

A MINERALOGICAL EVALUATION OF GRINDING CIRCUIT B  
AND THE LEAD FLOTATION CIRCUIT OF THE FARO  
CONCENTRATOR, FARO, YUKON

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A MINERALOGICAL EVALUATION OF GRINDING CIRCUIT B  
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by

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ABSTRACT

The composition, liberation and behaviour of galena and sphalerite in grinding circuit B and the lead flotation circuit of the Faro concentrator were investigated to determine ways to improve metal recovery and plant efficiency.

~~Lead losses are mainly due to fine-grained galena grains (<20  $\mu$ m) being locked in much larger particles of gangue and the presence of galena slimes (<1  $\mu$ m).~~ Finer grinding in grinding circuit B and several flotation circuit modifications are suggested to improve lead recovery and plant efficiency.

Silver content of galena averaged 884 ppm which accounts for 66% of the silver in the ore. Only 24% of the silver lost to tailings is accounted for as solid solution in galena. Tetrahedrite, native silver and electrum were also identified as silver carriers.

Zinc content of sphalerite averaged 55%.

**Keywords:** Mineral liberation, image analysis, materials balance, flotation, circuit analysis, lead-zinc ore

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## INTRODUCTION

### PLANT SAMPLING AND ANALYSIS

Grinding circuit B and the lead flotation circuit were sampled on August 19, 1987 by Curragh and CANMET personnel during a four hour period while the feed to the plant was predominantly EF-EG ore but included a small component, about 20%, of 2BCD ore. During that time the two circuits were stable. All samples were collected in buckets, filtered, dried, split, and assayed for lead, zinc, copper, silver, gold, iron, and sulphur. A split of each stream sample was sieved in preparation for analysis by means of the MP-SEM-IPS image analysis system at CANMET. Samples of the grinding circuit were sieved at 300, 150, 100, 75, and 38  $\mu\text{m}$  while those of the lead flotation circuit were sieved at 75 and 38  $\mu\text{m}$ . A polished section was made of each sieve fraction. The major and minor minerals were identified by means of optical microscopy, X-ray diffraction and qualitative energy dispersive X-ray analysis. Electron microprobe analysis was performed on sphalerite and galena grains in selected samples. ~~Image analysis was performed to determine mineral quantities, apparent liberation of galena and sphalerite minerals, and their mineral associations.~~ A search for silver-bearing minerals other than galena was performed using the optical microscope and the image analyser. Apparent grain size distributions of galena, sphalerite, chalcopyrite and pyrite in the rod mill feed were determined by the image analyzer.

### RESULTS

Flowsheets for both circuits are shown in Figures 1 and 2. The balanced solid flowrates calculated by the BILMAT program are given in Table 1, the balanced sieve analysis data are given in Table 2, and the balanced assays for lead, zinc, copper, silver and gold in each stream are given in Table 3 for each circuit.

The major and minor minerals identified in the samples are pyrite, quartz, siderite, ~~muca~~, pyrrhotite, ~~kaolinite~~, galena, sphalerite, chalcopyrite, and ~~calcite~~. Trace amounts of marcasite, calcite and rutile were

also observed. Graphite was not observed. The balanced quantities of these minerals in each stream are given in Table 4.

Results of the electron probe microanalysis of sphalerite are found in Tables 6 and 7 and those of galena in Table 8.

Apparent liberation of sphalerite and galena was measured and is expressed as the mineral distribution by weight among the areal classes of ore particles. Because normal base metal milling practice tends to recover a concentrate consisting of ore particles of a grade 70% and higher, liberation is defined as the proportion of ore mineral which belongs to particles of a grade 70% or higher. The various particle classes reported are: the tailings class which includes particles consisting of from 0 to 20% ore mineral by area; similarly, the milling class, 20 to 70%; and the liberated class, 70 to 100%. The particle class data are balanced for galena and sphalerite within each particle sieve size and are shown in Table 9 for the grinding circuit and Table 10 for the lead flotation circuit. Recoveries of galena by size for each particle class are shown in Table 11.

