORY FROTH FLOTATION TESTWORK OF BIDJOVAGGE D-DYP ORE

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1. SUMMARY

Five samples of Bidjovagge D dyp ore was submitted to Geoanalytical Laboratory for analysis and froth flotation tests.

The elemental assays of the flotation feed was:

Cu 0.87 %, S 4.41 %, Fe 7.30 % Au 2.7 g/t

and it contains roughly 2.5 wt-% chalcopyrite and 7.0 wt-% iron sulphides, mainly pyrite. No gold particles were observed in the flotation feed or in the flotation products in microscopical study.

The grinding tests indicate fairly easy grindability of the ore. The necessary grinding fineness about 89 % - 74 µm was achieved by 15+15 minute grinding in laboratory ball mill for the combined flotation tailing.

In the flotation tests with regrinding of the rougher tailing total recovery of copper was about 96 % and concentrate grade 5.3 % Cu. In four stage open cleaning for the combination of rougher and scavenger concentrates Cu grade 22.8 % was achieved on the recovery 75.1 %.

Gold follows pyrite in flotation. In the four stage open cleaning gold recovery to the final concentrate was only 24.4 % and gold assay in the concentrate 21.3 g/t. Gold concentrates to the cleaner tailings of third and fourth cleanings. Gold assay of the combined cleaner tailings was 43.3 g/t and recovery 37.3 %

The estimated total recovery of copper in closed circuit is about 94 % at the concentrate grade 15-16 % Cu. Pyrite content of the concentrate is about 40 %. Gold assay of the concentrate will be about 30 g/t and the estimated gold recovery about 68 %.

To raise the copper assay over the level 15-16 % Cu it is necessary to depress pyrite. Depression of pyrite causes remarkable reduction in gold recovery because the gold assays are higher in the cleaner tailings than in the concentrate.

The flotation results indicate that the gold might occur in pyrite either as invisible inclusions or in the crystal lattice of pyrite.

Possibility of invisible gold in pyrite can be investigated by a SIMS study which is recommended.

2. INTRODUCTION

Five samples of Bidjovagge D-dyp ore from the drill holes S52E, S44L, S48L, S44M, and S48N were received 10.8.1990 by Geoanalytical Laboratory of Outokumpu Mining Services from Mr. Markus Ekberg, Bidjovagge A/S for analysis and metallurgical tests by froth flotation.

The aim of the testwork was to measure the degree of grinding fineness necessary for gold/copper flotation and to estimate concentrate grade and recoveries.

3. PREPARATION AND ANALYSIS OF FEED SAMPLE

The drill core samples were crushed separately to -3 mm by jaw and roll crushers, homogenised and divided by sample splitter and further by bottle divider and prepared for analysis. The subsamples were combined to flotation feed samples, homogenised and divided to 1000 g test samples by bottle divider and packed to plastic bags. The test samples were stored in freezer to avoid oxidation. Elemental assays were as follows:

	DD/S52E	DD/S44L	DD/S48L	DD/S44M	DD/S48N	Flot. feed average
Cu (%)	1.02	0.49	0.94	0.86	1.77	0.87
Au (g/t)	2.2	2.1	3.8	2.0	2.7	2.7
Fe (%)	3.34	11.5	5.47	6.59	5.73	7.30
S (%)	2.01	11.0	3.05	5.59	4.69	4.41
C tot.(%)	1.77	6.12	5.58	2.02	4.92	4.22

4. MICROSCOPICAL OBSERVATIONS ON THE FEED SAMPLES

Resin mounts from the five crushed drill core samples were prepared and studied microscopically. The ore mineralogy is rather simple. The main ore minerals are pyrite and chalcopyrite with pyrrhotite, ilmenite and sphalerite as accessories. Galena occurs only sporadically. The ore minerals usually occur as disseminations within the host rock. No gold was found in the feed.

Pyrite usually occurs as rather well-formed separate grains (average grain size roughly 340-600 µm with some smaller grains) and sometimes as intergroths with silicate minerals and chalcopyrite. Chalcopyrite forms rather irregular shaped grains, which are often intergrown with silicate minerals and in some cases with pyrrhotite. It also occurs as separate grains. The average grain size is about 340 µm with some smaller grains. Pyrrhotite usually occurs together with chalcopyrite, ilmenite as small rounded inclusions in silicate minerals and sphalerite and galena often together as small intergrowths.

5. ANALYTICAL METHODS

The feed samples and the products were analysed for gold by fire assay. The determinations of Cu, Fe were made by flame AAS. The final concentrate was analysed by flame AAS for As, Te, Bi and Sb. S and C were determined by Leco analyser.

XRF-analysis for 53 elements were made with Philips PW 1400 spectrometer and fundamental parameter correction calculation (RRFPO).

Sieve analysis of the tailings were made by the sieves 37, 74, 105 µm of Tyler serie. The fines were washed off through 37 µm sieve before dry sieving of the coarser fractions.

