outokumpu
MINING SERVICES
Geoanalytical Laboratory

REPORT
075/Bidjovagge,C3,Cu,Au/VIP/1990

V. Palosaari

Date
September 21, 1990

LABORATORY FROTH FLOTATION TESTWORK OF BIDJOVAGGE C3 ORE

Veikko Palosaari

Geoanalytical Laboratory

Veikko Palosaari
Manager

DISTR. Bidjovagge/
GAL/V. Palosaari
Archives
H. Alaniska, M. Ekberg

LABORATORY FROTH FLOTATION TESTWORK OF BIDJOVAGGE C3 ORE

CONTENTS PAGE NUMBER

Appendices

1. Flowsheet of the tests C301-09
2. Flotation reports of the tests C301-09
3. Grade-recovery graphs
   3/1 Grinding tests C301-04
   3/2 Collector tests C304-C307
   3/3 Test C305 with closed circuit estimation
4. Photomicrographs of the feed and the fraction -37 µm of rougher tailing in the test C304
5. XRF- and AAS-analysis of the final concentrate (CC3) of the test C305

1. SUMMARY

Two samples of Bidjovagge C3 ore was submitted to Geoanalytical laboratory for analysis and froth flotation tests. The elemental assays of the samples were:

C3 (S144G) Cu 2.22 %, S 9.5 %, Au 1.9 g/t, Te 0.0083 %
C3 (S146A) Cu 4.55 %, S 9.17%, Au 1.9 g/t, Te 0.0090 %.

The combined flotation feed contains roughly 9.8 wt-% chalcopyrite and 11.5 wt-% iron sulphides. Pyrite/pyrrhotite ratio is approximately 3/1. Chalcopyrite occurs casually as fracture fillings in pyrite, magnetite or gangue minerals. A single grain of native gold was observed. The grain measures 130*50 µm in diameter.

The grinding tests indicate easy grindability of the ore. Main problem of processing is the formation of fine grained chalcopyrite which is lost to the fines of rougher tailing. The lowest copper assay achieved in the fraction - 37 µm was 0.45 % Cu.

The main loss of gold is into the coarse fraction of scavenger tailing where the gold may be as high as 12 g/t and clearly indicates the occurrence of coarse gold particles.

Optimum grinding fineness in rougher flotation for copper is about 25 % - 37 µm which means roughly 55 % - 74 µm.

In the flotation tests with regrinding of the rougher tailing total recovery of copper was about 95 % and concentrate grade 12 % Cu. In three stage open cleaning of the combination of rougher and scavenger concentrates Cu grade 17.9 % was achieved on the recovery 86.8 %.

The estimated total recovery of copper in closed circuit is 92 % at the concentrate grade 18 %. On the same estimation gold recovery will be about 88 % and concentrate grade 11 g/t.

Flotation results for copper with xanthate were nearly the same as with Aerophine 3418A. The impurities of the concentrate in xanthate flotation are iron sulphides and in the case of Aerophine flotation mainly gangue minerals. Flotation results for gold are generally better with Aerophine as collector than with Amylxanthate at all the tested pH levels (10.0-11.0).

The tellurium assay of the flotation concentrate is 0.014 % and As, Sb, Bi assays are below the detection limit of AAS flame analysis.

The clear indication of occurrence of coarse gold particles supports the adoption of gravity separation methods.

2. INTRODUCTION

Two samples of Bidjovagge C3 ore from the drill holes S144G and S146A was 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 to subsamples of 4 kg which were further divided to 500 g test samples by bottle divider and packed to plastic bags. The test samples were stored in freezer to avoid oxidation. One 500 g sample of both the samples was prepared for analysis. The elemental assays were as follows:

	C3 S144G		C3 S146A		Flotation feed (average of the calculated feed)
		(ast		(me	
Cu (%)	2.22	2.5	4.55	3.01	3.38
Au (g/t)	1.9	1.9	1.9	1.5	2.5
Fe (%)	11.7		12.8		11.7
S (%)	9.50		9.17		9.11
C total (%)	3.30		4.85		3.96
Te (g/t)	83		90		
Bi (g/t)	<0.1		<0.1		

The feed samples for flotation tests were formed by combining one 500 g test sample from both the drill holes to form a 1000 g flotation test sample.

4. MICROSCOPICAL OBSERVATIONS ON THE FEED

One polished section from the crushed ore (feed for the flotation tests) was prepared and studied microscopically. Chalcopyrite, pyrite and pyrrhotite occur as main sulphides. Galena and gold were encountered as rare constituents. Magnetite is a common oxide mineral and some ilmenite grains were also observed.

Based on the chemical analysis the feed contains roughly about 9.8 wt-% chalcopyrite and 11.5 wt-% iron sulphides. According to the microscopical estimation the pyrite/ pyrrhotite ratio is approximately 3/1.

Chalcopyrite occurs generally as coarse-grained particles, but casually also as fracture fillings in pyrite, magnetite or gangue minerals (see Appendix 4). The width of the fracture fillings is in places less than 10 µm.

A single grain of native gold was observed in the polished section. The grain measures roughly 130*50 µm in diameter and it is a locked particle containing in addition to gold also some gangue minerals (Appendix 4).

5. ANALYTICAL METHODS

The feed samples and most of products were analysed for gold by fire assay. Aqua regia dissolution and organic extraction by dibutylketone/dibutylsulfide was used for the first three tests but the results were not satisfactory without roasting especially for the concentrates. The determinations of Cu, Fe were made by flame AAS. The feed was analysed by graphite furnace AAS for Te and Bi. The concentrate was analysed by flame AAS for As, Te, Bi and Sb. S and C 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 Aerophine flotation tests. In xanthate flotation the collector was added after pH adjustment to conditioning. In two step grinding the tailing of rough 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 and Sodium Amylxanthate (NAX) were used as collectors and Dowfroth 210 as frother throughout the tests. Lime was used as pH regulator.

7. GRINDING TESTS

All the grinding tests (C301-04) 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.	C304	C301	C302	C303
Grinding (min)	10+10	15+15	20+20	25+25
Fraction µm	Wt-%	Wt-%	Wt-%	Wt-%
+105	9.1	2.7	0.6	0.4
+74-105	13.1	6.7	2.6	1.3
+37-74	25.9	24.2	17.4	11.6
-37	51.9	66.4	79.4	86.7

The grinding tests indicate easy grindability of the ore. The formation of slime in the first grinding stage is the biggest problem in copper flotation. Flotation time of rougher flotation was increased from 6 to 9 min in the test C304 and the lowest copper assay (0.45 %) of the fraction -37 µm of rougher tailing was achieved. In microscopical study of the fraction following observations were done:

Pyrite and pyrrhotite are the most common sulphides in the tailing, and they occur usually as free particles. Chalcopyrite sunk into the tailing occurs also mainly as liberated particles (Appendix 4).

The total recovery of copper was 95.6 % at concentrate grade 10.4 % Cu. Gold recovery was nearly the same as that of

copper in most the tests. The high gold assays in some of the coarse sieve fractions and in some tailing samples indicate the occurrence of coarse gold particles. As a whole the flotation results were not very sensitive to the grinding and that is why the collector tests were done on the coarsest grinding tested (10+10 min).

8. COLLECTOR TESTS

8.1 Dosage of Aerophine

In the test C305 a lower dosage of Aerophine 3418A was used. (40 g/t in rougher flotation and 20 g/t in scavenger flotation). Total recovery of copper in the combination of rougher and scavenger flotations was 94.1 % and concentrate grade 12.4 % Cu. In three stage open cleaning of the concentrate (RC+SC) the grade 17.9 % was achieved on the recovery 86.8 %. The gold assay of concentrate was 10.9 g/t and recovery 79.5 %. The estimated total copper recovery in closed circuit is 92 % at the concentrate grade 18 % Cu. The estimation is based on assumption that 2/3 of copper content of the cleaner tailings will be recovered in closed flotation circuit (Appendix 3/3). On the same estimation gold recovery will be about 88 % and concentrate grade 11 g/t.

8.2 Xanthate flotation

Sodium Amylxantahate (Säteri/Kemira) was tested as a collector in pH 10.5 and 11.0. The collector was added to conditioning after pH adjustment. Collector dosage was 80 g/t in rougher flotation and 40 g/t in scavenger flotation. Flotation results for copper were nearly the same as with Aerophine but for gold both the recovery and concentrate grade were clearly lower.