Galena and sphalerite liberation, as defined above, was determined for each stream in both circuits and is shown in Table 12. Note that this table shows that 83% of the galena in the final concentrate is liberated. This value could be taken as a benchmark for the degree of liberation required to make a saleable lead concentrate.

Mineral associations of the galena and the sphalerite were measured and are shown in Tables 13 and 14, respectively. In those tables the distribution data for each sample consists of two lines. The upper line shows the distribution of the ore mineral among several classes of particles. Ternary<sup>+</sup> particles are particles which contain the ore mineral and at least two other minerals. Binary particles are particles which contain the ore mineral and only one other mineral. Free particles are simply ore particles with no other mineral attached. Thus the sum of the numbers in the upper line equals 100%. The lower line shows how the ore mineral in the ternary<sup>+</sup> particles is distributed.

For example, in Table 12, to determine the mineral associations of galena in the -38  $\mu\text{m}$  sieve fraction of the third cleaner concentrate we note in the upper line that 24.6% of the galena is locked with barite in binary particles and another 5.99% of the galena is locked with siderite in binary

particles. The line also shows that 16.1% of the galena is locked in ternary<sup>+</sup> particles. The second line shows for example that 13% of the galena is attached to ternary<sup>+</sup> particles with siderite being one of the other minerals. By adding the numbers together columnwise it is determined that 18.99% of the galena is associated with siderite and 38.6% with barite.

The silver search found electrum, tetrahedrite and native silver as silver-bearing minerals. Table 15 shows electron microprobe results of electrum grains found.

### **DATA INTERPRETATIONS**

#### **Slimes Production**

Assuming the galena consists of 86.6% lead and the sphalerite has an average composition of 55.3% zinc (Table 6) and that these minerals constitute the only significant bearers of these metals then the quantity of slimes may be roughly estimated. This is done by comparing unlinked balanced galena and sphalerite mineral quantities with balanced lead and zinc assays. Any unaccounted lead and zinc is assumed to be due to the presence of very fine or slimed mineral particles (<1  $\mu\text{m}$ ). Such material is too small to be resolved by the image analyzer.

The estimated slimes were calculated for selected streams and are shown in Table 16. Confirmation of the estimate for the lead scavenger tails was obtained by assaying each sieve fraction of the sample of that stream and comparing the results with the measured quantities of sphalerite and galena in each sieve fraction by image analysis. The data in Table 15 show a trend of increasing slimes content from the rod mill feed to the regrind discharge which is consistent with the assumption that the observed differences are due to slimes. The unbalanced data show that approximately 2 TPH of galena slimes are formed in the grinding circuit and another 2 TPH are formed in the lead flotation circuit due to the regrind. For sphalerite the numbers are 2.5 and 1 TPH, respectively.

Except where stated, all the data and discussion in the rest of this report refer only to observations made on particles which were detected by the image analyzer.

### Rougher-Scavenger Flotation

The rougher cells recover, in the rougher concentrate, 77% of the galena and 31% of the sphalerite from the total feed (total feed being the sum of new rougher feed + scav conc + cl 1 tail). The best galena recovery is obtained from the -38  $\mu\text{m}$  sieve fraction (Table 11). The galena reporting to the rougher tails amounts to 9 TPH of which about 40% is liberated (70 - 100% class). The sphalerite recovered in the rougher concentrate amounts to 28 TPH of which 22 TPH is liberated. However, a large portion of it is attached to siderite and galena in the -38  $\mu\text{m}$  fraction, and to galena (about 80%) in the +38  $\mu\text{m}$  fraction (see Table 14).

The scavenger cells recover 56% of the galena from the rougher tails which results in a combined rougher-scavenger galena recovery of 88%. The remaining 12% of the galena which is lost to the scavenger tails is predominantly (71%) locked in particles of the 0 - 20% class of the +38  $\mu\text{m}$  sieve fraction. The scavengers recover, in the scavenger concentrate, 26% of the sphalerite from the rougher tail. Most of this sphalerite is associated with siderite in the -38  $\mu\text{m}$  fraction and with galena in the +38  $\mu\text{m}$  fraction. The combined rougher-scavenger sphalerite recovery in the rougher concentrate is 38%. The scavenger concentrate consists of 4.9 TPH galena of which 55% is liberated and 16.0 TPH sphalerite of which 81% is liberated.