6. PROCEDURE OF FROTH FLOTATION TESTS

6.1. Grinding

The test samples were ground in laboratory ball mill (1 kg sample/500 ml water/6.8 kg iron balls). The first addition of collector was made to the mill. In the two step grinding the tailing of rougher flotation was settled. The pulp density in regrinding was approximately similar to that in the first grinding stage (50 %).

6.2. Conditioning

One minute conditioning time was used for the frother. Rpms of the cell were the same as in flotation.

6.3. Flotation

Outokumpu laboratory flotation machine was used both in conditioning and flotation. The cell conditions of 2.0 litre cell in rougher flotation were 1500 rpm and 1.5 l/min air. In cleaner flotations cells of 1.6 l and 1.0 l volume were used.

Aerophine 3418 A was used as collectors and Dowfroth 210 as frother throughout the tests.

7. GRINDING TESTS

All the grinding tests (DD01-04) were performed with regrinding. The process of Bidjovagge concentrator was simulated as closely as it is possible laboratory scale. The rougher flotation was performed after 10 - 25 min grinding and the tailing was sieved wet by 37 µm sieve. The coarse fraction of tailing was settled and clear water was separated before regrinding. Pulp density in regrinding was approximately 50 %. Grinding times of the regrinding were the same as those of first grinding. The fineness of the combined flotation tailing on different grinding times was as follows:

Test No.	DD01	DD02	DD03	DD04
Grinding (min)	10+10	15+15	20+20	25+25
Fraction µm	Wt-%	Wt-%	Wt-%	Wt-%
+105	12.6	3.4	1.3	0.5
+74-105	14.0	7.9	3.7	1.4
+37-74	25.9	27.2	19.4	12.9
-37	46.7	61.5	75.6	85.2

The grinding tests indicate fairly good grindability of the ore. Flotation time in rougher flotation was 9 min and in scavenger flotation 7 min. As a whole the flotation results in rougher and scavenger flotation were not very sensitive to the grinding. In cleaner flotation at the coarsest grinding the recovery and grade for copper were clearly lower. The gold followed pyrite and concentrated into the cleaner tailings of the 3rd cleaner flotation in all the grinding tests. It was assumed that one reason for this behaviour would be the low pulp density in the cleaner flotation. That is why the rougher flotation was done twice in the test DD05 and the concentrates were combined before the second cleaner flotation to double the pulp density.

8. CLEANER FLOTATION IN HIGHER PULP DENSITY

In the test DD05 the rougher flotation was done twice and the concentrates were combined in the second cleaner flotation to raise the pulp density. Grinding times were 15+15 min and grinding fineness of the final tailing (RT -37 µm + ST) 88.7 % -74 µm and 61.5 % -37 µm.

Total copper recovery into the combined rougher - scavenger concentrate (RC+SC) is 96.3 % at the grade 5.3 % Cu. Gold recovery is 86.4 % at the grade 13.7 g/t. Pyrite recovery is 62.8 % and pyrite assay 27.4 %. (Appendix 4, the calculation of pyrite is based on the assumption that all the sulphur is carried by chalcopyrite and pyrite, and the minerals are stoichiometric $CuFeS_2$ and FeS_2.)

In the cleaner flotation chalcopyrite can be floated fairly easily. In four stage open cleaning of the combination of rougher and scavenger concentrates Cu grade 22.8 % was achieved on the recovery 75.1 %.

The estimated copper recovery in closed circuit is about 94 % at the grade 15-16 % Cu. (The estimation is based on the assumption that 2/3 of the copper content of the cleaner tailings is recovered in closed circuit, Appendix 3.) Pyrite content of the concentrate is about 40 %. Gold assay of the concentrate will be about 30 g/t and gold recovery about 68 %.

Gold follows pyrite in the cleaner flotation (Appendix 5). To raise the copper assay over the level 15-16 % Cu it is necessary to depress pyrite. Depression of pyrite causes remarkable reduction in gold recovery because the gold assays are higher in the cleaner tailings than in the concentrate.

9. MICROSCOPICAL OBSERVATIONS ON THE PROCESS SAMPLES

Resin mounts from the cleaner tailings (CT3 and CT4) and the final concentrate CC4 of the test DD05 were prepared and studied microscopically. The main ore minerals are pyrite and chalcopyrite with pyrrhotite and ilmenite as accessories. Sphalerite is a rare constituent. No gold was found in the samples.

The occurrence of ore minerals is very similar in all the three samples. The ore minerals usually occur as separate grains. Pyrite is sometimes included as euhedral grains in chalcopyrite, and pyrrhotite is intergrown with chalcopyrite.

10. ANALYSIS OF THE FINAL CONCENTRATE

The final concentrate (CC4) of test DD05 was analysed by XRF for the 53 elements. As, Te, Sb, Bi were also analysed with flame AAS (Appendix 6). Only the Sb assay was over the detection limit of flame AAS.

11. PROPOSAL FOR PROCESS DEVELOPMENT

So far no gold particles were observed in the microscopical study of the eight polished sections made from the flotation feed and products. The flotation results indicate that the gold might occur in pyrite either as invisible inclusions or in the crystal lattice of pyrite.

Possibility of invisible gold in pyrite can be investigated by a SIMS study which is recommended.