9. COARSE FLOTATION

Coarse flotation in the tests C308 and C309 was performed after 5 min grinding (14.5 % - 37 µm) with Sodium Amylxanthate in pH 10.0 and with Aerophine 3418A in natural pH.
Test results of xanthate flotation were poorer than in the comparison test C306 with 10 min grinding and pH 10.5.
The copper assay of the fraction -37 µm of rougher tailing in Aerophine flotation was slightly lower than in the comparison test C305 but the copper loss to scavenger tailing was higher so the total copper recovery was lower.
Also the results of gold flotation were slightly poorer in coarse flotation than in the comparison test with 10 min grinding time (20.8 % - 37 µm).

10. ANALYSIS OF THE FINAL CONCENTRATE

The concentrate (CC3) of test C305 was analysed by XRF for the 53 elements and As, Te, Sb, Bi were analysed with AAS. The tellurium assay is 0.014 % and all the others are below the detection limit of flame AAS method.

11. PROPOSAL FOR PROCESS DEVELOPMENT

The main problem in copper flotation of the Bidjovagge C3 ore is the formation of fine chalcopyrite in first grinding stage. Good classification and skim air type flotation of cyclone underflow will lower the loss of chalcopyrite to the fine fraction of rougher tailing. The clear indication of occurrence of coarse gold particles (Appendix 4) supports the adoption of gravity separation methods.

WULFF 200 MUOVIKIELIHAKEMISTO
PLASTTAB-REGISTER
218206/A4

1

2

3

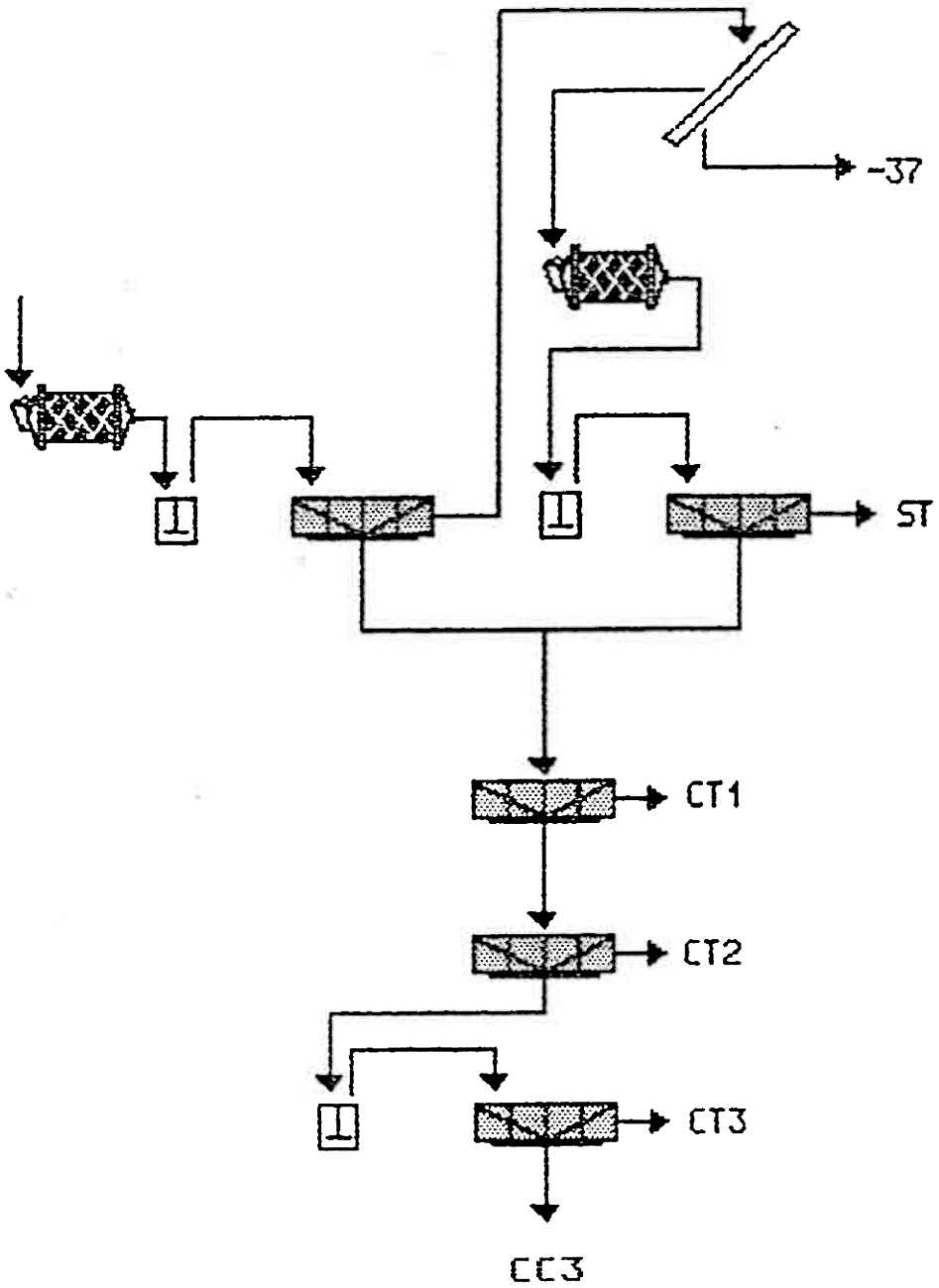
4

5

6

1

Flowsheet for tests C301-09



OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 14.8.1990

Sample — BIDJOVAGGE C3/S146A.S144G

Purpose — Grinding test 1

Test — C301

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	4.3	0.090	5.0	0.70	11.2	0.86	2.1
+74-105	10.3	0.060	8.1	0.99	38.1	0.88	5.1
+37-74	37.5	0.050	24.4	0.17	23.8	1.65	35.0
-37	47.9	0.100	62.5	0.15	26.8	2.13	57.8
Bulk	100	0.077	100	0.27	100	1.77	100

STEP	FEED	TIME			REAGENTS				CELL			pH	PRODUCT	WEIGHT		GRADES AND RECOVERIES									
																Cu		Au		S		Fe		C		Others	
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%	%	R-%
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm																
													FEED	1019	100.0	3.404	100.0	2.9	100.0	9.22	100.0	11.40	100.0	3.92	100.0	72.06	100.0
Rougher	ORE	15	1	6			30	60	2.0	1.5	1500	9.0	RC RT														
Classif.	RT												+37 -37	257	25.2	0.740	5.5	0.40	3.5	2.60	7.1	5.81	12.8	3.98	25.6	86.87	30.3
Scaveng.	RT +37	15	1	9			20	40	2.0	1.5	1500	9.0	SC ST	470	46.1	0.100	1.4	1.07	16.9	1.09	5.5	5.55	22.5	5.01	59.0	88.25	56.5
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	203 90	19.9 8.8	14.992 2.180	87.5 5.7	11.0 1.53	75.0 4.6	37.77 6.30	81.4 6.0	32.83 9.67	57.2 7.5	1.06 4.46	5.4 10.1	13.35 77.39	3.7 9.5
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	184 19	18.0 1.9	16.194 3.390	85.7 1.9	11.9 2.62	73.3 1.7	40.26 13.79	78.6 2.8	34.46 17.00	54.4 2.8	0.76 3.99	3.5 1.9	8.33 61.83	2.1 1.6
3:d clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	173 11	16.9 1.1	16.900 5.120	84.0 1.6	12.20 6.49	70.9 2.4	41.07 27.49	75.4 3.2	34.80 29.20	51.7 2.8	0.66 2.30	2.9 0.6	6.57 35.89	1.5 0.5
													RC+SC	293	28.7	11.050	93.2	8.08	79.6	28.09	87.4	25.70	64.7	2.11	15.4	33.05	13.2
													ST+ -37	727	71.3	0.326	6.8	0.83	20.4	1.62	12.6	5.64	35.3	4.65	84.6	87.76	86.8