It is concluded that the rougher-scavengers recover most of the recoverable galena.

### Hydrocyclone - Regrind Ball Mill

The hydrocyclone recovers in the underflow 57% of the galena from the total feed (rougher concentrate + mill discharge). The galena recoveries for the liberated, middling and tailing classes are 59%, 55% and 33%, respectively. Table 14 shows that galena liberation is 83% in the feed to the regrind mill and 81% in the regrind mill discharge, indicating, within experimental error, no measureable increase in liberation.

Sphalerite recovery in the cyclone underflow is 45%. Sphalerite recoveries for the liberated, middling and tailings classes are 40%, 65% and 56%, respectively. Sphalerite liberation increases from 68% to 73% across the ball mill.

In summary, the regrind mill does not increase galena liberation by a measureable amount. This is probably due to the heavy free galena fines being pulled into the cyclone underflow whereas the lighter galena middlings are recovered in the cyclone overflow. Sphalerite liberation is however increased in the regrind mill. It is expected that the large recirculating load of free galena will tend to increase production of galena slimes.

### **First Cleaners**

Recovery of galena in the first cleaner concentrate is 85% whereas recovery of liberated galena is 92%. Recovery of sphalerite in the first cleaner concentrate is 62% whereas recovery of liberated sphalerite is also 62%. This shows poor rejection of sphalerite by the first cleaners.

Table 9 shows that the first cleaner tail consists of 6.6 TPH galena of which 42% is liberated and 22.6 TPH sphalerite of which 86% is liberated. The composition and liberation characteristics of this stream are almost identical to those of the rougher tail.

### **Second Cleaners**

Total sphalerite recovery has dropped to 32% in the second cleaner concentrate from 62% in the first cleaners. This suggests that the depression of newly liberated sphalerite in the regrind mill is too slow after the sulphate addition at the lead regrind mill and that a longer retention time is required in the first cleaners to allow for this.

Total galena recovery is 68% whereas liberated galena recovery is 72%. Recovery of locked galena (0 - 70% class) is 53%.

### **Third Cleaners**

Total galena recovery is 69% whereas total sphalerite recovery is 29%. The locked galena (0 - 99.99%) in the final concentrate is mostly attached to siderite and barite. Approximately 80% of the sphalerite in the final concentrate is attached to another mineral and 80% of that is attached to galena (Table 13).

### Grinding Circuit B

Galena liberation increases through the circuit from 41% in the rod mill discharge to 67% in the secondary cyclone overflow to 77% in the tertiary cyclone overflow. The secondary hydrocyclone recovers 72% of the galena from its feed in the underflow. It recovers 64% of the liberated galena (70 - 100% class), 73% of the middling galena (20 - 70% class) and 86% of the tailings class galena (0 - 20%) in the underflow. The tertiary hydrocyclone underflow recovers 65% of the total galena, 63% of the liberated galena, 72% of the middling galena and 70% of the tailings galena.

Sphalerite liberation increases through the circuit from 47% in the rod mill discharge to 69% in the secondary cyclone overflow to 83% in the tertiary cyclone overflow. The secondary cyclone underflow recovers 71% of the total sphalerite, 58% of the liberated sphalerite, 81% of the middling sphalerite and 86% of the tailings sphalerite. The tertiary cyclone underflow recovers 52% of the sphalerite, 61% of the liberated sphalerite, 46% of the middling sphalerite and 33% of the tailings sphalerite.

Due to its finer size distribution galena does not reach as high a state of liberation as sphalerite (77% liberated versus 83%, respectively).