However there is a possibility that fine-grained gold has not polished properly for light microscopy in the preparation of resin mounts.

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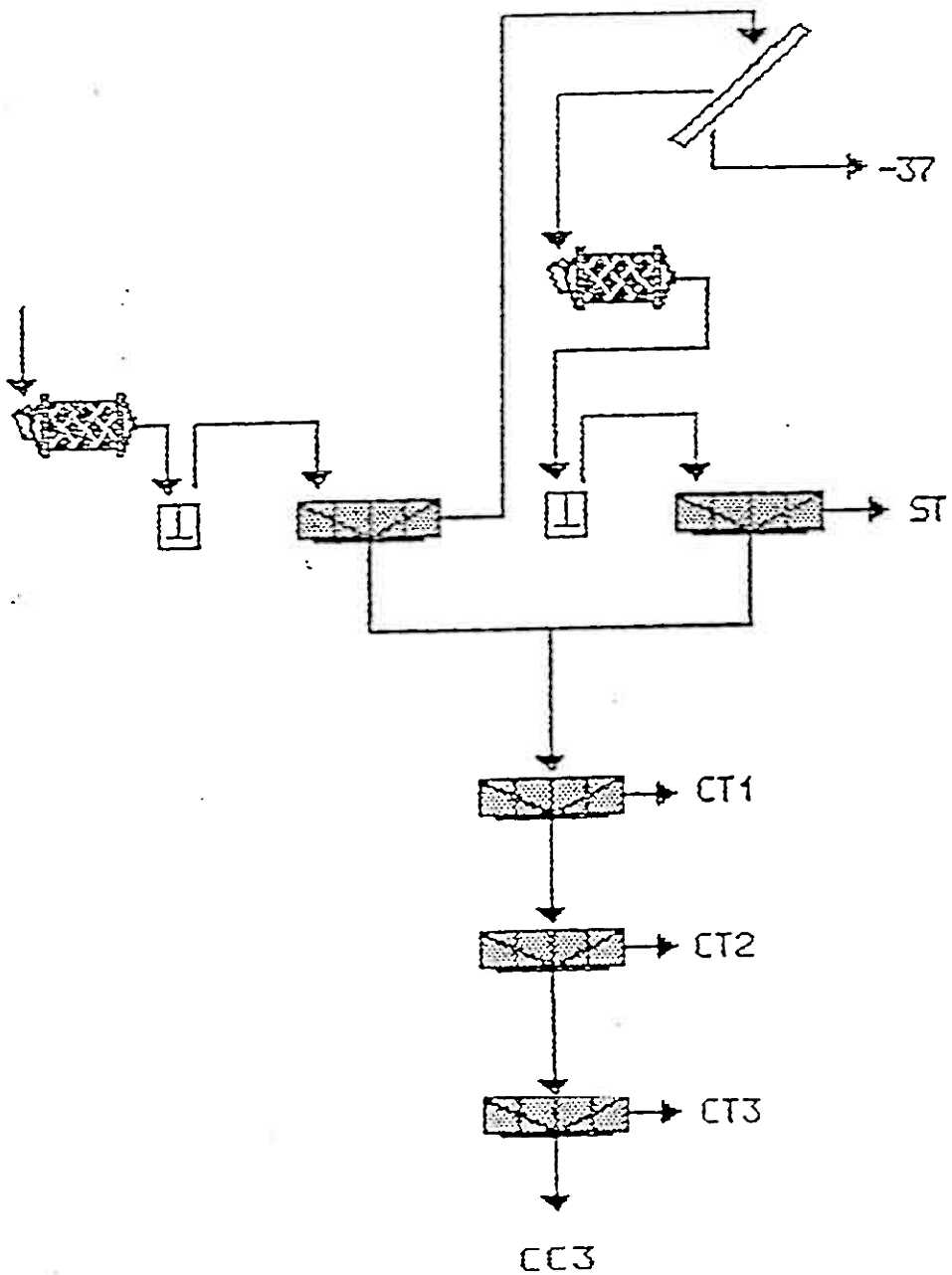
APPENDIX 1

Flowsheet for tests DD01-04



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FLOTATION REPORT Date 13.9.1990

Sample BIDJOVAGGI D-DYP

Purpose Grinding

Test DD01

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	16.9	0.039	34.4	1.700	35.9	2.05	14.2
+74-105	16.8	0.019	18.6	1.000	23.5	2.44	18.6
+37-74	33.7	0.014	24.6	0.600	25.3	2.43	33.5
-37	30.6	0.014	22.4	0.400	15.3	2.67	33.5
Bulk	100	0.019	100	0.800	100	2.44	100