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 14.8.1990

Sample — BIDJOVAGGE C3/S146A,S144G

Purpose — Grinding test 2

Test — C302

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	1.0	0.100	1.4	0.200	0.5	1.48	0.8
+74-105	4.4	0.070	4.3	2.680	32.0	2.10	5.0
+37-74	29.5	0.050	20.8	0.490	39.2	1.99	32.0
-37	65.1	0.080	73.4	0.16	28.3	1.75	62.1
Bulk	100	0.071	100	0.369	100	1.83	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					Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	1001	100.0	3.396	100.0	2.1	100.0	8.84	100.0	11.651	100.0	3.9	100.0	72.18	100.0
Rougher	ORE	20	1	6			30	60	2.0	1.5	1500	9.0	RC RT														
Classif.	RT												+37 -37	296	29.5	0.580	5.0	0.19	2.7	2.80	9.4	5.620	14.2	4.11	30.9	86.89	35.5
Scaveng.	RT +37	20	1	9			20	40	2.0	1.5	1500	9.0	SC ST	423	42.3	0.110	1.4	0.15	3.0	1.49	7.1	6.660	24.2	5.02	54.0	86.72	50.8
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	196 87	19.6 8.6	15.558 1.530	89.7 3.9	9.76 0.85	90.8 3.5	35.17 5.76	77.9 5.6	32.893 8.530	55.3 6.3	1.04 4.54	5.2 10.0	15.34 79.64	4.2 9.5
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	174 22	17.4 2.2	17.043 3.810	87.2 2.5	10.70 2.35	88.4 2.5	37.65 15.55	74.0 3.9	34.675 18.800	51.7 3.5	0.70 3.78	3.1 2.1	9.94 58.06	2.4 1.8
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	160 15	15.9 1.4	18.200 4.320	85.4 1.8	11.4 3.0	86.2 2.1	37.96 34.19	68.4 5.6	34.800 33.300	47.6 4.1	0.6 1.9	2.4 0.7	8.45 26.32	1.9 0.5
													RC+SC	283	28.2	11.263	93.6	7.0	94.3	26.16	83.5	25.433	61.6	2.1	15.2	35.03	13.7
													ST+ -37	719	71.8	0.303	6.4	0.2	5.7	2.03	16.5	6.232	38.4	4.6	84.8	86.79	86.3

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 15.8.1990

Sample — BIDJOVAGGE C3/S146A.S144G

Purpose — Grinding test 3

Test — C303

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
mm	%	%	R-%	g/t	R-%	%	R-%
+105	0.7	0.110	0.8	0.200	0.8	2.84	1.0
+74-105	2.5	0.100	2.7	0.140	2.0	0.97	1.2
+37-74	22.5	0.070	16.9	0.280	36.6	1.87	21.0
-37	74.3	0.100	79.6	0.140	60.5	2.07	76.8
Bulk	100	0.093	100	0.172	100	2.00	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					Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	1019	100.0	3.444	100.0	2.3	100.0	9.47	100.0	11.562	100.0	4.0	100.0	71.56	100.0
Rougher	ORE	25	1	6			30	60	2.0	1.5	1500	8.9	RC RT														
Classif.	RT												+37 -37	354	34.7	0.670	6.8	0.16	2.4	3.50	12.8	6.160	18.5	4.1	36.0	85.56	41.5
Scaveng.	RT +37	25	1	9			20	40	2.0	1.5	1500	8.9	SC ST	378	37.1	0.150	1.6	0.15	2.4	2.95	11.6	6.980	22.4	5.1	48.1	84.78	44.0
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	186 101	18.3 9.9	16.306 1.810	86.4 5.2	11.6 0.74	92.0 3.2	36.15 5.69	69.7 6.0	32.811 8.510	51.8 7.3	1.0 4.5	4.5 11.4	13.74 79.45	3.5 11.0
2nd clean.	CC1		1	5					1.6	1.5	1200		CC2 CT2	164 23	16.0 2.2	17.934 4.480	83.5 2.9	12.9 2.46	89.6 2.4	39.05 15.15	66.1 3.5	34.863 17.900	48.4 3.4	0.6 3.8	2.4 2.1	7.56 58.69	1.7 1.8
3rd clean.	CC2		1	4					1.0	1.5	1000		CC3 CT3	150 14	14.7 1.4	19.000 6.550	80.9 2.6	13.60 5.13	86.6 3.1	39.40 35.26	61.0 5.1	35.000 33.400	44.4 4.0	0.5 1.6	1.9 0.5	6.09 23.21	1.2 0.4
													RC+SC	287	28.2	11.205	91.6	7.79	95.2	25.43	75.6	24.259	59.1	2.2	15.9	36.87	14.5
													ST+ -37	732	71.8	0.401	8.4	0.15	4.8	3.22	24.4	6.583	40.9	4.6	84.1	85.16	85.5

APPENDIX 2/4

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 20.8.1990

Sample — BIDJOVAGGE C3/S146A,S144G

Purpose — Grinding test 4

Test — C304

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
mm	%	%	R-%	g/t	R-%	%	R-%
+105	12.5	0.120	21.8	8.530	76.1	1.61	9.3
+74-105	18.0	0.050	13.1	0.220	2.8	1.78	14.8
+37-74	35.6	0.040	20.7	0.640	16.3	3.83	63.1
-37	33.9	0.090	44.4	0.200	4.8	0.81	12.7
Bulk	100	0.069	100	1.401	100	2.16	100

STEP	FEED	TIME			REAGENTS				CELL			pH	PRODUCT	WEIGHT		GRADES AND RECOVERIES										Fe		C		Others	
																Cu		Au		S											
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%	g/t	R-%	%	R-%
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm																				
													FEED	1027	100.0	3.153	100.0	3.2	100.0	9.91	100.0	11.674	100.0	3.9	100.0	71.36	100.0				
Rougher	ORE	10	1	6			30	60	2.0	1.5	1500	8.9	RC RT																		
Classif.	RT												+37 -37	200	19.4	0.450	2.8	0.23	1.4	2.46	4.8	4.370	7.3	4.0	19.8	88.74	24.2				
Scaveng.	RT +37	10	1	9			20	40	2.0	1.5	1500	8.9	SC ST	531	51.7	0.100	1.6	0.17	2.8	1.82	9.5	5.100	22.6	5.0	65.9	88.01	63.8				
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	232 65	22.6 6.3	12.927 1.570	92.5 3.1	13.1 1.41	93.0 2.8	36.09 5.60	82.1 3.6	33.696 9.350	65.1 5.0	1.2 4.5	7.0 7.2	16.07 79.01	5.1 7.0				
2nd clean.	CC1		1	5					2.0	1.5	1500		CC2 CT2	208 24	20.2 2.3	14.066 2.940	90.3 2.2	14.1 4.34	89.9 3.2	38.43 15.57	78.5 3.6	35.109 21.300	60.9 4.2	0.9 3.6	4.9 2.1	11.45 56.59	3.2 1.8				
3rd clean.	CC2		1	4					1.6	1.5	1200		CC3 CT3	193 15	18.8 1.4	14.700 5.620	87.8 2.5	14.70 5.73	87.3 2.6	39.40 25.49	74.9 3.6	35.500 29.900	57.3 3.6	0.8 2.4	4.1 0.9	9.56 36.61	2.5 0.7				
													RC+SC	296	28.8	10.453	95.6	10.54	95.8	29.45	85.7	28.390	70.1	1.9	14.3	29.78	12.0				
													ST+ -37	731	71.2	0.196	4.4	0.19	4.2	1.99	14.3	4.901	29.9	4.7	85.7	88.21	88.0				

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 21.8.1990

Sample — BIDJOVAGGE C3/S146A.S144G

Purpose — Collector dosage

Test — C305

Sieve fractions of the scavenge: tails

Fraction	Weight	Cu		Au		S	
mm	%	%	R-%	g/t	R-%	%	R-%
+105			ERR		ERR		ERR
+74-105			ERR		ERR		ERR
+37-74			ERR		ERR		ERR
-37			ERR		ERR		ERR
Bulk	0	ERR	ERR	ERR	ERR	ERR	ERR

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					Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	998	100.0	3.573	100.0	2.4	100.0	9.07	100.0	11.538	100.0	3.9	100.0	71.89	100.0
Rougher	ORE	10	1	9			30	40	2.0	1.5	1500	8.9	RC RT														
Classif.	RT												+37 -37	208	20.8	0.610	3.6	0.20	1.8	2.15	4.9	5.110	9.2	4.1	21.7	88.03	25.5
Scaveng.	RT +37	10	1	9			20	20	2.0	1.5	1500	8.9	SC ST	520	52.1	0.160	2.3	0.30	6.6	1.98	11.4	5.460	24.7	5.0	65.6	87.45	63.4
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1 CT1	209 62	20.9 6.2	15.565 1.800	91.0 3.1	9.9 1.80	87.0 4.7	34.54 6.06	79.6 4.1	33.676 9.620	61.0 5.1	1.1 4.4	5.8 6.9	15.13 78.11	4.4 6.7
2nd clean.	CC1		1	5					2.0	1.5	1500		CC2 CT2	189 20	18.9 2.0	16.815 3.450	89.1 1.9	10.5 3.80	83.9 3.1	36.39 16.69	76.0 3.6	34.984 21.000	57.4 3.6	0.8 3.5	4.0 1.8	10.98 55.33	2.9 1.5
3rd clean.	CC2		1	4					1.6	1.5	1200		CC3 CT3	173 16	17.3 1.6	17.900 5.080	86.8 2.3	10.90 6.40	79.5 4.3	37.21 27.47	71.1 4.9	35.500 29.400	53.3 4.1	0.7 2.4	3.0 1.0	8.70 35.61	2.1 0.8
													RC+SC	270	27.1	12.429	94.1	8.05	91.7	28.06	83.7	28.196	66.1	1.8	12.7	29.47	11.1
													ST+ -37	728	72.9	0.289	5.9	0.27	8.3	2.03	16.3	5.360	33.9	4.7	87.3	87.62	88.9