### Grain Size Distribution of Ore Minerals in the Rod Mill Feed

The apparent grain size distributions for galena, sphalerite, pyrite and chalcopryrite of selected ore samples taken from the rod mill feed are shown in Table 5. Samples 1 and 2 displayed the buckshot texture of the 2EF-EG type ore. Sample 3 and 5 appeared to be the siliceous 2BCD type ore however no galena was detected in either sample so the data will not be analyzed further. Sample 4 appeared to be a carbonate-bearing pyritic type rock. It is felt that the average of the size distributions of samples 1 and 2 best represent the rod mill feed during the time of the sampling campaign.

The size distribution data are used to empirically predict the minimum and optimum grinds for liberating the minerals. The minimum grind is the coarsest grind at which significant liberation of the ore mineral begins to occur. This occurs when the size distribution of the ore is equal to the size distribution of the mineral (the same as K<sub>80</sub> ore = K<sub>80</sub> mineral). The so-called optimum grind is the finest grind at which a significant increase in liberation can still be obtained. This is arbitrarily defined as the

condition where  $K_{80}$  ore =  $K_{30}$  mineral. Normal base metal plant practice produces a grind somewhere between these two extremes.

It is interpreted from the average size distribution of the 2EF-EG ore samples 1 and 2 that the minimum grinds for sphalerite and galena are 80% passing 106  $\mu\text{m}$  and 75  $\mu\text{m}$ , respectively whereas the optimum grinds are 80% passing 38  $\mu\text{m}$  and 16  $\mu\text{m}$ , respectively. This result may be compared with the actual grinds achieved which, from Table 2, is 80% passing 75  $\mu\text{m}$  in the lead rougher feed and the lead scavenger tail, the latter being feed to the sphalerite circuit. The lead regrind circuit achieves 80% passing 38  $\mu\text{m}$  in the regrind cyclone overflow. Thus for galena the grind is almost halfway between minimal and optimal. The size distribution of the zinc regrind cyclone overflow was found to be 80% passing 38  $\mu\text{m}$ . It is concluded that the optimal grind for sphalerite has been attained.

#### Silver Distribution in Selected Stream Samples

From the data in Table 7 it is calculated that the average silver content of the galena is 884 ppm. Therefore, in the lead rougher concentrate 85% of the silver is present as solid solution in the galena. Similarly, in the final concentrate the galena accounts for 100% of the silver and in the lead scavenger tails galena accounts for 24%.

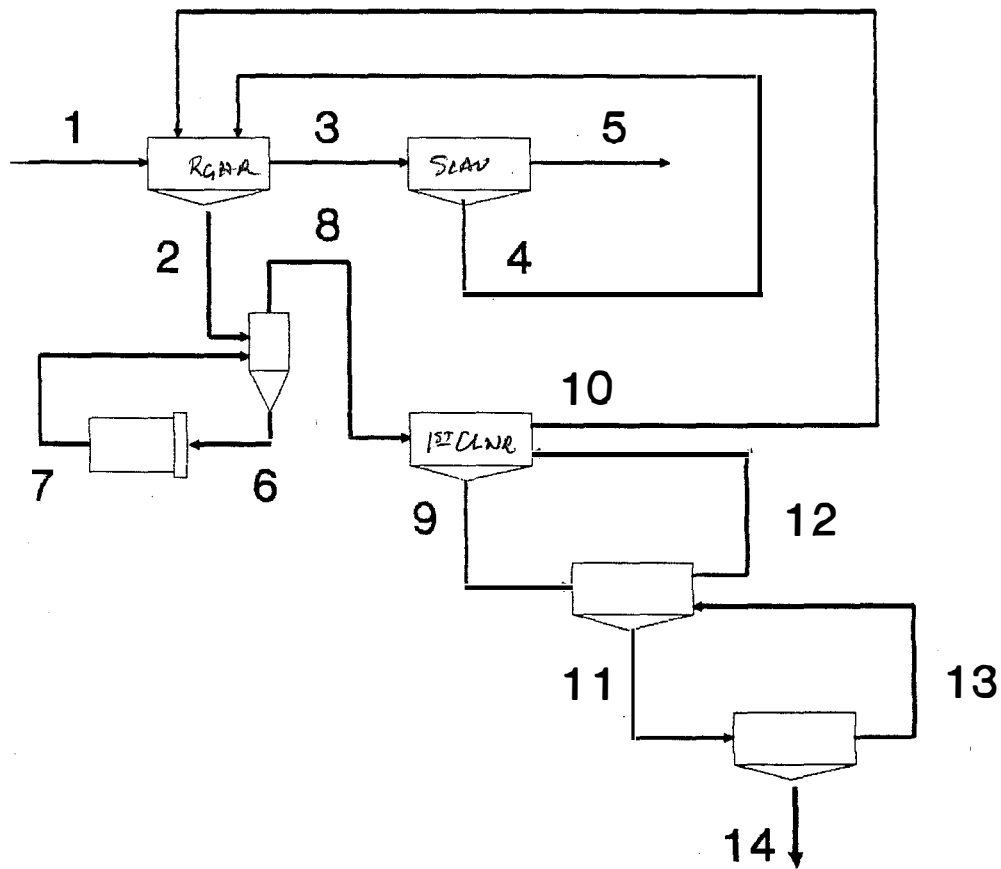
Overall silver recovery in the final lead concentrate is 55% and only 11% of the silver is lost to tails as solid solution in the galena.

