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LABORATORY FROTH FLOTATION TESTWORK OF BIDJOVAGGE B-VEST ORE II

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Archives

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1. SUMMARY

An other sample of Bidjovagge B-vest ore from the drill hole N94G was submitted to Geoanalytical Laboratory for froth flotation tests.

The average elemental assays of the sample were: Cu 0.54 %, Au 9.5 g/t, S 1.80 % and Te 0.055 %.

The elemental assays of the earlier sample from the drill hole N98D were: Cu 0.31 %, Au 26.0 g/t, S 0.88 % and Te 0.062 %. The predominant gold bearing mineral was calaverite $AuTe_2$ and only about 15 % of the total gold occurs as native gold.

Lime conditioning at pH 12.0 in Aerophine 3418A flotation depressed tellurium minerals very selectively. In separation flotation with two open cleanings the grade of copper concentrate was 25.0 % Cu and recovery 72.2 %. Tellurium assay of the concentrate was 0.090 %. The combined cleaner tailings of the separation flotation formed a gold-tellurium concentrate. The grades of concentrate were 405.5 g/t Au and 2.90 % Te and recoveries 63.6 % and 69.9 % respectively.

In the separation flotation test on the mixture of the ore samples nearly similar results were obtained. In that case the tellurium assay of copper concentrate was 0.208 %.

Based on the average grade of the ore (Cu 0.50 %, Au 8.0 g/t and Te 0.060 %) the estimated grade of copper concentrate is 26.0 % Cu, 80 g/t Au and 0.15 % Te and that of gold concentrate 4.7 % Cu, 340 g/t Au and 3.3 % Te. Total recovery for copper is 92.0 % and for gold 81.0 %.

0.54% Cu => 50t ≈ 5 MFIM
8g/t Au => 800g ≈ 40 MFIM
0.06% Te => 60t ≈ 15 MFIM

2. INTRODUCTION

An other sample of Bidjovagge B-vest ore from the drill hole N94G was received 27.10.1989 by Geoanalytical Laboratory of Outokumpu Mining Services from Mr. Markus Ekberg, Bidjovagge A/S for metallurgical tests by froth flotation.

The aim of the testwork was to compare the flotation properties of the sample to those of the earlier sample of B-vest ore from the drill hole N98D and to estimate concentrate grade and recoveries for the mixture of these two samples. Shaking table test was done for the rougher concentrate to check the possibilities to use gravity separation for the concentration of tellurium minerals. There was technical problems with the laboratory shaking table and that is why the results of the test are not reported here. Later, when it was found that conditioning in high pH depressed tellurium minerals very selectively in Aerophine 3418A flotation also separation tests on the sample N94G and on the mixture were performed.

3. PREPARATION AND ANALYSIS OF FEED SAMPLE

The drill core sample was crushed to -3 mm by jaw and roll crusher, homogenised and divided by sample splitter to sub-samples of 8 kg which were further divided to 1 kg flotation test samples (flotation feed) by bottle divider and packed to plastic bags. The test samples were stored in a freezer to avoid oxidation. One 1000 g sample was prepared for analysis. The elemental assays were as follows:

	Cu (%)	Au (g/t)	S (%)	Te (%)
Bidjovagge B-vest N98D	0.31	26.0	0.88	0.062
B-vest N94G	0.54	9.5	1.8	0.055

4. MINERALOGY

No additional mineralogical study was performed on the sample N94G. Based on metallurgical test results it can be assumed that both the samples are mineralogically quite similar. Sulphide contents of the sample N94G is about 4 wt-%. The main sulphides are chalcopyrite (~1.5 %) and iron sulphides (~2.5 %).

The report of earlier mineralogical study on the sample N98D was as follows:

Sulphide contents of the mineralisation is about 2 wt-%. One half consists of chalcopyrite and the other half of iron sulphides mainly pyrite.

Native gold was hard to find even in the samples richest in gold. It occurs as fine grained (about 10-20 μm) dissemination in silicates and tellurides. The predominant gold mineral in the mineralisation is calaverite, AuTe_2 . According to microprobe investigation carried out on the cleaner concentrate (CC2) about 77 % of gold is in calaverite, about 19 % as native gold, and the rest 4 % in a bismuth bearing gold telluride (Table 1). The largest grain of gold mineral observed was 20*35 μm . About 78 % of gold is in mineral grains smaller than 20 μm and 22 % in grains smaller than 10 μm .

Table 1 Distribution of gold in cleaner concentrate (CC2).

Size (μm)	20-30	10-20	5-10	<5	Sum
Calaverite, AuTe_2	22.2	33.8	19.0	2.2	77.2
Native gold	-	18.5	-	0.5	19.1
AuBi-telluride	-	3.7	-	-	3.7
Total	22.2	56.0	19.0	2.7	100.0

The telluride content of the mineralisation is about 0.1 wt-%. Predominating tellurides are melonite, NiTe_2 , tellurobismuthite, Bi_2Te_3 and altaite, PbTe . The grain size of the main tellurides, especially that of melonite is relatively coarse, up to some hundred micrometers.

5. ANALYTICAL METHODS

The test products, and sieve fractions were analysed for gold by aqua regia dissolution and organic extraction by dibutylketone/dibutylsulfide. The determination was made by flame AAS. Sample weight 5 g was used when possible.

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 (1kg sample/500 ml water/6.8 kg iron balls). In two step grinding the tailing of coarse flotation was settled. The pulp density in regrinding was approximately similar to that in first grinding stage (50 %).

6.2. Conditioning

One to three minute conditioning times were used for frother. Rpm's 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 flotation cell of 1.6 l volume was used.

Aerophine 3418 A was used as collector and Dowfroth 210 as frother throughout the tests. Lime was used as pH regulator.

7. REGRINDING TESTS

In the regrinding test BV21 with grinding times of 20 minutes for both rougher and scavenger flotation very good floatability was achieved. Total recovery for copper after two open cleanings was 91.8 %, for gold 63.0 % and for tellurium 85.0 %. The concentrate assays were 17.6 % Cu, 178.9 g/t Au and 1.248 % Te. Addition of collector dosage and grinding time of scavenger flotation in the test BV22 didn't improve flotation results.

8. COARSE ROUGHER FLOTATION TESTS

In the coarse flotation tests BV23 and BV24 the goal was to float copper minerals before the liberation of tellurium minerals. The tests were only partly successful. Recovery of tellurium was clearly lower than that of copper but in every case the assay of tellurium was about 1.0 % in the second cleaner concentrate (CC2).

9. FLOTATION IN ELEVATED pH

In the tests BV25, BV26 and BV28 the flotation pH was elevated by lime. The lime was added to 10 min conditioning before collector addition. The flotation rate of tellurium

minerals and also gold were clearly lower in the higher pH. The effect was clearest in the test BV28 at pH 12.0. The grade of second cleaner concentrate (CC2) was 25.8 % Cu, 66.7 g/t Au and 0.112 Te %. Recoveries were 65.7 % for copper, 9.9 % for gold and 3.0 % for tellurium.

In the earlier tests on the sample N98D when Sodium Amyl-xanthate was used as collector elevation of pH to 11.5 didn't have any effect on the flotation of tellurium minerals. Possibly the depressive effect in xanthate flotation can be found at still higher pH levels and with bigger lime dosages. One reason can also be the addition of xanthate to grinding before pH regulation in the conditioning stage.

10. SEPARATION FLOTATION AT pH 12.0

Separation flotation tests were performed both on the sample N94G and on the mixture of samples (N98D/N94G 1:1). Rougher and scavenger concentrates were brought together, cleaned twice in open circuit and subjected to separation flotation after 15 min conditioning in pH 12.0. In the test BV29 on the sample N94G the grade of cleaner concentrate (CC4) was 25.0 % Cu, 97.6 g/t Au and 0.090 % Te. The recoveries were 72.2 %, 14.2 % and 2.0 % respectively (Appendix 3/2 and Appendix 4).