STEP	FEED	TIME			REAGENTS				CELL			pH	PRODUCT	WEIGHT		GRADES AND RECOVERIES											
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm					%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	1012	100.0	0.869	100.0	2.7	100.0	4.59	100.0	7.297	100.0	4.3	100.0	82.91	100.0
Rougher	ORE	10	1	9			30	40	2.0	1.5	1500	8.9	RC RT														
Classif.	RT												+37 -37	213	21.0	0.080	1.9	0.40	3.1	1.16	5.3	4.420	12.7	3.9	19.2	90.40	23.0
Scaveng.	RT +37	10	1	7			20	20	2.0	1.5	1500		SC ST	620	61.2	0.030	2.1	0.70	15.9	2.22	29.6	5.440	45.6	4.8	67.6	87.54	64.6
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	89 91	8.7 9.0	9.332 0.420	91.8 4.2	21.4 3.40	69.6 11.4	28.93 5.04	55.2 9.9	26.761 7.740	32.1 9.5	2.0 4.4	4.0 9.2	32.97 82.37	3.5 8.9
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	60 29	5.9 2.9	13.013 1.720	86.1 5.7	26.1 11.60	57.2 12.4	33.47 19.62	42.9 12.3	29.861 20.400	24.1 8.0	1.4 3.3	1.9 2.2	22.29 54.89	1.6 1.9
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	41 18	4.1 1.8	16.800 4.420	77.1 8.9	21.40 36.90	32.5 24.7	33.52 33.35	29.8 13.1	29.800 30.000	16.7 7.4	1.2 1.9	1.1 0.8	18.73 30.38	0.9 0.7
													RC+SC	180	17.7	4.814	96.0	12.26	80.5	16.82	65.0	17.118	41.6	3.2	13.3	58.02	12.4
													ST+ -37	833	82.3	0.043	4.0	0.62	19.1	1.95	35.0	5.179	58.4	4.6	86.7	88.27	87.6

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FLOTATION REPORT — Date 14.9.1990

Sample — BIDJOVAGGE D-DYP

Purpose — Grinding

Test — DD02

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	5.1	0.023	7.9	4.000	30.5	2.58	6.0
+74-105	11.7	0.017	13.3	0.900	15.7	1.70	9.1
+37-74	36.6	0.013	31.9	0.600	32.8	2.14	36.0
-37	46.6	0.015	46.9	0.300	20.9	2.26	48.8
Bulk	100	0.015	100	0.669	100	2.18	100

STEP	FEED	TIME Grin min	TIME Cond min	TIME Flot min	REAGENTS Ca(OH)2 kg/t	REAGENTS NAX g/t	REAGENTS Dow-froth 210 g/t	REAGENTS Aero-phine 3418A g/t	CELL Vol l	CELL Air l/min	CELL Speed rpm	pH	PRO-DUCT	WEIGHT g	WEIGHT %	GRADES AND RECOVERIES Cu %	Cu R-%	Au g/t	Au R-%	S %	S R-%	Fe %	Fe R-%	C g/t	C R-%	Others %	Others R-%
													FEED	1014	100.0	0.861	100.0	2.9	100.0	4.42	100.0	7.335	100.0	4.3	100.0	63.09	100.0
	ORE	15						40																			
Rougher			1				30					8.9	RC														
				9					2.0	1.5	1500		RT														
Classif.	RT												+37														
													-37	265	26.1	0.080	2.4	0.30	2.7	0.68	4.0	4.460	15.9	4.0	24.5	90.76	28.5
	RT +37	15						20																			
Scaveng.			1				20						SC														
				7					2.0	1.5	1500		ST	553	54.5	0.030	1.9	0.80	15.3	1.53	18.9	5.220	38.8	4.8	61.3	68.40	58.0
1st clean.	RC+SC		1										CC1	85	8.3	9.396	90.9	24.3	70.9	32.59	61.4	27.952	31.8	1.6	3.1	28.46	2.9
				5					2.0	1.5	1500		CT1	112	11.0	0.370	4.7	2.90	11.1	6.29	15.7	9.030	13.5	4.3	11.1	79.97	10.6
2nd clean.	CC1		1										CC2	53	5.2	14.080	84.7	30.2	54.7	37.18	43.6	31.581	22.3	0.8	1.0	16.33	1.0
				5					1.6	1.5	1200		CT2	32	3.2	1.710	6.3	14.60	16.1	25.06	17.9	22.000	9.5	2.9	2.1	46.35	1.8
3rd clean.	CC2		1										CC3	33	3.2	29.000	74.5	22.70	25.4	35.85	26.0	30.400	13.3	0.6	0.5	13.14	0.5
				4					1.0	1.5	1000		CT3	20	2.0	4.460	10.2	42.50	29.3	39.33	17.6	33.500	9.0	1.2	0.6	21.51	0.5
													RC+SC	196	19.3	4.261	95.7	12.13	82.0	17.63	77.1	17.188	45.3	3.2	14.2	57.76	13.4
													ST+ -37	819	80.7	0.046	4.3	0.64	18.0	1.25	22.9	4.974	54.7	4.6	85.8	39.16	86.6

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FLOTATION REPORT — Date 14.9.1990

Sample — BIDJOVAGGE D-DYP

Purpose — Grinding

Test — DD03

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	2.1	0.022	3.1	1.000	4.6	0.35	0.9
+74-105	6.2	0.019	7.6	1.100	14.6	1.31	4.0
+37-74	32.1	0.014	29.8	0.600	41.8	1.82	28.6
-37	59.6	0.015	59.3	0.300	36.8	2.26	66.5
Bulk	100	0.015	100	0.461	100	2.04	100