Due to the high concentration of silver in galena the lead scavenger tailings sample was the only one to be searched for the occurrence of silver-bearing minerals. Four electrum grains, one tetrahedrite grain and one native silver grain were found. All these grains were free except for the tetrahedrite which was found locked to a (Fe-K) silicate.

#### **RECOMMENDATIONS**

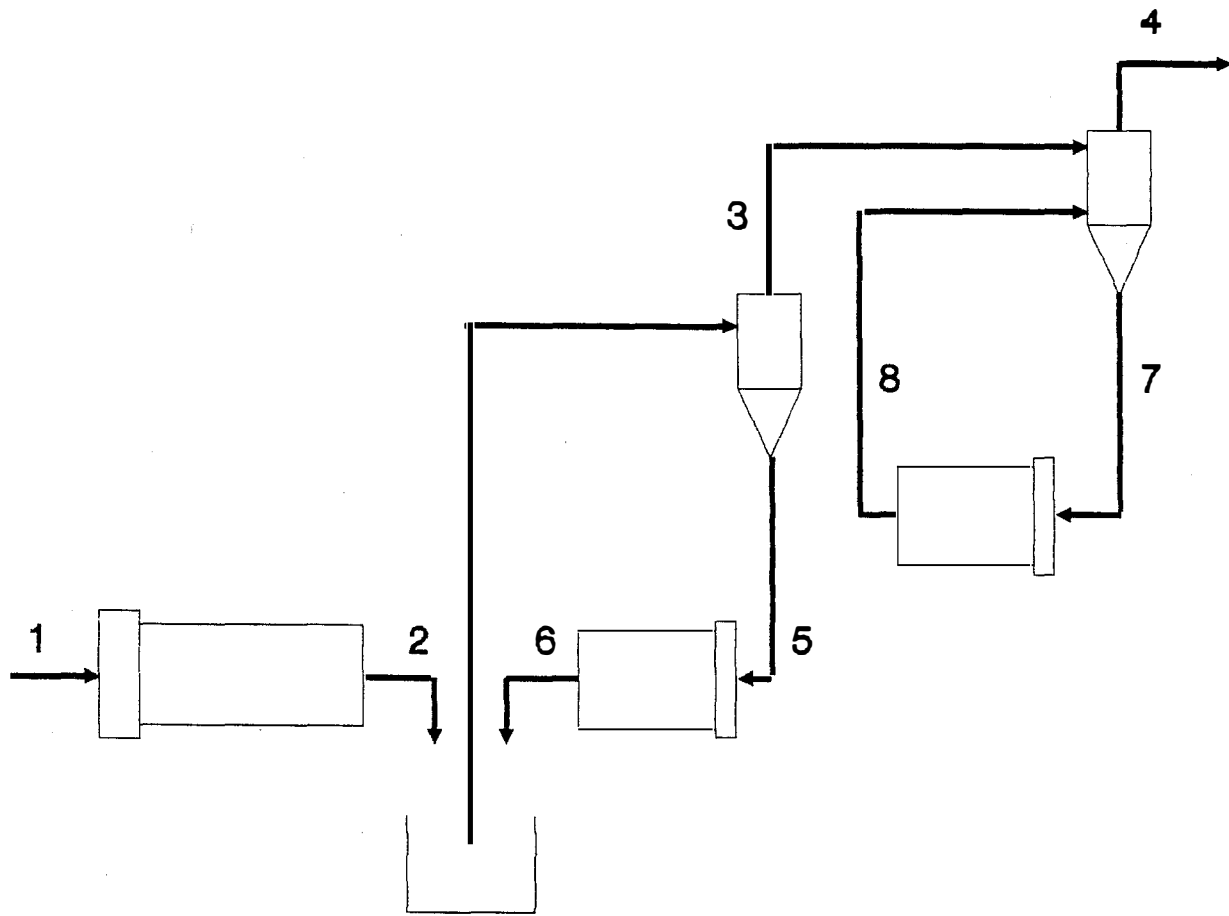
1. The data show that the optimum grind for galena recovery is a  $K_{80}$  of 16  $\mu\text{m}$ . Therefore it is suggested that a finer grind be attempted in grinding circuit B. However, due to the expected increase in slimes production the  $K_{80}$  should initially be decreased only to 63  $\mu\text{m}$  to allow the monitoring of possible increased slime losses.