The separation flotation of the test BV30 on the sample mixture gave the results as follows:

	Cu		Au		Te	
	%	R-%	g/t	R-%	%	R-%
CC4 (Cu-conc.)	27.1	81.0	164	24.1	0.208	4.3
CT3+CT4(Au-conc.)	5.06	19.0	413	75.9	3.67	95.7
Total(Bulk conc.)	14.8	100.0	303	100.0	2.14	100.0

Copper concentrate (CC4) is a rather clean chalcopyrite fraction (fig 1, appendix 5/2). The mineral contents of the product is chalcopyrite 78 %, silicates 14 %, pyrite 7 % and tellurides less than 1 %. The carrier of gold in copper concentrate is calaverite, which occurs as composite particles with chalcopyrite.

Pyrite and silicates are predominating minerals in gold concentrate (fig. 2, appendix 5/2). Calculated mineral contents of the concentrate (CT3+CT4) is pyrite 42 %, silicates 38 %, chalcopyrite 15 %, melonite 5 % and other tellurides less than 1 %. Liberated calaverite and native gold are the main gold carriers in this product.

11. ESTIMATED PRODUCTS AND RECOVERIES

Based on the average grade of the ore (Cu 0.50 %, Au 8.0 g/t and Te 0.060 %) and on the test results of the tests BV29 and BV30 the estimated grades and recoveries of copper and gold-tellurium products has been calculated (Appendix 6). The grade of copper concentrate is 26.0 % Cu, 80 g/t Au and 0.15 % Te and that of gold concentrate 4.7 % Cu, ~340 g/t Au and 3.3 % Te. Total recovery of copper is 92.0 % and that of gold 81.0 %.

12. PROPOSAL FOR PROCESS DEVELOPMENT

The separation flotation of tellurium minerals has been very selective and the further development of the process is best to do on the concentrate samples from full scale test runs at the Bidjovagge concentrator. The pH sensitivity of the process, conditioning and need of regrinding are worth to check as well as the determination of mineralogical composition of the products.

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1

2

3

4

5

6

1

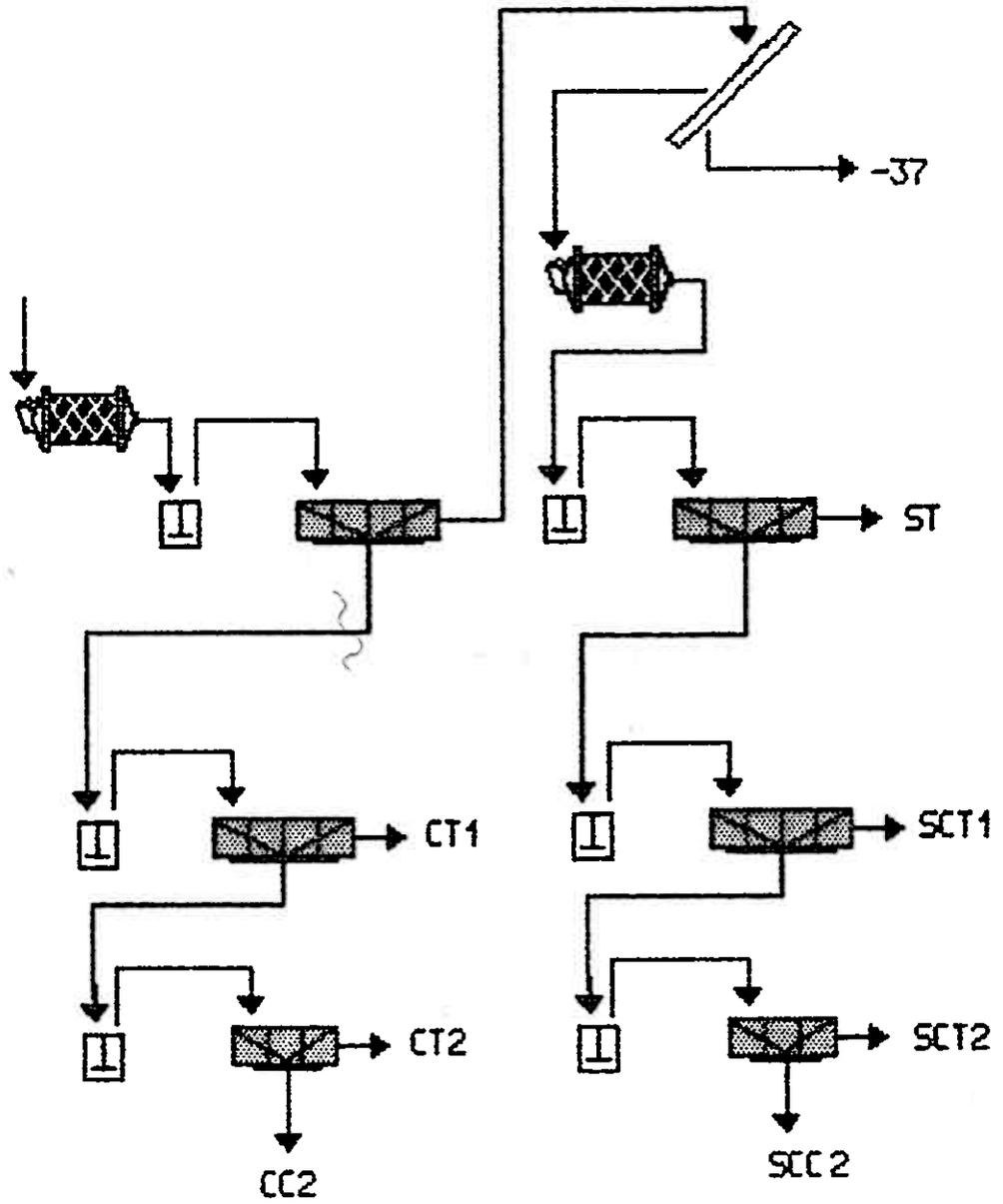
GUTOKUMPU OY, MINING SERVICES, GEONALYTTINEN LABORATORIO
XRF-ANALYYSITULOKSIA 22.12.89

TILAAJA: **V. PALOSAARI/GAL**
ALUE: BIDJOVAGGE-30

LASK.P: 5534307 OPER: MLM 287
KARTTAL.: KR-4 J JAKELU: EH, VTM, MLM

	8912304KR	8912303KJ
	%	%
SI02	10.2	25.0
TIO2	0.127	0.238
AL2O3	2.27	5.66
CR2O3	0.0098	0.0164
V2O3	0.0100	0.0218
FeO	35.25	30.92
MNO	0.0243	0.0589
MGO	0.16	0.28
CAO	1.59	5.86
HS2O	0.0026	0.0036
SRO	0.0001	0.0019
BAO	0.011	0.010
NA2O	0.56	3.45
K2O	0.016	0.026
ZRO2	0.0049	0.0079
P2O5	0.005	0.052
CO2		
OKSUM	96.1	96.6
CU	23.34	3.42
NI	0.144	1.02
CO	0.0633	0.172
ZN	0.0246	0.0096
PB	0.018	0.14
AG	0.000	0.000
S	32.1	27.8
AS	0.0000	0.0000
SB	0.000	0.000
BI	0.012	0.26
TE	0.201	3.82
Y	0.0004	0.0004
NB	0.0000	0.0000
MO	0.0182	0.0461
SN	0.002	0.006
W	0.000	0.001
PT		
CL	0.006	0.008
BR	0.0000	0.0000
TH	0.0025	0.0097
U	0.0073	0.0513
OS	0.002	0.000
LA	0.002	0.001
CE	0.005	0.031
PR	0.000	0.000
NO	0.01	0.01
SM	0.00	0.00
EU	0.00	0.00
GD	0.00	0.00
TB	0.00	0.00
OY	0.00	0.00
HO	0.00	0.00
ER	0.00	0.00
TM	0.00	0.00
YB	0.01	0.00
LB	0.00	0.00
HF	0.000	0.000
TA	0.001	0.001
LOI		