STEP	FEED	TIME Grin min	TIME Cond min	TIME Flot min	REAGENTS Ca(OH)2 kg/t	REAGENTS NAX g/t	REAGENTS Dow-froth 210 g/t	REAGENTS Aero-phine 3418A g/t	CELL Vol l	CELL Air l/min	CELL Speed rpm	pH	PRO-DUCT	WEIGHT g	WEIGHT %	GRADES AND RECOVERIES Cu %	Cu R-%	Au g/t	Au R-%	S %	S R-%	Fe %	Fe R-%	C g/t	C R-%	Others %	Others R-%
													FEED	1009	100.0	0.623	100.0	2.6	100.0	4.23	100.0	7.434	100.0	4.3	100.0	83.21	100.0
Rougher	ORE	20	1	9			30	40	2.0	1.5	1500	8.9	RC RT														
Classif.	RT												+37 -37	325	32.2	0.060	3.1	0.30	3.7	0.77	5.9	4.680	20.3	4.2	31.0	90.31	34.9
Scaveng.	RT +37	20	1	7			20	20	2.0	1.5	1500		SC ST	496	49.1	0.020	1.2	0.40	7.5	1.70	19.7	5.420	35.9	4.8	54.6	88.06	52.0
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	78 111	7.7 11.0	9.576 0.450	85.6 6.0	26.9 2.20	79.4 9.3	32.16 6.05	56.5 15.5	29.464 8.950	30.6 13.3	1.6 4.5	2.8 11.6	27.21 80.00	2.5 10.6
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	48 30	4.7 3.0	14.627 1.630	83.7 5.9	34.1 15.40	61.7 17.7	36.74 24.89	40.9 17.7	32.302 25.000	20.5 10.3	0.8 2.8	0.9 1.9	15.53 45.56	0.9 1.6
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	31 17	3.0 1.7	20.300 4.450	74.6 9.1	24.50 50.70	25.9 32.8	36.16 37.79	25.8 15.1	31.300 34.100	12.7 7.7	0.6 1.2	0.4 0.5	11.65 22.43	0.4 0.5
													RC+SC	189	18.7	4.202	95.7	12.33	88.7	15.60	74.4	17.389	43.9	3.3	14.4	58.39	13.1
													ST+ -37	820	81.3	0.044	4.3	0.36	11.3	1.33	25.6	5.127	56.1	4.5	85.6	88.95	86.9

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Geoanalytical Laboratory

FLOTATION REPORT Date 17.9.1990

Sample BIDJOVAGGE D-DYP

Purpose Grinding

Test DD04

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	0.9	0.025	1.6	4.200	6.5	2.00	0.8
+74-105	2.7	0.019	3.7	2.300	11.1	2.46	2.8
+37-74	24.2	0.013	22.5	1.300	56.3	2.26	22.9
-37	72.2	0.014	72.2	0.200	25.6	2.43	73.5
Bulk	100	0.014	100	0.559	100	2.39	100

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES											
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm					%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	1007	100.0	0.858	100.0	2.7	100.0	4.21	100.0	7.399	100.0	4.3	100.0	83.26	100.0
Rougher	ORE	25	1	9			30	40	2.0	1.5	1500	8.8	RC														
													RT														
Classif.	RT												+37														
													-37	371	36.8	0.090	3.9	0.30	4.2	1.12	9.8	4.860	24.2	4.2	35.7	89.78	39.7
Scaveng.	RT +37	25	1	7			20	20	2.0	1.5	1500		SC														
													ST	426	42.3	0.030	1.5	0.40	6.4	1.94	19.5	5.810	33.2	4.6	47.0	87.47	44.4
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1	75	7.5	10.217	89.7	26.1	73.2	30.09	53.2	26.033	28.2	1.8	3.1	29.89	2.7
													CT1	136	13.5	0.360	6.0	3.20	16.2	5.47	17.5	7.910	14.4	4.5	14.2	81.73	18.2
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2	45	4.5	15.922	82.9	35.4	59.6	35.68	37.9	32.254	19.5	0.8	0.8	15.34	0.9
													CT2	30	3.0	1.550	5.8	12.10	13.6	21.69	15.4	21.700	8.7	3.2	2.3	51.72	1.9
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3	31	3.0	21.200	74.6	28.30	32.3	35.00	25.2	31.900	13.1	0.6	0.4	11.35	0.4
													CT3	15	1.4	4.620	8.1	50.30	27.3	37.12	12.7	33.000	6.4	1.3	0.5	23.72	0.4
													RC+SC	211	20.9	3.865	94.7	11.35	69.5	14.24	70.7	15.080	42.6	3.5	17.3	63.26	15.9
													ST+ -37	796	79.1	0.058	5.3	0.35	10.5	1.56	29.3	5.360	57.4	4.5	82.7	88.55	84.1

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Mining Services
Geoanalytical laboratory