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT — Date 24.8.1990

Sample — BIDJOVAGGE C3/S146A.S144G

Purpose — Xanthate flotation/pH 10.5

Test — C306

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	12.8	0.110	23.0	2.860	63.3	0.29	35.8
+74-105	17.9	0.050	14.6	0.510	15.8	0.12	20.7
+37-74	34.4	0.040	22.5	0.160	9.5	0.05	16.6
-37	34.9	0.070	39.9	0.190	11.5	0.08	26.9
Bulk	100	0.061	100	0.579	100	0.10	100

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES											
																Cu		Au		S		Fe		C		Others	
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm																
													FEED	1004	100.0	3.496	100.0	2.3	100.0	8.78	100.0	12.144	100.0	4.0	100.0	71.55	100.0
Rougher	ORE	10	5	9	0.35	80	30		2.0	1.5	1500	10.5	RC														
													RT														
Classif.	RT												+37														
													-37	202	20.1	0.490	2.8	0.30	2.6	1.03	2.4	4.020	6.7	4.3	21.4	90.16	25.3
Scaveng.	RT +37	10	5	9	0.25	40	20		2.0	1.5	1500	10.5	SC														
													ST	494	49.2	0.090	1.3	0.60	12.9	0.25	1.4	4.520	18.3	5.2	63.4	89.95	61.9
1st clean.	RC+SC		1	5	0.15				2.0	1.5	1500	10.5	CC1	225	22.4	14.188	91.0	7.8	76.2	34.23	87.4	34.726	64.1	1.2	6.6	15.67	4.9
													CT1	83	8.3	2.070	4.9	2.30	8.3	9.35	8.8	16.000	10.9	4.2	8.6	68.41	7.9
2nd clean.	CC1		1	5	0.10				2.0	1.5	1500	10.5	CC2	199	19.8	15.566	88.3	8.3	71.5	36.41	82.3	35.617	58.2	0.9	4.5	11.49	3.2
													CT2	26	2.6	3.630	2.7	4.10	4.6	17.55	5.2	27.900	5.9	3.2	2.1	47.69	1.7
3rd clean.	CC2		1	4	0.10				1.6	1.5	1200	10.5	CC3	180	17.9	16.500	84.6	8.30	65.0	37.59	76.8	35.800	52.9	0.8	3.4	9.34	2.3
													CT3	19	1.9	6.810	3.7	7.90	6.6	25.31	5.5	33.900	5.3	2.4	1.1	31.63	0.8
													RC+SC	308	30.7	10.925	95.9	6.30	84.5	27.53	96.2	29.683	75.0	2.0	15.2	29.87	12.8
													ST+ -37	696	69.3	0.206	4.1	0.51	15.5	0.48	3.8	4.375	25.0	4.9	84.8	90.01	87.2

APPENDIX 27

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT

Date 24.8.1990

Sample BIDJOVAGGE C3/S146A,S144G

Purpose Xanthate flotation/pH 11.0

Test C307

Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
mm	%	%	R-%	g/t	R-%	%	R-%
+105			ERR		ERR		ERR
+74-105			ERR		ERR		ERR
+37-74			ERR		ERR		ERR
-37			ERR		ERR		ERR
Bulk	0	ERR	ERR	ERR	ERR	ERR	ERR

STEP	FEED	TIME			REAGENTS				CELL			pH	PRODUCT	WEIGHT		GRADES AND RECOVERIES											
																Cu		Au		S		Fe		C		Others	
		Grin	Cond	Flot	Ca(OH)2	NAX	Dow-froth 210	Aero-phine 3418A	Vol	Air	Speed			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm																
													FEED	1011	100.0	3.192	100.0	2.4	100.0	8.48	100.0	11.811	100.0	4.1	100.0	72.46	100.0
Rougher	ORE	10	5	9	0.50	80	30		2.0	1.5	1500	11.0	RC RT														
Classif.	RT												+37 -37	193	19.1	0.620	3.7	0.40	3.2	0.29	0.7	4.280	6.9	4.2	19.7	90.61	23.9
Scaveng.	RT +37	10	5	9	0.30	40	20		2.0	1.5	1500	11.0	SC ST	504	49.8	0.090	1.4	0.70	14.7	0.26	1.5	4.840	20.4	5.2	63.3	89.65	61.6
1st clean.	RC+SC		1	5	0.25				2.0	1.5	1500	11.0	CC1 CT1	222 93	21.9 9.2	13.261 1.340	91.0 3.9	8.0 2.10	73.9 8.1	34.60 7.75	89.4 8.4	33.386 13.800	61.9 10.7	1.3 4.3	7.2 9.7	17.41 72.81	5.3 9.2
2nd clean.	CC1		1	5	0.15				2.0	1.5	1500	11.0	CC2 CT2	194 28	19.1 2.8	14.662 3.580	87.9 3.1	8.5 4.30	68.9 5.0	37.11 17.22	83.8 5.6	34.614 24.900	56.1 5.8	1.0 3.6	4.8 2.4	12.59 50.75	3.3 1.9
3rd clean.	CC2		1	4	0.15				1.6	1.5	1200	11.0	CC3 CT3	180 14	17.8 1.3	15.300 6.150	85.3 2.6	8.70 6.30	65.3 3.5	38.11 23.82	80.0 3.8	34.900 30.800	52.6 3.5	0.9 2.7	3.9 0.9	10.79 36.56	2.7 0.7
													RC+SC	315	31.1	9.736	94.9	6.25	82.1	26.66	97.8	27.594	72.7	2.2	17.0	33.79	14.5
													ST+ -37	697	68.9	0.237	5.1	0.62	17.9	0.27	2.2	4.685	27.3	4.9	83.0	89.92	85.5

APPENDIX 2/8

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT

Date 24.8.1990

Sample BIDJOVAGGE C3/S146A,S144G

Purpose Coarse flotation by Xanthate/pH 10.0

Test C308

Sieve fractions of the scavenger tails

Fraction µm	Weight %	Cu %	Cu R-%	Au g/t	Au R-%	S %	S R-%
+105	7.5	0.120	9.3	12.000	68.0	0.24	7.4
+74-105	15.0	0.070	10.9	1.000	11.3	0.31	19.2
+37-74	29.4	0.050	15.2	0.600	13.3	0.21	25.5
-37	48.1	0.130	64.6	0.200	7.3	0.24	47.8
Bulk	100	0.097	100	1.323	100	0.24	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	992	100.0	3.187	100.0	2.4	100.0	8.56	100.0	11.673	100.0	4.0	100.0	72.57	100.0
Rougher	ORE	5	5	9	0.20	80	30		2.0	1.5	1500	10.0	RC RT														
Classif.	RT												+37 -37	159	16.0	0.560	2.8	0.50	3.3	0.42	0.8	4.260	5.9	4.3	17.3	90.44	20.0
Scaveng.	RT +37	15	5	9	0.12	40	20		2.0	1.5	1500	10.0	SC ST	548	55.2	0.160	2.8	0.40	9.2	0.22	1.4	4.500	21.3	5.1	69.9	90.04	68.5
1st clean.	RC+SC		1	5	0.08				2.0	1.5	1500	10.0	CC1	217	21.9	13.175	90.5	8.9	81.2	35.44	90.6	34.380	64.5	1.1	6.0	15.91	4.8
													CT1	68	6.9	1.830	3.9	2.20	6.3	8.92	7.1	14.300	8.4	4.0	6.8	70.95	6.7
2nd clean.	CC1		1	5	0.08				2.0	1.5	1500	10.0	CC2	196	19.7	14.187	87.8	9.6	78.5	37.09	85.5	35.246	59.5	0.9	4.4	12.58	3.4
													CT2	22	2.2	3.970	2.7	3.00	2.7	20.44	5.2	26.500	4.9	2.9	1.6	46.19	1.4
3rd clean.	CC2		1	4	0.08				1.6	1.5	1200	10.0	CC3	180	18.2	14.900	84.9	10.00	75.4	38.05	80.7	35.500	55.2	0.8	3.5	10.77	2.7
													CT3	16	1.6	5.910	2.9	4.90	3.2	25.91	4.7	32.300	4.3	2.3	0.9	33.60	0.7
													RC+SC	285	28.7	10.468	94.4	7.33	87.5	29.11	97.8	29.589	72.9	1.8	12.8	29.04	11.5
													ST+ -37	707	71.3	0.250	5.6	0.42	12.5	0.27	2.2	4.446	27.1	4.9	87.2	90.13	88.5