Flowsheet for tests BU21-BU28



FLOTATION REPORT

Date 1.12.1989

Sample

BIDJOVAGGE/N94G

Purpose

pH-test 12.0

Test

BV28

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO- DUCT	WEIGHT		GRADES AND RECOVERIES							
		G r i n	C o n d	F l o t	Ca(OH) ₂	KAX	Dow- froth 210	Aero- phine 3418A	V o l	A i r	S p e e d			g	%	Cu		Au		S		Te	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm					%	R-%	g/t	R-%	%	R-%	%	R-%
													FEED	1018	100.0	0.548	100.0	9.4	100.0	1.79	100.0	0.053	100.0
Rougher	ORE	10	10 3	3	*		30	20				8.9 12.0	RC RT	49 : 969	4.8 : 95.2	8.672 : 0.136	76.4 : 23.6	40.6 : 7.8	20.9 : 79.1	15.54 : 1.09	41.9 : 58.1	0.159 : 0.048	14.5 : 85.5
1st clean.	RC		1	3	*				2.0	1.5	1500	12.0	CC1 CT1	19 : 30	1.9 : 2.9	20.610 : 0.940	71.3 : 5.0	65.6 : 24.4	13.3 : 7.6	29.09 : 6.76	30.8 : 11.1	0.093 : 0.201	3.3 : 11.1
2nd clean.	CC1		1	3	*				1.6	1.5	1200	12.0	CC2 CT2	14 : 5	1.4 : 0.5	25.800 : 6.160	65.7 : 5.6	66.7 : 62.6	9.9 : 3.3	33.07 : 18.02	25.8 : 5.0	0.112 : 0.040	3.0 : 0.4
Classif.	RT												+37 -37	735 : 234	72.2 : 23.0	0.154 : 0.080	20.3 : 3.4	8.4 : 5.9	64.6 : 14.5	1.36 : 0.25	54.9 : 3.2	0.050 : 0.040	68.1 : 17.4
Scaveng.	RT +37	30	10 3	9	*		20	30	2.0	1.5	1500	12.0	SC ST	49 : 686	4.8 : 67.3	2.022 : 0.020	17.8 : 2.5	54.6 : 5.1	28.1 : 36.5	3.90 : 1.18	10.5 : 44.4	0.188 : 0.040	17.2 : 50.9
Scaveng. 1st clean.	RC		1	4	*				1.6	1.5	1200	12.0	SCC1 SCT1	8 : 42	0.7 : 4.1	11.700 : 0.250	15.9 : 1.9	128.0 : 41.2	10.2 : 17.9	16.76 : 1.55	7.0 : 3.5	0.479 : 0.135	6.8 : 10.4
Scaveng. 2nd clean.	SCC1		1	3	*				1.6	1.5	1200	12.0	SCC2 SCT2	3 : 5	0.3 : 0.5								
													RC+SC CC1+SCC1	98 : 27	9.6 : 2.6	5.347 : 18.093	94.2 : 87.3	47.6 : 83.2	49.0 : 23.5	9.72 : 25.61	52.4 : 37.8	0.173 : 0.202	31.6 : 10.1
													ST+ -37	920	90.4	0.035	5.8	5.3	51.0	0.94	47.6	0.040	68.4

APPENDIX 2/12

FLOTATION REPORT

Date 1.12.1989

Sample

BIDJOVAGGE/N94G

Purpose

pH-test 11.0

Test

BV26

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES							
		G r i n n	C o n d	F l o t	Ca(OH) ₂	KAX	Dow- froth 210	Aero- phine 3418A	V o l	A i r	S p e e d			g	%	Cu		Au		S		Te	
		min	min	min	kg/t	g/t	g/t	g/t	l	l/min	rpm			%	R-%	g/t	R-%	%	R-%	%	R-%		
													FEED	1001	100.0	0.524	100.0	9.6	100.0	1.83	100.0	0.066	100.0
Rougher	ORE	10	10 3	3	*		30	20	2.0	1.5	1500	9.0 11.0	RC RT	56 944	5.6 94.4	8.423 0.053	90.4 9.6	113.1 3.4	66.4 33.6	18.10 0.86	55.8 44.2	0.278 0.054	23.5 76.5
1st clean.	RC		1	3	*				1.6	1.5	1200	11.0	CC1 CT1	27 30	2.7 2.9	16.880 0.740	86.3 4.2	197.1 36.7	55.1 11.3	29.93 7.36	43.9 11.9	0.331 0.229	13.4 10.2
2nd clean.	CC1		1	3	*				1.6	1.5	1200	11.0	CC2 CT2	21 5	2.1 0.5	20.400 2.930	83.3 3.0	208.0 154.0	46.4 8.7	32.37 20.24	37.9 6.0	0.339 0.300	10.9 2.4
Classif.	RT												+37 -37	724 220	72.4 22.0	0.048 0.070	6.6 2.9	3.7 2.6	27.8 5.9	1.03 0.29	40.8 3.5	0.058 0.040	63.2 13.3
Scaveng.	RT +37	30	10 3	9	*		20	30	2.0	1.5	1500	11.0	SC ST	66 658	6.6 65.8	0.428 0.010	5.4 1.3	28.0 1.3	19.2 8.6	2.62 0.87	9.4 31.3	0.239 0.040	23.6 39.6
Scaveng. 1st clean.	RC		1	4	*				1.6	1.5	1200	11.0	SCC1 SCT1	7 59	0.7 5.8	3.300 0.070	4.6 0.8	116.0 17.0	8.8 10.4	10.92 1.58	4.4 5.1	1.390 0.095	15.3 8.4
Scaveng. 2nd clean.	SCC1		1	3	*				1.6	1.5	1200	11.0	SCC2 SCT2	2 5	0.2 0.5								
													RC+SC CC1+SCC1	122 34	12.2 3.4	4.115 13.973	95.8 90.9	67.2 179.8	85.5 63.9	9.76 25.86	65.2 48.2	0.257 0.558	47.1 28.6
													ST+ -37	879	87.8	0.025	4.2	1.6	14.5	0.72	34.8	0.040	52.9

FLOTATION REPORT

Date 15.11.1989

Sample

BIDJOVAGGE/N94G

Purpose

Grinding test 4

Test

BV24

FRACTION µm	Weight %	Cu		Au		S	
		%	R-%	g/t	R-%	%	R-%
+105	1.6	0.022	2.2	13.90	22.1	1.15	3.5
+74-105	5.6	0.019	6.7	2.99	16.6	1.66	17.7
+37-74	27.1	0.015	25.4	1.54	41.2	0.66	33.9
-37	65.7	0.016	65.7	0.31	20.1	0.36	44.8
Bulk	100.0	0.016	100.0	1.01	100.0	0.53	100.0