2. Reroute the scavenger concentrate directly to the regrind mill. Galena liberation is only 54% in the scavenger concentrate compared to 77% in the rougher feed. This indicates a large amount of middling galena present in the scavenger concentrate which should be reground before being refloated.
  
3. The regrind circuit is not increasing the liberation of galena due to the fact that the cyclone tends to feed the regrind mill only liberated galena particles while most of the locked galena particles bypass the mill. Thus the circuit tends to produce slimes of liberated galena. Three alternative reactions are:
  - a) Remove the whole regrind circuit.
  - b) Remove only the regrind cyclone thus guaranteeing the locked galena at least one pass of the mill. This should improve galena liberation.
  - c) Ensure that most of the liberated galena grains are removed from this recycling action by placing the regrind circuit after the first cleaners. This modification will reduce galena slimes production.
  
4. The first cleaners are recovering too much sphalerite which is probably due to a lack of retention time for sphalerite depression. It is suggested that retention time be increased.



- |                            |                               |
|----------------------------|-------------------------------|
| 1. Lead Rougher Feed       | 8. Cyclone Overflow           |
| 2. Lead Rougher Conc.      | 9. Lead First Cleaner Conc.   |
| 3. Lead Rougher Tail       | 10. Lead First Cleaner Tail   |
| 4. Lead Scavenger Conc.    | 11. Lead Second Cleaner Conc. |
| 5. Lead Scavenger Tail     | 12. Lead Second Cleaner Tail  |
| 6. Cyclone Underflow       | 13. Lead Third Cleaner Tail   |
| 7. Re-grind Mill Discharge | 14. Lead Third Cleaner Conc.  |

FIGURE 1. LEAD FLOTATION CIRCUIT



1. Rod Mill Feed
2. Rod Mill Discharge
3. Secondary Cyclone Overflow
4. Tertiary Cyclone Overflow
5. Secondary Cyclone Underflow
6. Secondary Ball Mill Discharge
7. Tertiary Cyclone Underflow
8. Tertiary Ball Mill Discharge