FLOTATION REPORT Date 24.9.1990

Sample BIDJOVAGGE D-DYP

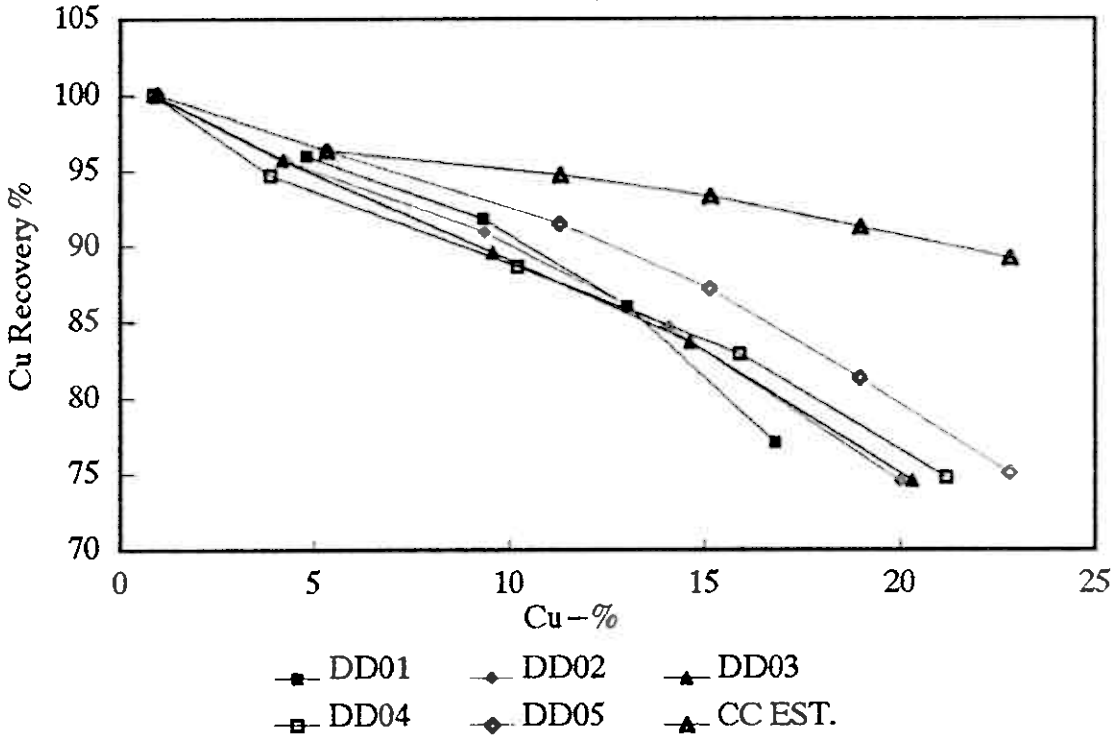
Purpose Cleaning in higher pulp density

Test DD05

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES											
		Grin min	Cond min	Flot min	Ca(OH)2 kg/t	KAX g/t	Dow-froth 210 g/t	Aero-phine 3418A g/t	Vol l	Air l/min	Speed rpm			g	%	Cu %	R-%	Au g/t	R-%	S %	R-%	Fe %	R-%	C %	R-%	Others %	R-%
													FEED	2046	100.0	0.532	100.0	2.7	100.0	5.83	100.0	7.28	100.0	4.14	100.0	82.62	100.0
Rougher	ORE	15	1	9			30	40	2.0	1.5	1500	8.8	RC PT														
Classif.	PT												+37														
													-37	529	25.9	0.090	2.5	0.3	2.9	1.31	7.0	4.34	15.4	3.90	24.4	90.36	28.2
Scaveng.	RT +37	15	1	7			20	20	2.0	1.5	1500		SC ST	1171	57.2	0.020	1.2	0.5	10.7	2.00	20.7	5.15	40.5	4.59	63.5	88.24	61.0
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1	155	7.6	11.284	91.5	26.2	78.5	33.83	51.9	25.59	30.6	1.44	2.6	23.93	2.2
													CT1	192	9.4	0.450	4.8	2.0	7.0	8.44	16.4	10.60	13.5	4.20	9.5	76.38	8.6
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2	110	5.4	15.126	67.2	30.7	61.6	36.62	47.6	31.41	23.2	0.87	1.1	15.97	1.0
													CT2	45	2.2	1.520	4.2	22.0	17.8	26.83	12.1	24.30	7.4	2.66	1.5	43.59	1.1
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3	82	4.0	16.553	81.3	25.4	37.6	36.17	30.0	30.79	15.9	0.73	0.7	18.36	0.6
													CT3	28	1.4	4.010	5.9	46.3	23.8	37.93	10.5	33.20	6.3	1.29	0.4	23.57	0.4
4th clean.	CC3		1	3					1.0	1.5	1000		CC4	63	3.1	20.500	75.1	21.3	24.4	35.46	22.5	30.00	12.6	0.61	0.5	11.13	0.4
													CT4	19	0.9	6.260	6.2	36.6	13.5	38.52	7.4	33.40	4.3	1.11	0.2	20.71	0.2
													RC+SC	346	16.9	5.305	96.2	12.7	66.4	19.78	69.3	16.89	44.1	2.57	12.1	52.96	10.6
													ST+ -37	1700	83.1	0.082	3.7	0.4	13.6	1.79	30.7	4.98	55.9	4.36	87.9	88.90	89.2