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO- DUCT	WEIGHT		GRADES AND RECOVERIES										
		G r i n d min	C o n d min	F l o t min	Ca(OH) ₂ kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te				
															g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	10												FEED	1002	100.0	0.583	100.0	7.8	100.0	1.92	100.0	0.052	100.0		
Rougher			3	3			30	20	2.0	1.5	1500			RC	57	5.7	9.199	90.2	78.0	57.2	18.95	56.5	0.582	63.8		
														RT	945	94.3	0.061	9.8	3.5	42.8	0.88	43.5	0.020	36.2		
1st clean.	RC		1	3					1.6	1.5	1200			CC1	29	2.9	17.172	85.3	127.7	47.4	30.78	46.5	0.994	55.2		
														CT1	28	2.8	1.000	4.8	27.0	9.8	6.78	10.0	0.159	8.6		
2nd clean.	CC1		1	3					1.6	1.5	1200			CC2	24	2.3	20.500	82.5	133.0	40.0	32.81	40.2	1.180	53.1		
														CT2	6	0.5	2.950	2.8	105.0	7.4	22.11	6.3	0.200	2.1		
Classif.	RT													+37	727	72.6	0.052	6.5	3.9	36.0	1.02	38.7	0.023	32.0		
														-37	218	21.7	0.089	3.3	2.5	6.9	0.42	4.8	0.010	4.2		
Scaveng.	RT +37	30	2	9			20	30	2.0	1.5	1500			SC	58	5.8	0.473	4.7	41.4	30.7	6.02	18.2	0.173	19.2		
														ST	669	66.8	0.016	1.8	0.6	5.2	0.59	20.6	0.010	12.8		
Scaveng. 1st clean.	RC		1	4					1.6	1.5	1200			SCC1	10	1.0	2.270	4.0	179.0	23.8	23.96	13.0	0.841	16.8		
														SCT1	48	4.7	0.079	0.6	11.3	6.9	2.09	5.2	0.027	2.5		
Scaveng. 2nd clean.	SCC1		1	3					1.6	1.5	1200			SCC2	4	0.4		0.0		0.0		0.0		0.0		
														SCT2	6	0.6		0.0		0.0		0.0		0.0		
														RC+SC	115	11.5	4.809	94.8	59.6	87.9	12.44	74.7	0.377	83.0		
														CC1+SCC1	39	3.9	13.238	89.4	141.2	71.3	28.98	59.5	0.954	72.0		
														ST+ -37	887	88.5	0.034	5.2	1.1	12.1	0.55	25.3	0.010	17.0		

AP02401X 2/15

FLOTATION REPORT

Sample

Purpose

Test

Date 15.11.1989

BIDJOVAGGE/N94G

Grinding test 3

BV23

Sieve fractions of the scavenger tails

FRACTION µm	Weight %	Cu		Au		S	
		%	R-%	g/t	R-%	%	R-%
+105	3.0	0.038	3.0	6.05	11.7	0.63	2.5
+74-105	8.2	0.034	7.1	1.61	8.4	1.22	12.9
+37-74	29.6	0.024	18.3	2.55	48.2	0.90	34.6
-37	59.2	0.047	71.6	0.84	31.8	0.65	50.0
Bulk	100.0	0.039	100.0	1.57	100.0	0.77	100.0

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES										
		G r i n min	C o n d min	F l o t min	Ca(OH) ₂ kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te				
															g	%	%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	5	3				20						FEED	1003	100.0	0.547	100.0	7.8	100.0	1.75	100.0	0.045	100.0			
Rougher				3		30							RC	13	1.3	13.892	32.1	204.4	33.1	19.43	14.1	0.668	18.8			
													RT	983	98.0	0.379	67.9	5.3	66.9	1.53	85.9	0.037	81.2			
1st clean.	RC		1										CC1	7	0.7	23.000	30.2	313.0	28.7	29.01	11.9	1.000	* 15.9			
													CT1	13	1.3	0.853	2.0	27.0	4.4	2.98	2.2	0.101	2.8			
2nd clean.	CC1		1										CC2		0.0		0.0		0.0		0.0		0.0			
				3									CT2		0.0		0.0		0.0		0.0		0.0			
Classif.	RT												+37	795	79.3	0.398	57.7	4.8	48.3	1.71	77.7	0.044	77.1			
													-37	188	18.7	0.297	10.1	7.8	18.6	0.77	8.2	0.010	* 4.1			
Scaveng.	RT +37	30	2			20	30						SC	98	9.7	2.948	52.4	34.5	42.9	8.09	45.0	0.286	61.7			
				9									ST	698	69.6	0.042	5.3	0.6	5.4	0.82	32.6	0.010	* 15.4			
Scaveng. 1st clean.	RC		1										SCC1	26	2.6	10.836	51.3	97.1	32.2	24.61	36.5	0.996	57.2			
				4									SCT1	72	7.1	0.079	1.0	11.8	10.8	2.09	8.5	0.028	4.4			
Scaveng. 2nd clean.	SCC1		1										SCC2	15	1.5	17.200	47.6	157.0	30.4	31.69	27.5	1.440	48.4			
				3									SCT2	11	1.1	1.880	3.7	12.8	1.8	14.64	9.0	0.371	8.9			
													RC+SC	110	11.0	4.209	84.5	54.1	76.0	9.40	59.1	0.330	80.4			
													CG1+SCC1	33	3.3	13.474	81.5	143.9	60.9	25.56	48.4	0.997	73.2			
													ST+ -37	885	88.3	0.096	15.5	2.1	24.0	0.81	40.9	0.010	19.6			

AARVIX 2/6

FLOTATION REPORT

Sample BIDJOVAGGE/N94G
Purpose Grinding test 2
Test BV22

Date 1.11.1989

Sieve fractions of the scavenger tails

FRACTION µm	Weight %	Cu		Au		S	
		%	R-%	g/t	R-%	%	R-%
+105	1.1	0.024	2.5	10.50	14.2	2.32	4.6
+74-105	4.1	0.014	5.8	4.44	23.6	2.18	17.0
+37-74	27.1	0.009	24.3	1.04	36.2	0.59	30.1
-37	67.7	0.010	67.4	0.30	26.0	0.38	48.3
Bulk	100.0	0.010	100.0	0.78	100.0	0.53	100.0

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO- DUCT	WEIGHT		GRADES AND RECOVERIES								
		G r i n d min	C o n d min	F l o t min	Ca(OH) ₂ kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te		
															%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	20										8.7	FEED	1018	100.0	0.598	100.0	8.1	100.0	1.89	100.0	0.045	100.0	
Rougher			3	6			30	60					RC	199	19.5	2.946	96.3	32.6	78.8	7.26	75.1	0.223	97.0	
									2.0	1.5	1500		RT	819	80.5	0.027	3.7	2.1	21.2	0.58	24.9	0.002	3.0	
1st clean.	RC		1	4									CC1	55	5.4	10.220	91.6	103.5	68.7	22.26	63.1	0.810	96.5	
									1.6	1.5	1200		CT1	144	14.2	0.199	4.7	5.8	10.1	1.59	11.9	0.002	0.5	
2nd clean.	CC1		1	3									CC2	33	3.3	16.200	88.4	155.0	62.7	31.41	54.3	1.260	91.5	
									1.6	1.5	1200		CT2	21	2.1	0.898	3.1	23.2	6.0	8.01	8.9	0.108	5.0	
Classif.	RT												+37	637	62.5	0.022	2.3	2.4	18.6	0.67	22.1	0.002	2.6	
													-37	182	17.9	0.046	1.4	1.1	2.5	0.30	2.8	0.001	0.4	
Scaveng.	RT +37	30					20	30					SC	61	6.0	0.138	1.4	17.8	13.2	1.49	4.7	0.010	1.3	
			2	7					2.0	1.5	1500		ST	576	56.6	0.010	0.9	0.8	5.5	0.58	17.4	0.001	1.3	
Scaveng. 1st clean.	RC		1	4									SCC1	8	0.8	0.820	1.1	85.3	8.1	6.29	2.6	0.043	0.7	
									1.6	1.5	1200		SCT1	53	5.2	0.037	0.3	7.9	5.1	0.78	2.1	0.005	0.6	
Scaveng. 2nd clean.	SCC1		1	3									SCC2	2	0.2	3.410	0.9	149.0	2.9	17.84	1.5	0.200	0.7	
									1.6	1.5	1200		SCT2	6	0.6	0.151	0.2	68.8	5.2	3.31	1.1	0.003	0.0	
													RC+SC	259	25.5	2.290	97.7	29.1	92.0	5.91	79.8	0.173	98.3	
													CC1+SCC1	62	6.1	9.043	92.6	101.2	76.8	20.26	65.7	0.714	97.2	
													CC2+SCC2	35	3.4	15.612	89.3	154.7	65.6	30.79	55.7	1.211	92.2	
													ST+ -37	758	74.5	0.019	2.3	0.9	8.0	0.51	20.2	0.001	1.7	