OUTOKUMPU
Mining Services
Geoanalytical Laboratory

FLOTATION REPORT

Date 29.8.1990

Sample BIDJOVAGGE C3/S146A,S144G

Purpose Coarse flotation by Aerophine

Test C309

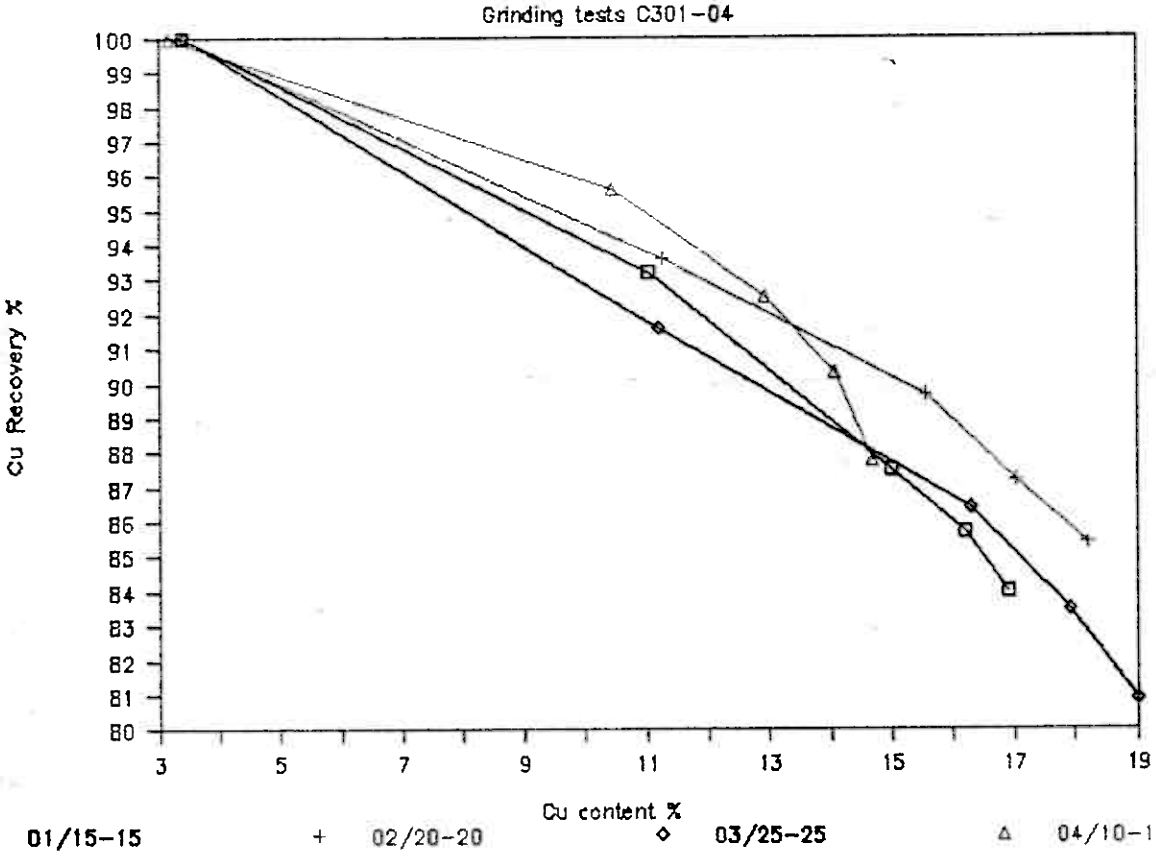
Sieve fractions of the scavenger tails

Fraction	Weight	Cu		Au		S	
µm	%	%	R-%	g/t	R-%	%	R-%
+105	8.6	0.570	18.5	0.700	10.7	2.64	13.1
+74-105	15.6	0.360	21.2	1.100	30.6	2.56	23.1
+37-74	29.6	0.120	13.4	0.800	42.2	1.34	22.9
-37	46.2	0.270	47.0	0.200	16.5	1.53	40.9
Bulk	100	0.265	100	0.561	100	1.73	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					Cu		Au		S		Fe		C		Others	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm			g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	g/t	R-%	%	R-%
													FEED	992	100.0	3.350	100.0	2.0	100.0	9.25	100.0	12.032	100.0	4.0	100.0	71.34	100.0
Rougher	ORE	5	1	9			30	40	2.0	1.5	1500	8.6	RC														
													RT														
Classif.	RT												+37														
													-37	144	14.5	0.510	2.2	0.60	4.4	2.09	3.3	5.030	6.1	4.3	15.3	88.12	17.9
Scaveng.	RT +37	15	1	9			20	20	2.0	1.5	1500		SC														
													ST	580	58.5	0.350	6.1	0.40	11.7	2.57	16.2	6.000	29.2	4.9	71.7	86.14	70.6
1st clean.	RC+SC		1	5					2.0	1.5	1500		CC1	195	19.7	14.902	87.4	8.0	78.7	35.12	74.6	35.532	58.0	1.1	5.1	13.40	3.7
													CT1	73	7.4	1.930	4.2	1.40	5.2	7.35	5.8	11.000	6.7	4.3	7.8	75.44	7.8
2nd clean.	CC1		1	5					2.0	1.5	1500		CC2	176	17.7	16.066	84.8	8.4	74.4	36.96	70.7	36.947	54.3	0.8	3.6	9.21	2.3
													CT2	20	2.0	4.420	2.6	4.40	4.3	18.50	3.9	22.800	3.7	3.3	1.6	51.03	1.4
3rd clean.	CC2		1	4					1.6	1.5	1200		CC3	165	16.6	16.600	82.4	8.50	70.9	37.53	67.5	37.300	51.6	0.7	3.0	7.84	1.8
													CT3	11	1.1	7.680	2.4	6.60	3.5	28.03	3.2	31.400	2.8	2.1	0.5	30.82	0.5
													RC+SC	268	27.0	11.368	91.7	6.19	83.9	27.55	80.5	28.850	64.8	1.9	13.0	30.30	11.5
													ST+ -37	724	73.0	0.382	8.3	0.44	16.1	2.47	19.5	5.807	35.2	4.8	87.0	86.53	88.5