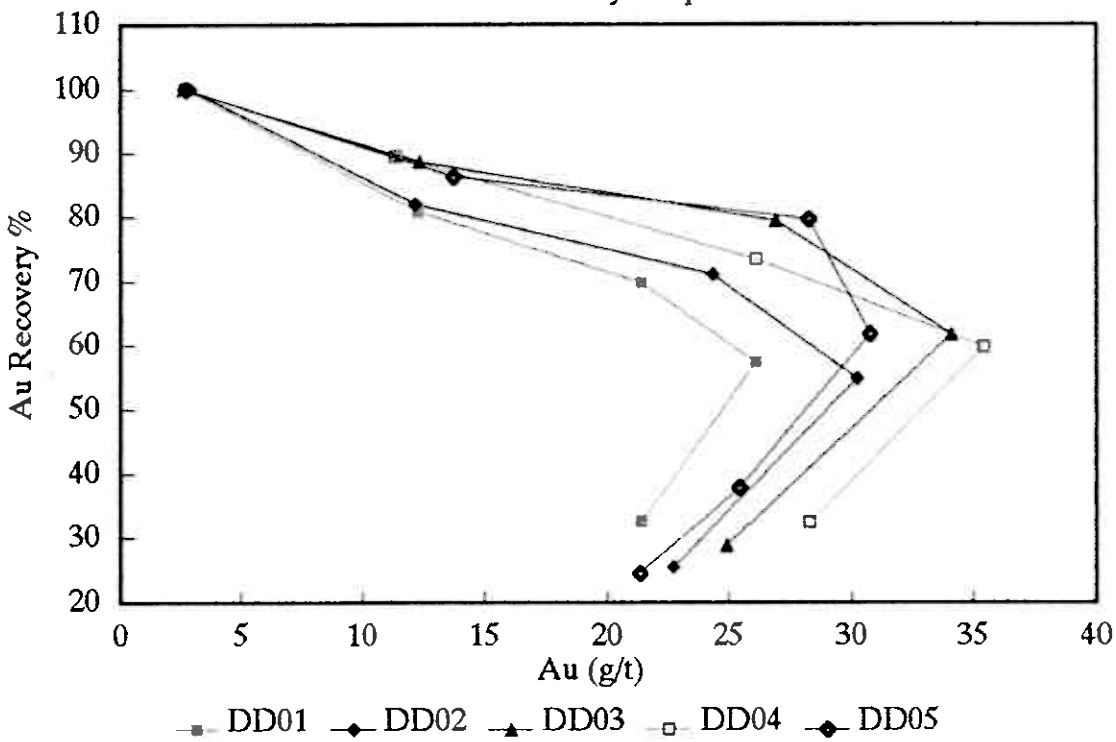
BIDJOVAGGE D–DYP

Grade – Recovery Graph for Copper



BIDJOVAGGE D–DYP

Grade – Recovery Graph for Gold



APPENDIX 4

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 24.9.1990

Sample — BIDJOVAGGE D-DYP

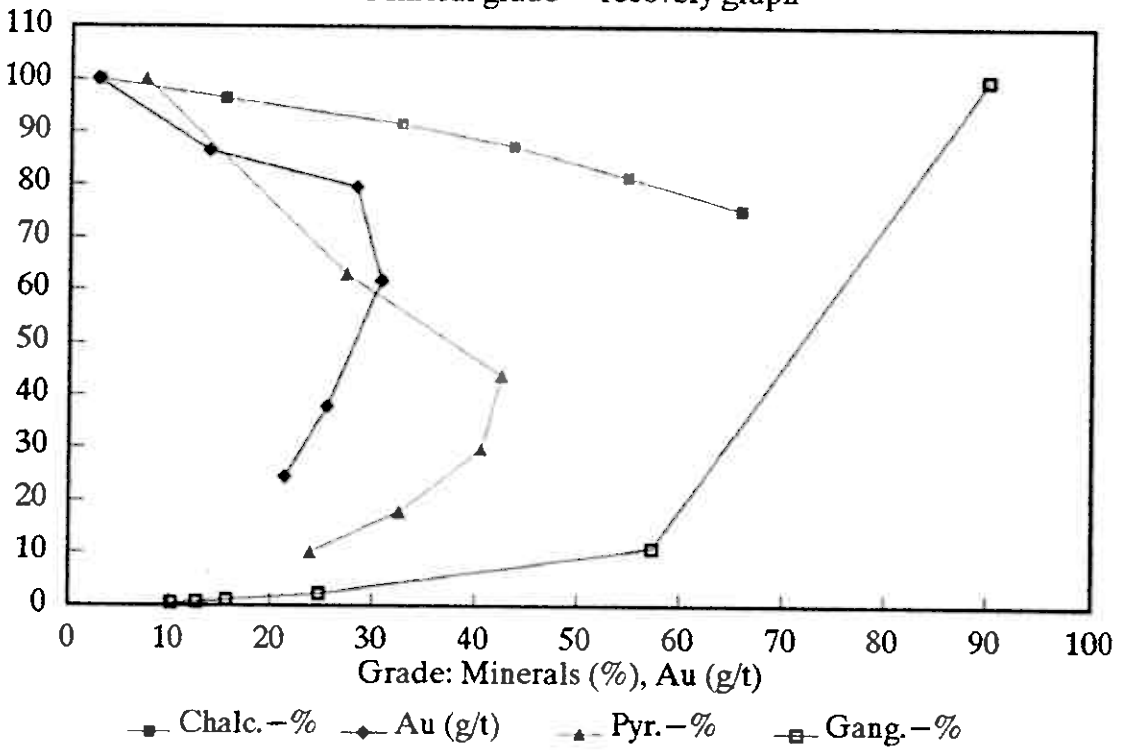
Purpose — Cleaning in higher pulp density