APPENDIX 2/7

FLOTATION REPORT

Sample
Purpose
Test

Date 1.11.1989
BIDJOVAGGE/N94G
Grinding test 1
BV21

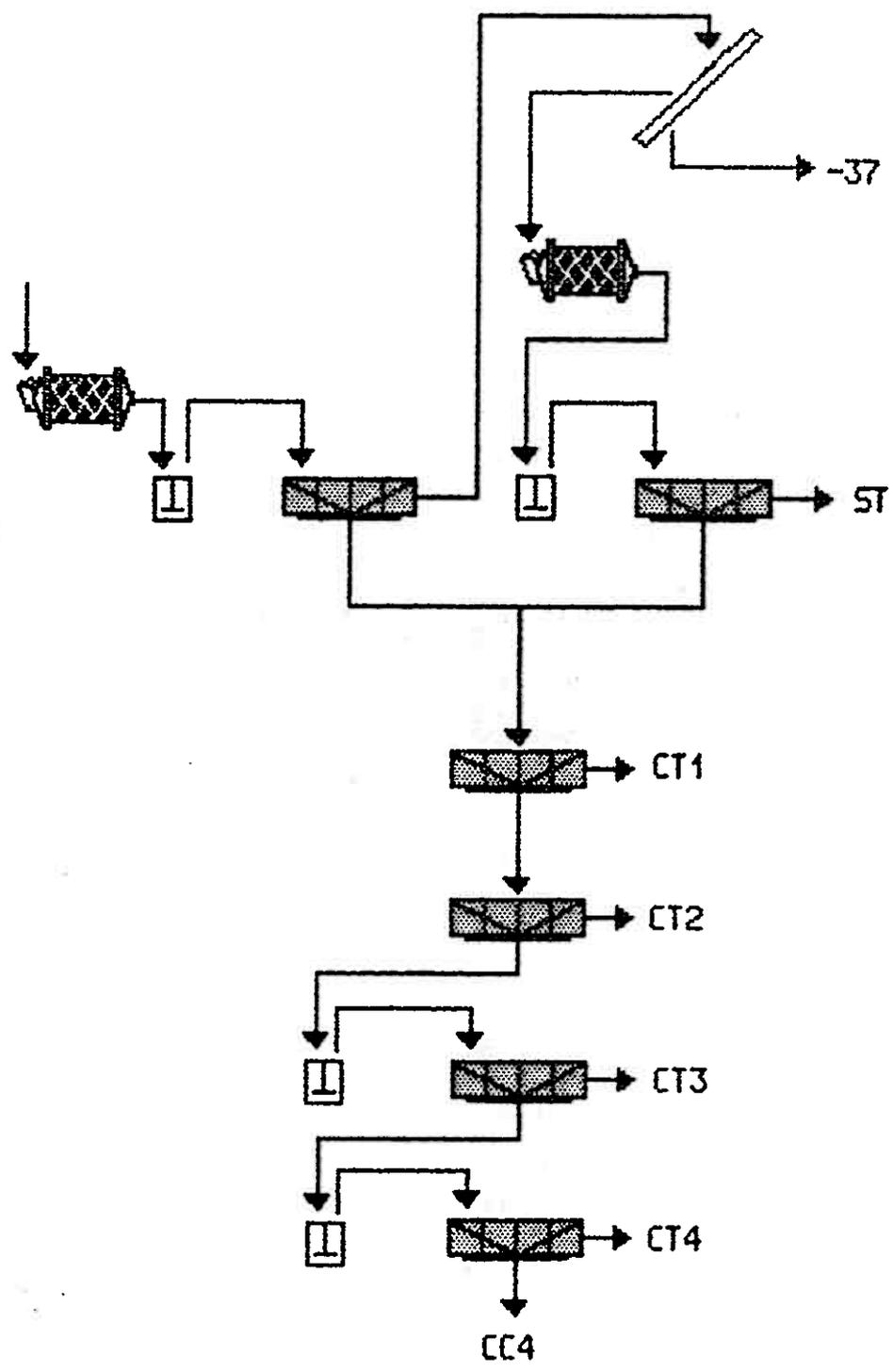
Sieve fractions of the scavenger tails

FRACTION µm	Weight %	Cu		Au		S	
		%	R-%	g/t	R-%	%	R-%
+105	2.3	0.014	3.8	0.51	1.0	0.45	2.7
+74-105	7.5	0.010	8.8	3.81	23.7	0.75	14.7
+37-74	33.2	0.007	27.2	2.04	56.3	0.42	36.4
-37	57.0	0.009	60.2	0.40	19.0	0.31	46.2
Bulk	100.0	0.009	100.0	1.20	100.0	0.38	100.0

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES								
		G r i n n	C o n d	F l o t	Ca(OH)2 kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te		
															%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	20					40					8.6	FEED	1003	100.0	0.665	100.0	9.9	100.0	1.93	100.0	0.051	100.0	
Rougher			3	6			30		2.0	1.5	1500		RC	181	18.1	3.591	97.6	47.2	86.6	8.77	82.0	0.276	98.0	
													RT	822	81.9	0.020	2.4	1.6	13.4	0.42	18.0	0.001	2.0	
1st clean.	RC		1	4					1.6	1.5	1200		CC1	56	5.5	11.349	94.5	131.1	73.6	24.10	69.0	0.854	92.9	
													CT1	126	12.5	0.166	3.1	10.2	13.0	2.01	13.0	0.021	5.2	
2nd clean.	CC1		1	3					1.6	1.5	1200		CC2	34	3.4	17.900	91.5	180.0	62.1	32.46	57.1	1.270	84.8	
													CT2	21	2.1	0.911	2.9	53.3	11.5	10.77	11.9	0.192	8.0	
Classif.	RT												+37	610	60.8	0.014	1.3	2.0	12.1	0.48	15.1	0.001	1.5	
													-37	212	21.1	0.036	1.1	0.6	1.3	0.26	2.8	0.001	0.4	
Scaveng.	RT +37	20					20	15					SC	44	4.3	0.078	0.5	11.9	5.2	0.87	2.0	0.005	0.4	
			2	5					2.0	1.5	1500		ST	567	56.5	0.009	0.8	1.2	6.9	0.45	13.2	0.001	1.1	
Scaveng. 1st clean.	RC		1	4					1.6	1.5	1200		SCC1	5	0.5	0.425	0.3	68.3	3.5	3.14	0.8	0.025	0.2	
													SCT1	39	3.8	0.033	0.2	4.5	1.8	0.58	1.2	0.003	0.2	
Scaveng. 2nd clean.	SCC1		1	3					1.6	1.5	1200		SCC2	1	0.1	2.240	0.2	124.0	0.9	12.64	0.5	0.159	0.2	
													SCT2	4	0.4	0.130	0.1	59.2	2.6	1.59	0.4	0.003	0.0	
													RC+SC	225	22.4	2.911	98.1	40.4	91.8	7.25	84.0	0.224	98.5	
													CC1+SCC1	61	6.0	10.446	94.8	126.0	77.1	22.36	69.8	0.786	93.1	
													CC2+SCC2	35	3.5	17.585	91.8	178.9	63.0	32.06	57.6	1.248	85.0	
													ST+ -37	778.5	77.6	0.016	1.9	1.0	8.2	0.40	16.0	0.001	1.5	