BIDJOVAGGE C3 ORE

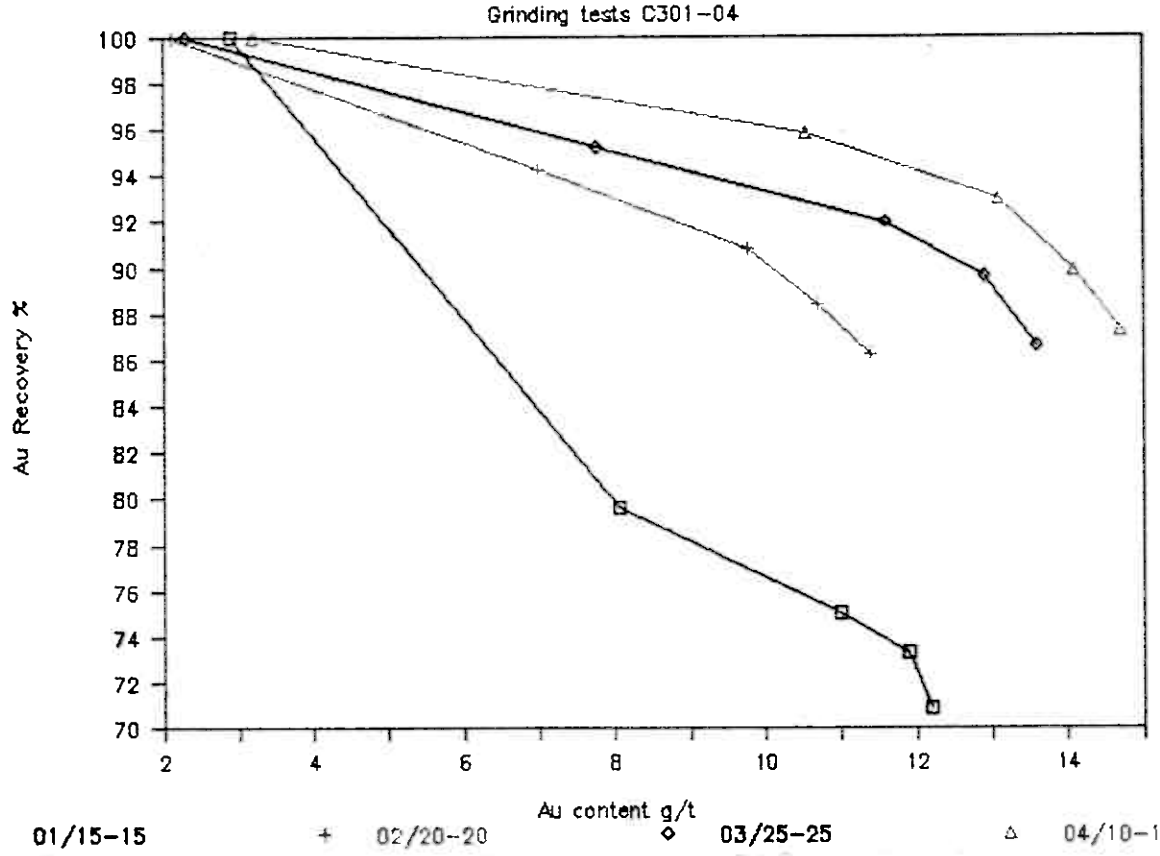
Grinding tests C301-04



01/15-15 + 02/20-20 ◇ 03/25-25 △ 04/10-10

BIDJOVAGGE C3 ORE

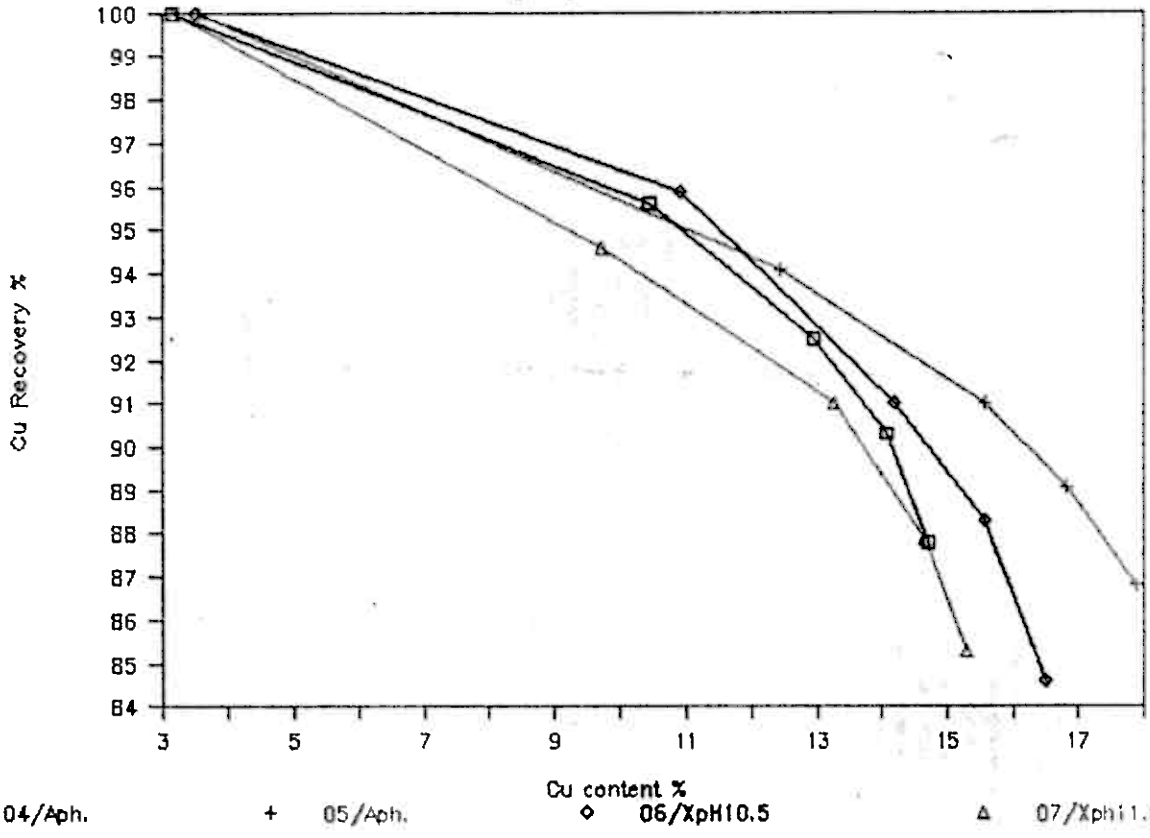
Grinding tests C301-04



01/15-15 + 02/20-20 ◇ 03/25-25 △ 04/10-10

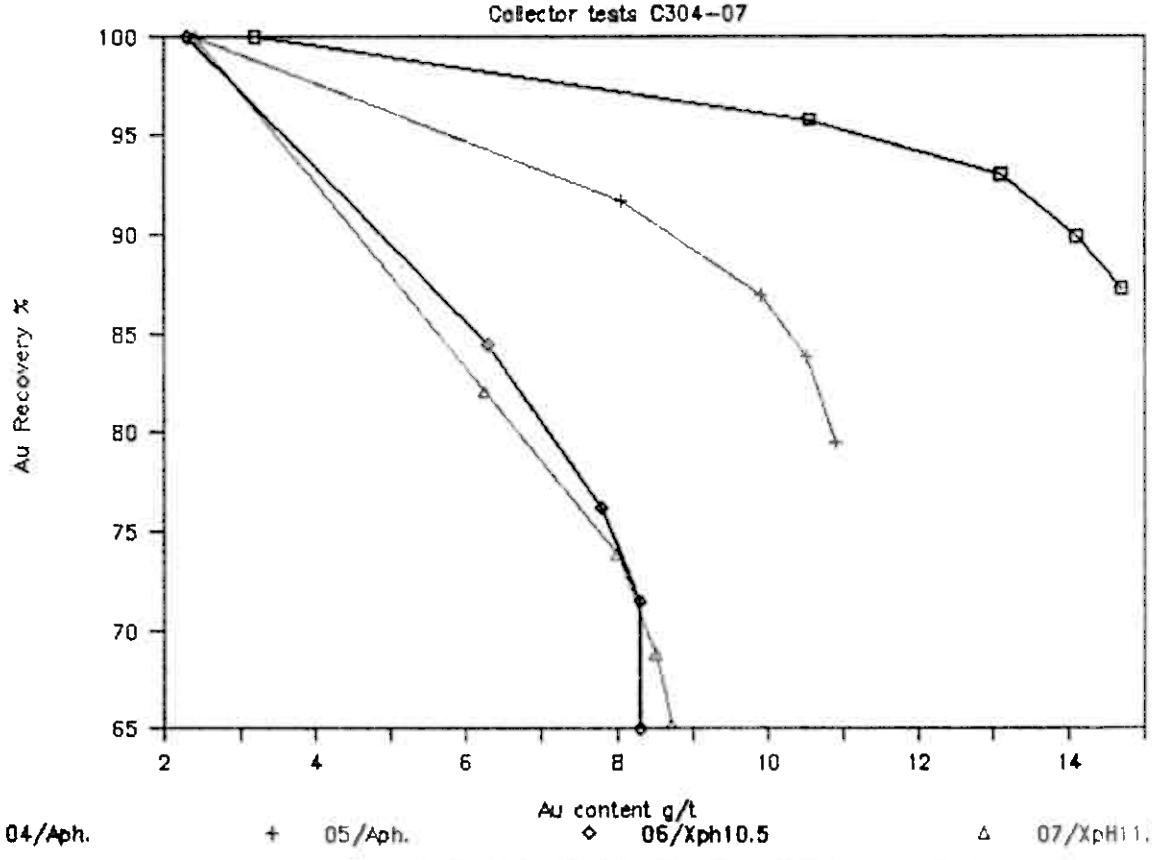
BIDJOVAGGE C3 ORE

Collector tests C304-07



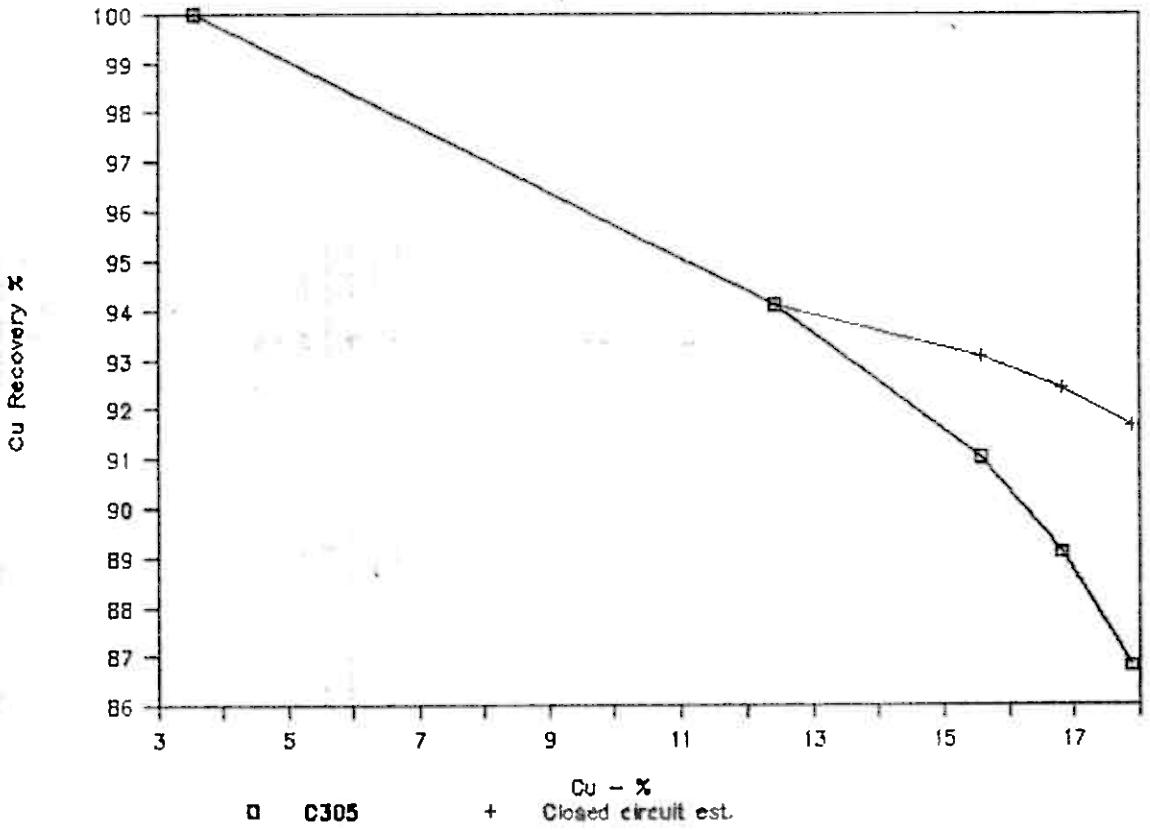
BIDJOVAGGE C3 ORE

Collector tests C304-07



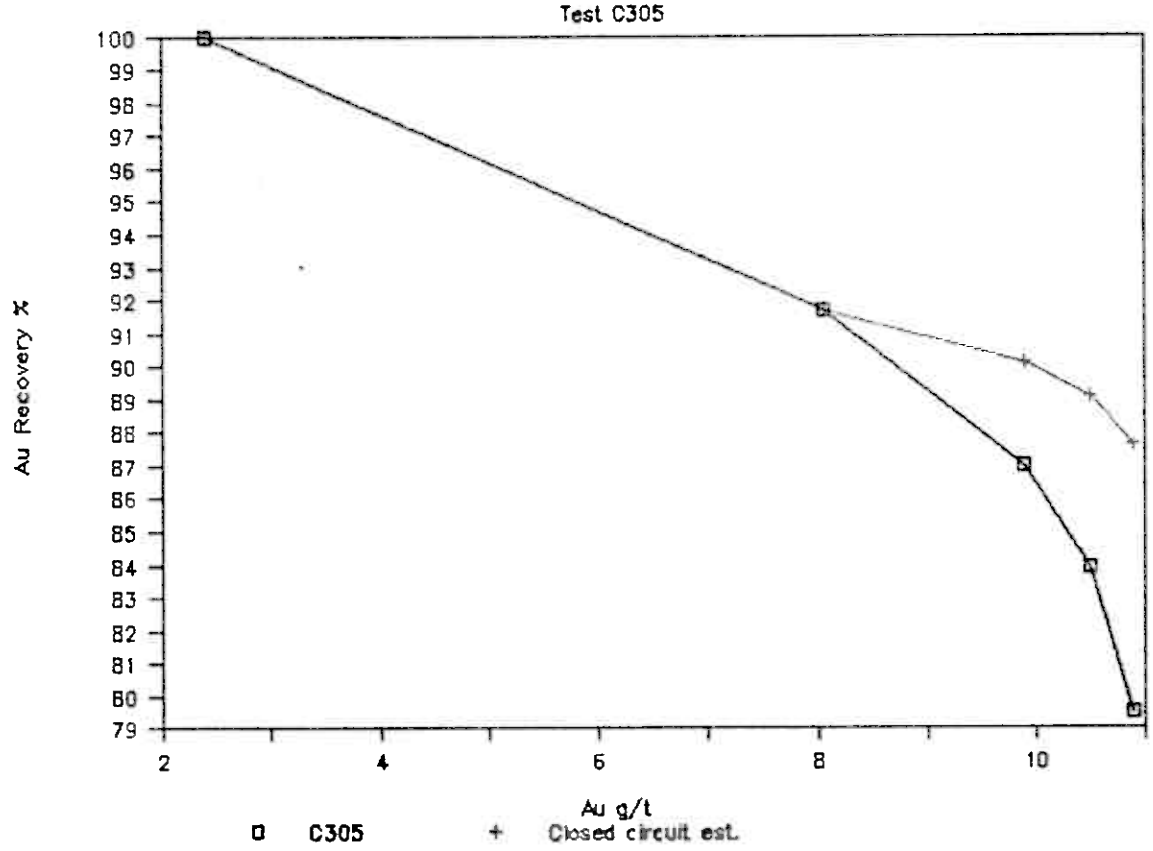
BIDJOVAGGE C3 ORE

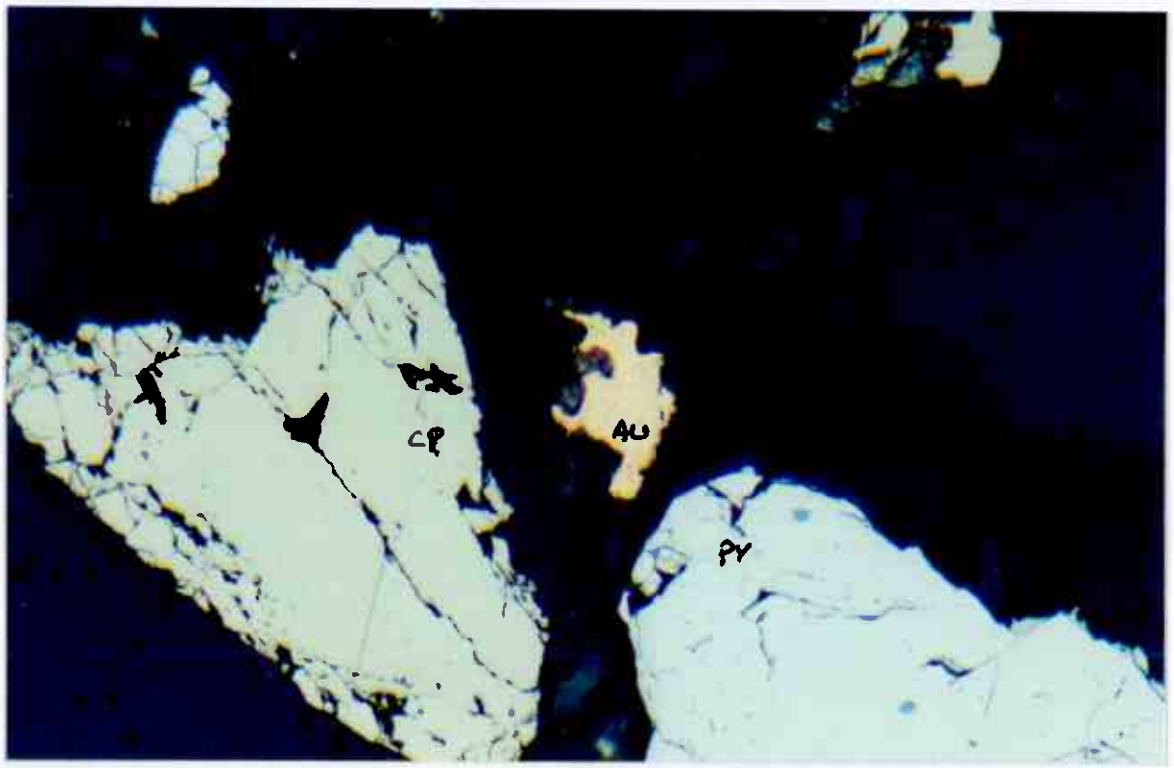
Test C305



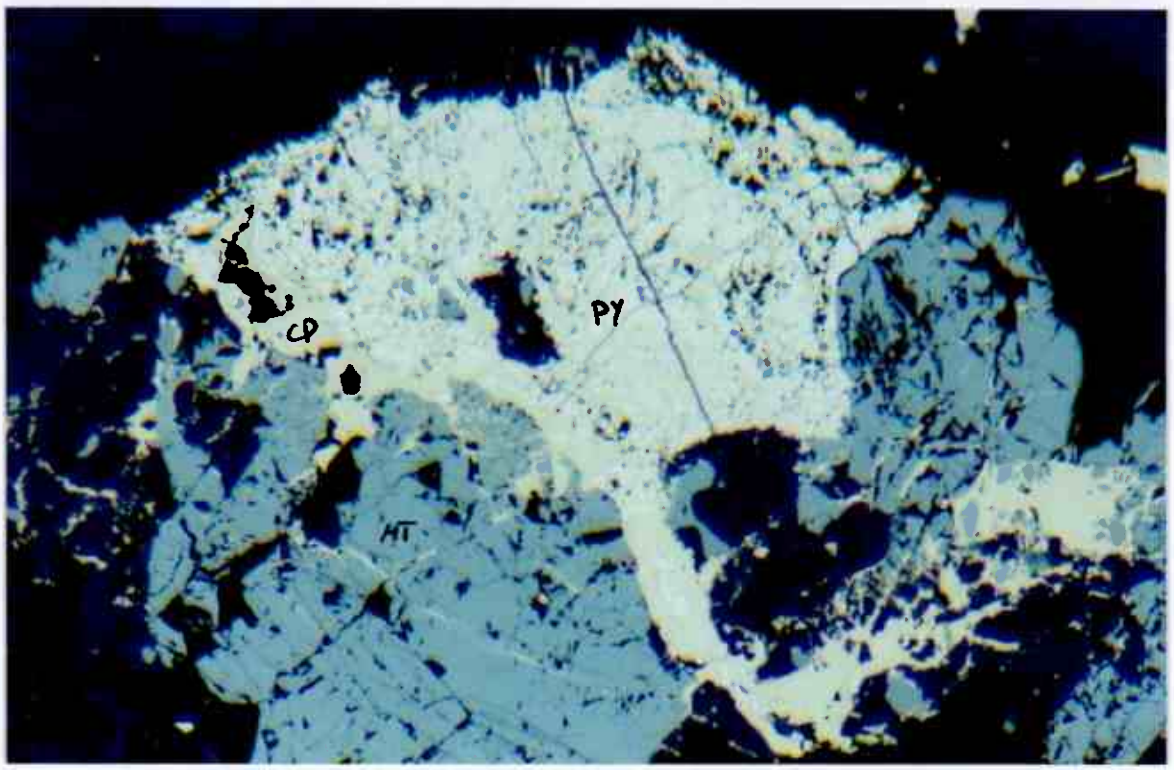
BIDJOVAGGE C3 ORE

Test C305

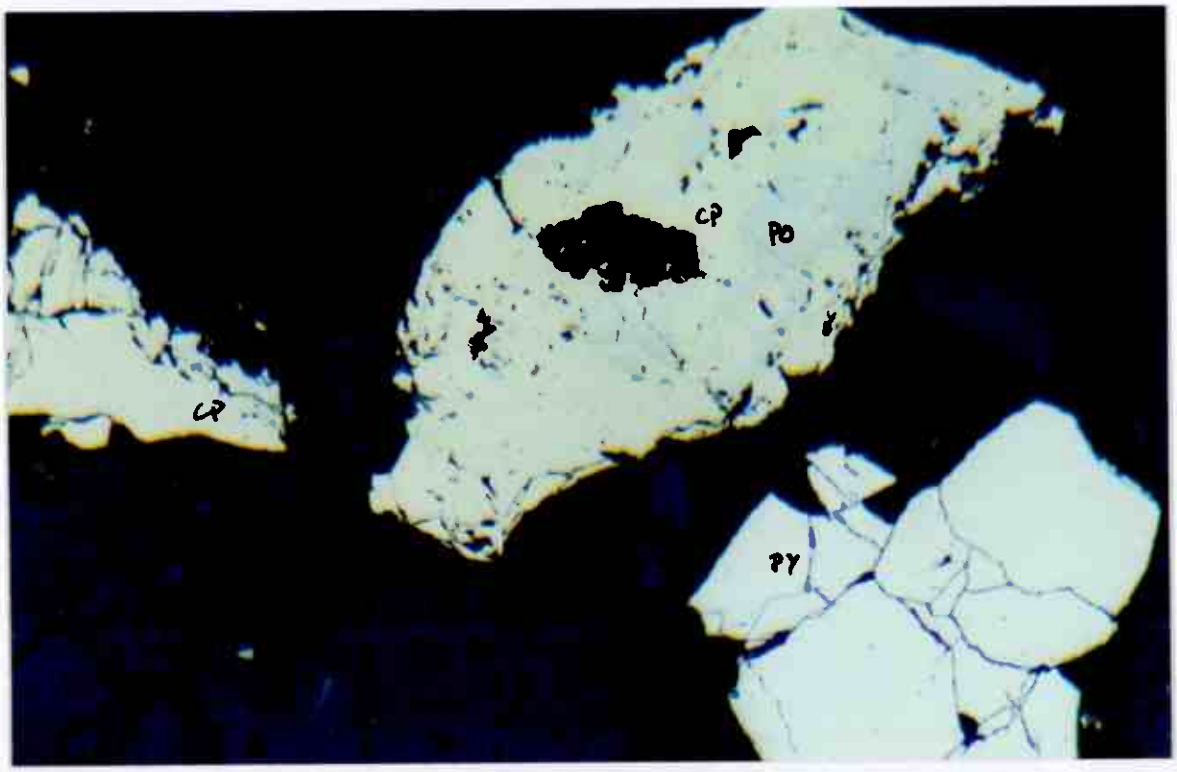