Test — DD05

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES, MINERALS AND RECOVERIES											
		Grin	Cond	Flot	Ca(OH)2	KAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	Cu		Au		S		Chalcopyrite		Pyrite		Gangue	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm					%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%	%	R-%
													FEED	2046	100.0	0.932	100.0	2.7	100.0	4.83	100.0	2.69	100.0	7.36	100.0	89.94	100.0
Rougher	ORE	15	1	9			30	40	2.0	1.5	1500	8.8	RC RT														
Classif.	RT												+37 -37	529	25.9	0.090	2.5	0.3	2.9	1.31	7.0	0.26	2.5	2.31	8.1	97.43	28.0
Scaveng.	RT +37	15	1	7			20	20	2.0	1.5	1500		SC ST	1171	57.2	0.020	1.2	0.5	10.7	2.00	23.7	0.06	1.2	3.74	29.1	96.20	61.2
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	155 192	7.6 9.4	11.294 0.480	91.5 4.8	28.2 2.0	79.5 7.0	33.83 8.44	52.9 16.4	32.64 1.39	91.5 4.8	42.59 15.04	43.7 19.1	24.77 83.57	2.1 8.7
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	110 45	5.4 2.2	15.126 1.820	87.2 4.2	30.7 22.0	61.6 17.8	36.62 26.93	40.8 12.1	43.71 5.26	87.2 4.2	40.63 47.46	29.7 14.0	15.66 47.28	0.9 1.1
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	82 28	4.0 1.4	18.958 4.010	81.3 5.9	25.4 46.3	37.8 23.8	36.17 37.93	30.0 10.8	54.79 11.59	81.3 5.9	32.53 64.11	17.7 12.0	12.68 24.30	0.6 0.4
4th clean.	CC3		1	3					1.0	1.5	1000		CC4 CT4	63 19	3.1 0.9	22.800 6.260	75.1 6.2	21.3 38.9	24.4 13.5	35.46 38.52	22.5 7.4	65.89 18.09	75.1 6.2	23.93 60.97	10.0 7.7	10.18 20.94	0.3 0.2
													RC+SC	346	16.9	5.309	96.3	13.7	86.4	19.78	69.3	15.34	96.3	27.35	62.8	57.31	10.8
													CT3+CT4	47	2.3	4.916	12.2	43.3	37.3	38.17	18.2	14.21	12.2	62.85	19.7	22.95	0.6
													ST+ -37	1700	83.1	0.042	3.7	0.4	13.6	1.79	30.7	0.12	3.7	3.30	37.2	96.58	89.2

BIDJOVAGGE D–DYP

Mineral grade – recovery graph



APPENDIX 6

OUTOKUMPU OY, MINING SERVICES, GEOANALYYTTINEN LABORATORIO
XRF-ANALYYSITULOKSIA (XRF ANALYSIS) 18.10.90

TILAAJA: V. PALOSAARI/GAL LASK.P: OPER: MLM 132
ALUE: BIDJO 9/90 D-DYP KARTTAL.: JAKELU: IAH, MLM

	90901S2 (CC4/DD05) %
C	
F	
NA	0.00
MG	0.70
AL	0.431
SI	3.11
P	0.011
S	33.2
CL	0.007
K	0.016
CA	1.99
TI	0.0329
V	0.0040
CR	0.0033
MN	0.0343
FE	29.88
CO	0.0671
NI	0.124
CU	21.93
ZN	0.0585
GA	0.0000
AS	0.0000 < 0.01 % (AAS FLAME)
BR	0.0000
RB	0.0009
SR	0.0006
Y	0.0003
ZR	0.0011
NB	0.0000
MO	0.0101
AG	0.000
SN	0.000
SB	0.000 0.04 % (AAS FLAME)
TE	0.004 < 0.025 % (AAS FLAME)
CS	0.006
BA	0.010
LA	0.003
CE	0.001
PR	0.000
ND	0.01
SM	0.00
EU	0.00
GD	0.00
TB	0.00
DY	0.00
HO	0.00
ER	0.01
TM	0.00
YB	0.00
LU	0.00
HF	0.000
TA	0.041
W	0.000
PB	0.40
BI	0.002 < 0.004 % (AAS FLAME)
TH	0.0000
U	0.0021