KORSAVIX 2/8

Flowsheet for tests BU29-BU30



FLOTATION REPORT

Date 7.12.1989

Sample

BIDJOVAGGE/N94G

Purpose

3rd and 4th cleaning in basic circuit/Separation flotation

Test

BV29

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO-DUCT	WEIGHT		GRADES AND RECOVERIES								
		G r i n min	C o n d min	F l o t min	Ca(OH) ₂ kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te		
															%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	15											FEED	2024	100.0	0.563	100.0	11.2	100.0	1.92	100.0	0.073	100.0	
Rougher			1				30	30					8.8	RC RT										
Classif.	RT			6					2.0	1.5	1500			+37 -37	480	23.7	0.070	2.9	1.9	4.0	0.30	3.7	0.012	3.9
Scaveng.	RT +37	25					20	30						SC ST	1253	61.9	0.021	2.3	0.9	5.0	0.61	19.7	0.003	2.6
1st clean.	RC+SC			5					1.6	1.5	1200			CC1 CT1	99	4.9	10.442	90.3	188.3	81.9	24.81	63.0	1.141	76.3
2nd clean.	CC1			5					1.6	1.5	1200			CC2 CT2	68	3.4	14.718	88.3	257.4	77.8	32.25	56.9	1.549	71.9
3rd clean.	CC2		15		0.4				1.0	1.5	1000	12.0		CC3 CT3	41	2.0	21.983	79.3	138.8	25.2	32.17	34.1	0.284	7.9
4th clean.	CC3		5		0.4				1.0	1.5	1000	12.0		CC4 CT4	33	1.6	25.000	72.2	97.6	14.2	33.01	28.0	0.090	2.0
														RC+SC CT3+CT4	291	14.4	3.710	94.7	70.8	91.0	10.21	76.6	0.474	93.5
															36	1.8	5.189	16.2	405.5	63.6	31.54	28.9	2.900	69.9
														ST+ -37	1733	85.6	0.035	5.3	1.2	9.0	0.52	23.4	0.005	6.5

APPENDIX 3/8

FLOTATION REPORT

Date 11.12.1989

Sample

BIDJOVAGGE/N94G+N98D

Purpose

3rd and 4th cleaning in basic circuit

Test

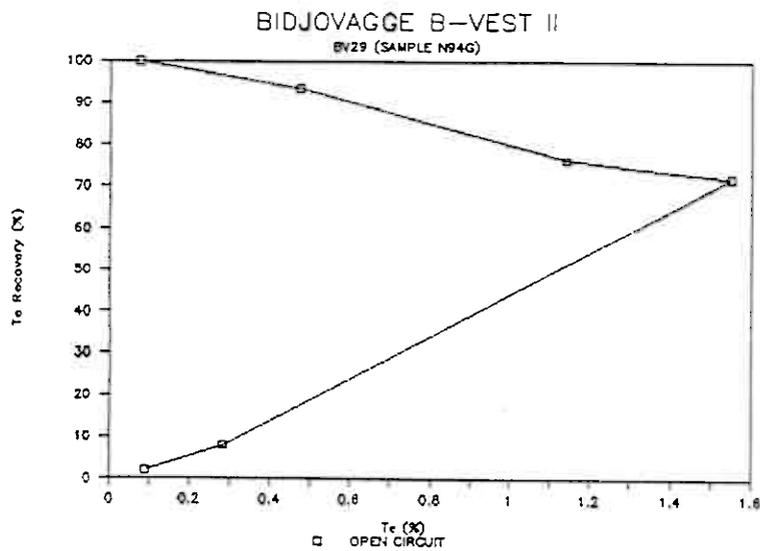
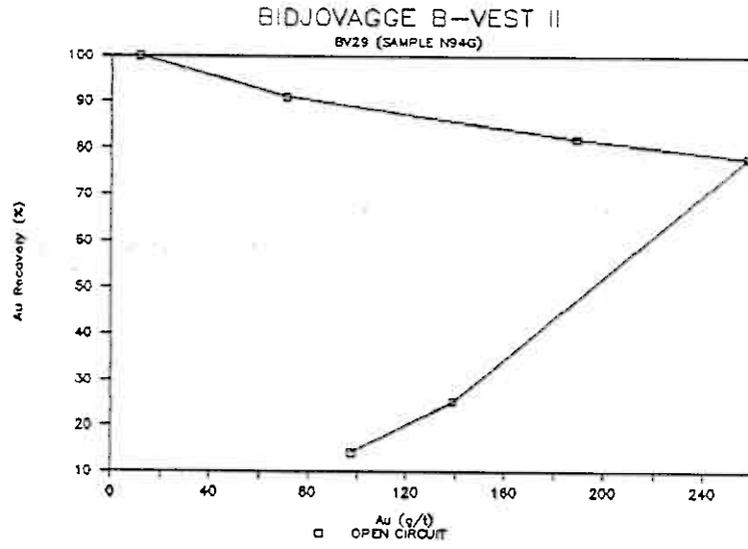
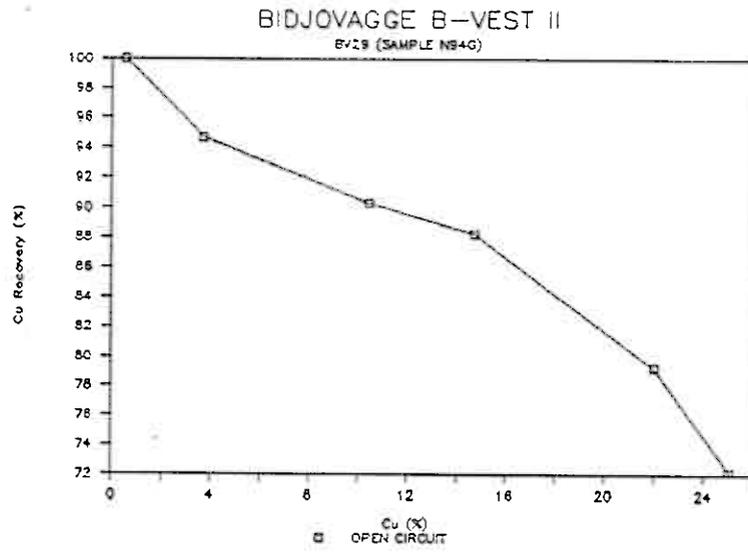
BV30

FRACTION µm	Weight %	Cu		Au		S		Te	
		%	R-%	g/t	R-%	%	R-%	%	R-%
+105	3.2	0.030	4.7	2.28	13.7	0.95	29.4	0.0045	96.1
+74-105	8.1	0.020	8.0	1.94	20.1	1.01	45.8	0.0028	93.0
+37-74	30.0	0.020	29.6	1.01	38.6	0.42	36.5	0.0014	37.1
-37	58.7	0.020	57.7	0.41	30.6	0.35	24.1	0.0010	17.5
Bulk	100.0	0.020	100.0	0.77	100.0	0.44	100.0	0.0014	100.0