Bidjovagge C3, feed. A locked particle consisting of native gold (AU) and gangue minerals. CP = chalcopyrite and PY = pyrite. Magnification 170x.



Bidjovagge C3, feed. An ore particle consisting of chalcopyrite (CP), pyrite (PY), magnetite (MT) and gangue minerals (black). Chalcopyrite occurs also as fracture fillings in pyrite, magnetite and gangue. Magnification 170x.



Bidjovagge C3, feed. An ore particle consisting of chalcopyrite (CP), pyrrhotite (PO) and gangue minerals (black). PY = pyrite. Magnification 170x.

Bidjovagge C3, C304/-37 µm. Chalcopyrite (CP) occurs usually as free particles. PY = pyrite. Magnification 340x.

APPENDIX 5

OUTOKUMPU OY, MINING SERVICES, GEOANALYYTTINEN LABORATORIO
XRF-ANALYYSITULOKSIA 13.09.90

TILAAJA: PALOSAARI/GAL LASK.P: OPER: MLM 97
ALUE: BIDJO C30S/CC3 KARTTAL.: JAKELU: VIP, IAH

	9090065
	%
C	
F	
NA	0.06
MG	0.61
AL	0.480
SI	1.90
P	0.005
S	38.1
CL	0.012
K	0.014
CA	1.25
TI	0.0545
V	0.0075
CR	0.0058
MN	0.0387
FE	35.23
CO	0.212
NI	0.0817
CU	16.37
ZN	0.0300
GA	0.0000
AS	0.0116
BR	0.0000
RB	0.0006
SR	0.0004
Y	0.0004
ZR	0.0020
NB	0.0000
MO	0.0058
AG	0.000
SN	0.000
SB	0.000
TE	0.000
CS	0.007
BA	0.007
LA	0.007
CE	0.002
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	0.00
TM	0.01
YB	0.00
LU	0.00
HF	0.000
TA	0.015
W	0.000
PB	0.023
BI	0.000
TH	0.0000
U	0.0026

As < 0.01 % / AAS FLAME

Te 0.0135 % / AAS FLAME

Bi < 0.004 % / AAS FLAME

Sb < 0.01 % / AAS FLAME

6