STEP	FEED	TIME			REAGENTS				CELL			pH	PRO- DUCT	WEIGHT		GRADES AND RECOVERIES								
		G r i n n d t min	C o n d t min	F l o t min	Ca(OH) ₂ kg/t	KAX g/t	Dow- froth 210 g/t	Aero- phine 3418A g/t	V o l l	A i r l/min	S p e e d rpm			g	%	Cu		Au		S		Te		
															%	R-%	g/t	R-%	%	R-%	%	R-%	%	R-%
	ORE	15	1	6			30	30				8.8	FEED	2010	100.0	0.465	100.0	11.1	100.0	1.48	100.0	0.074	100.0	
Rougher	RT								2.0	1.5	1500		RC RT											
Classif.	RT												+37 -37	485	24.1	0.050	2.6	1.3	2.9	0.26	4.3	0.007	2.2	
Scaveng.	RT +37	25	1	9			20	30					SC ST	1199	59.7	0.020	2.6	0.8	4.1	0.47	19.0	0.002	1.8	
1st clean.	RC+SC			5					1.6	1.5	1200		CC1 CT1	90 235	4.5 11.7	9.238 0.240	88.8 6.0	198.0 12.9	79.5 13.6	18.94 2.44	57.4 19.4	1.391 0.077	83.8 12.1	
2nd clean.	CC1			5					1.6	1.5	1200		CC2 CT2	54 36	2.7 1.8	14.842 0.690	86.2 2.6	302.6 38.6	73.3 6.1	28.40 4.51	52.0 5.4	2.135 0.257	77.7 6.1	
3rd clean.	CC2		15	4	0.5				1.0	1.5	1000	12.0	CC3 CT3	32 22	1.6 1.1	22.589 3.640	77.5 8.6	228.3 410.0	32.7 40.6	30.20 25.79	32.7 19.3	0.599 4.356	12.9 64.8	
4th clean.	CC3		5	3	0.4				1.0	1.5	1000	12.0	CC4 CT4	24 8	1.2 0.4	27.100 9.000	69.8 7.7	164.0 422.0	17.6 15.1	31.12 27.44	25.3 7.4	0.208 1.776	3.4 9.5	
													RC+SC CT3+CT4	325 30	16.2 1.5	2.727 5.060	94.8 16.3	64.1 413.2	93.0 55.7	7.00 26.23	76.7 26.7	0.440 3.673	96.0 74.3	
													ST+ -37	1684	83.8	0.029	5.2	0.9	7.0	0.41	23.3	0.004	4.0	

APPENDIX 3/13

GRADE-RECOVERY GRAPH, test BV29/Separation flotation



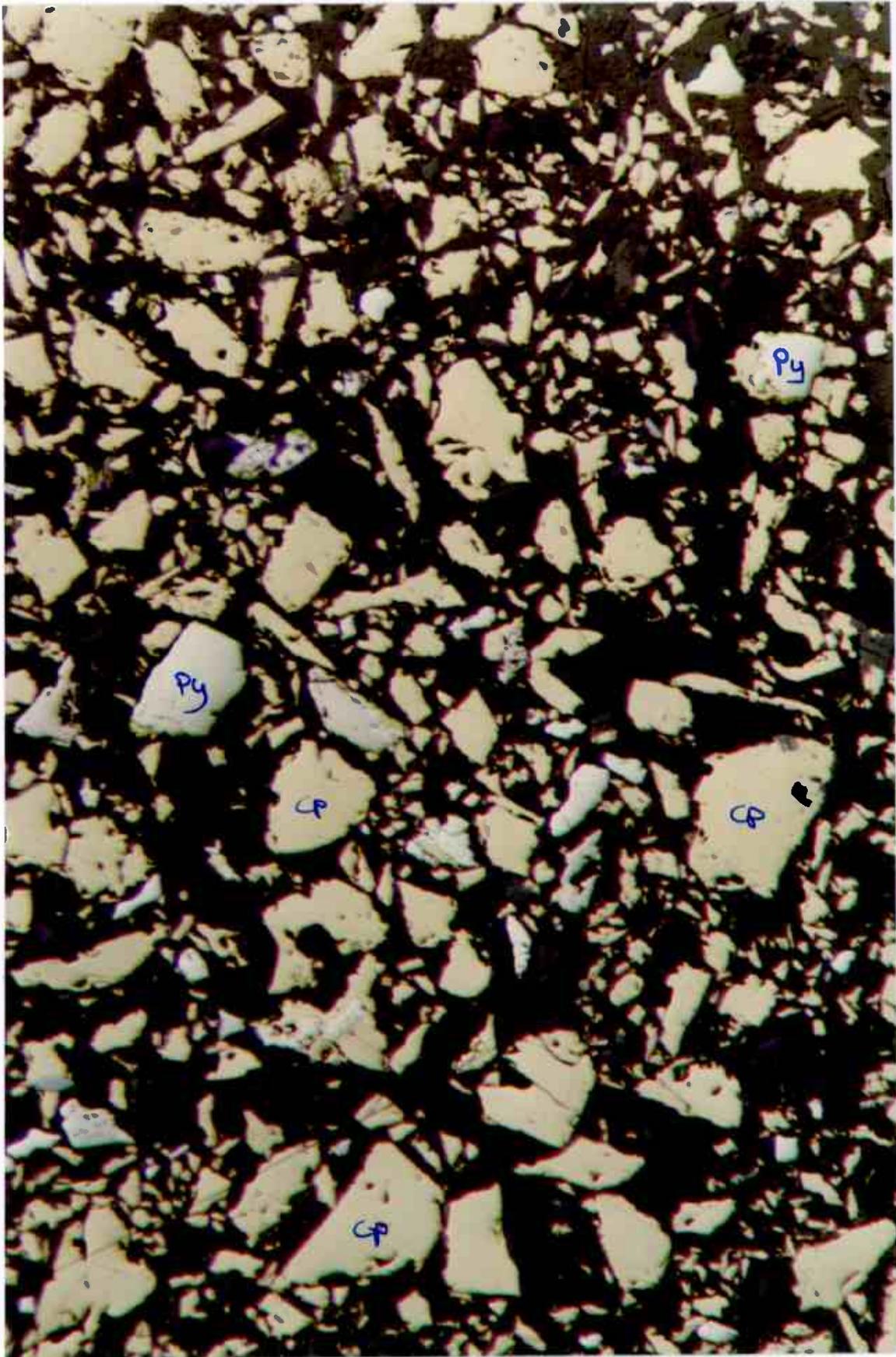


OHTOKUJPU
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Geoanalytical Laboratory

SEPARATION FLOTATION Test BV10

PRO-DUCT	WEIGHT		GRADES AND RECOVERIES																		
	g	%	Cu	Au	S	Te	Sb	Se	Bi	As	Cd	Hg									
			%	R-%	g/t	R-%	%	R-%	%	R-%	%		R-%	%	R-%	g/t					
CC2	54	100.0	14.842	100.0	302.6	100.0	28.40	100.0	2.135	100.0	0.0006	100.0	0.012	100.0	0.133	100.0	0.062	100.0	0.0002	100.0	< 1
CC3	32	59.1	22.589	90.0	228.3	44.6	30.20	62.9	0.599	16.6	0.0003	29.9	0.014	66.5	0.037	16.7	0.102	97.0	0.0002	74.3	< 1
CT3	22	40.9	3.640	10.0	410.0	55.4	25.79	37.1	4.356	83.4	0.0011	70.1	0.010	33.5	0.270	83.3	0.005	3.0	0.0001	25.7	< 1
CC4	24	44.4	27.100	81.0	164.0	24.1	31.12	48.6	0.208	4.3	0.0002	13.8	0.015	54.5	0.010	3.3	0.120	85.4	0.0002	55.8	< 1
CT4	8	14.7	9.000	8.9	422.0	20.5	27.44	14.2	1.776	12.3	0.0007	16.1	0.010	12.1	0.120	13.3	0.049	11.6	0.0002	18.5	< 1
AuC	30	55.6	5.060	19.0	413.2	75.9	26.23	51.4	3.673	95.7	0.0010	86.2	0.010	45.5	0.230	96.7	0.016	14.6	0.0001	44.2	< 1
CuC	24	44.4	27.100	81.0	164.0	24.1	31.12	48.6	0.208	4.3	0.0002	13.8	0.015	54.5	0.010	3.3	0.120	85.4	0.0002	55.8	< 1

APPENDIX 511



100 μ m



Fig. 1. BV30/CC4 160 x
High-grade chalcopyrite (cp) concentrate with minor pyrite (py) impurities.

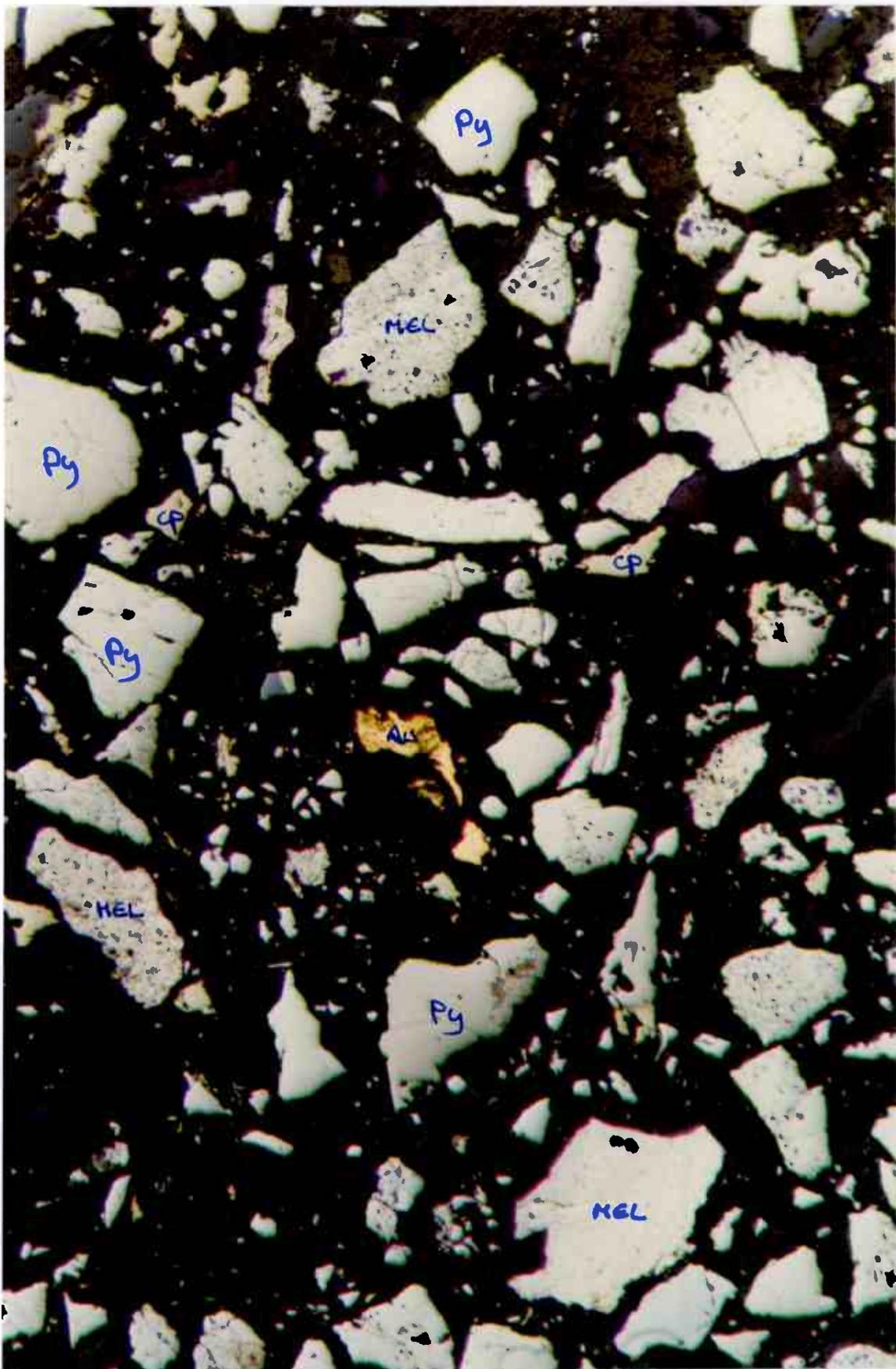
100 μ m

Fig. 2. BV30/CT3 160x
Pyrite (py), silicates (sil) and melonite (mel) are predominating minerals in Au concentrate. Some chalcopyrite (cp) is also met with. Note also liberated gold (Au) grains.

OUTOKUMPU
Mining Services
Geoanalytical Laboratory
Veikko Palosaari/Heikki Oravainen Dec. 28th 1989

BIDJOVAGGE B-VEST ORE/ESTIMATED PRODUCTS

	Feed	Bulk conc.	Cu concentr.	Au concentr.
Weight (%)	100.0	3.0	1.45	1.55
Cu (%)	0.50	15.0	26.0	4.7
Cu Rec. (%)	100.0	92.0	75.4	16.6
Au (g/t)	8.0	216	80	343
Au Rec. (%)	100.0	81.0	14.5	66.5
Te (%)	0.060	1.80	0.15	3.3
Te-Rec. (%)	100.0	90.0	3.6	86.4
Fe (%)			27.0	23.0
Ni (%)			0.14	1.02
Co (%)			0.063	0.17
Zn (%)			0.025	0.010
Pb (%)			0.018	0.14
Ag (g/t)			<10	<10
S (%)			31.0	26.5
As (%)			0.12	0.016
Sb (%)			0.015	0.010
Bi (%)			0.01	0.23
Cd (%)			0.0002	0.0001
Hg (g/t)			<1	<1
Y (%)			0.0004	0.0004
Nb (%)			<0.0001	<0.0001
Mo (%)			0.018	0.046
Sn (%)			0.002	0.006
W (%)			<0.001	0.001
Cl (%)			0.006	0.008
Br (%)			<0.0001	0.0008
Th (%)			0.003	0.010
U (%)			0.007	0.051
Cs (%)			0.002	<0.001
La (%)			0.002	0.001
Ce (%)			0.005	0.031
Pr (%)			<0.001	<0.001
Nd (%)			0.01	0.01
Lantanoids (Sm...Tm) (%)			<0.01	<0.01
Yb (%)			0.01	<0.01
Lu (%)			<0.01	<0.01
Hf (%)			<0.001	<0.001
Ta (%)			0.001	0.001
SiO ₂ (%)			10.0	24.5
TiO ₂ (%)			0.13	0.24
Al ₂ O ₃ (%)			2.3	5.7
Cr ₂ O ₃ (%)			0.01	0.02
V ₂ O ₃ (%)			0.010	0.021
MnO (%)			0.024	0.060
MgO (%)			0.16	0.28
CaO (%)			1.6	5.9
Rb ₂ O ₃ (%)			0.003	0.004
SrO (%)			0.0001	0.002
BaO (%)			0.01	0.01
Na ₂ O (%)			0.56	3.45
K ₂ O (%)			0.016	0.026
ZrO ₂ (%)			0.005	0.008
P ₂ O ₅ (%)			0.005	0.052

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