FIGURE 2. GRINDING CIRCUIT B

**TABLE 1**  
**SOLID FLOWRATES (TPH)**

LEAD CIRCUIT		
Stream	Measured	Balanced
PB RO FEED	550.60	550.555
PB RO CONC	-	129.937
PB RO TAIL	-	587.019
PB SC CONC	-	69.240
PB SC TAIL	-	517.778
PB CY UF	-	127.306
PB RG DISC	-	127.306
PB CY OF	-	129.937
PB 1 CL CO	-	134.036
PB 1 CL TA	-	97.160
PB 2 CL CO	-	68.637
PB 2 CL TA	-	101.259
PB 3 CL TA	-	35.860
PB 3 CL CO	-	32.777
GRINDING CIRCUIT B		
Stream	Measured	Balanced
RM FEED	295.10	295.122
RM DISCH	-	295.122
SEC CY OF	-	295.122
TERT CY OF	-	295.122
SEC CY UF	-	769.089
SEC BM DIS	-	769.089
TERT CY UF	-	583.162
TERT BM DS	-	583.162

} 2.6x  
} 2.0x

**TABLE 2**  
**BALANCED PARTICLE SIZE DISTRIBUTIONS\* (WT%)**

GRINDING CIRCUIT "B"							
Size ( $\mu\text{m}$ )	Rod mill Discharge	Sec cyc Overflow	Tert cyc Overflow	Sec cyc Underflow	Sec Bm Discharge	Tert cyc Underflow	Tert Bm Discharge
+300	48.01	8.00	1.03	32.52	17.17	5.57	2.04
+150	12.28	10.41	3.23	26.50	25.78	8.95	5.32
+75	12.77	27.49	14.85	21.50	27.15	38.77	32.37
+38	8.82	18.19	25.43	7.47	11.07	26.81	30.47
-38	18.11	35.93	55.46	11.99	16.83	19.90	29.79
LEAD FLOTATION CIRCUIT							
Size ( $\mu\text{m}$ )	Rougher Feed	Rougher Conc	Rougher Tail	Scavenger Conc	Scavenger Tail	Cyclone Underflow	Regrind Discharge
+75	17.92	4.20	17.30	8.55	18.46	6.73	4.76
+38	26.43	2.42	25.47	25.37	25.48	43.31	33.93
-38	55.64	69.38	57.24	66.08	56.05	49.97	61.31
Size ( $\mu\text{m}$ )	Cyclone Overflow	Cleaner 1 Conc	Cleaner 1 Tail	Cleaner 2 Conc	Cleaner 2 Tail	Cleaner 3 Tail	Cleaner 3 Conc
+75	2.27	2.00	2.46	1.88	2.09	2.02	1.73
+38	17.23	26.19	21.35	13.39	33.04	21.03	5.03
-38	80.49	71.80	76.20	84.73	64.87	76.95	93.24

\*Determined from sieve analysis

**TABLE 3**  
**METAL BALANCE\* (WT %)**

GRINDING CIRCUIT "B"							
	Rodmill Discharge	Sec.cyc. Overflow	Tert cyc. Overflow	Sec. cyc. Underflow	Sec. B.m. Discharge	Tert. cyc. Underflow	Tert. B.m. Discharge
Zinc	4.83	4.83	4.83	4.42	4.42	4.45	4.45
Lead	4.79	4.79	4.79	4.76	4.76	4.70	4.70
Silver*	65	65	65	79	79	82	82
Copper	.18	.18	.18	.16	.16	.14	.14
Gold*	.34	.34	.34	.40	.40	2.11	2.11
LEAD FLOTATION CIRCUIT							
	Rougher Feed	Rougher Conc.	Rougher Tail	Scav. Conc.	Scav. Tail	Cyc. U/F	Regrind Discharge
Zinc	5.26	11.87	6.01	12.67	5.12	9.45	9.45
Lead	4.37	19.96	1.41	6.49	0.73	26.43	26.43
Silver*	64	241	42	121	31	288	288
Copper	.17	1.29	.55	3.48	.16	.52	.52
Gold*	.31	.90	.30	1.20	.18	4.93	4.93
	Cyclone Overflow	Cleaner 1 Conc.	Cleaner 1 Tail	Cleaner 2 Conc.	Cleaner 2 Tail	Cleaner 3 Tail	Cleaner 3 Conc.
Zinc	11.87	15.43	13.39	12.25	18.05	16.73	7.35
Lead	19.96	25.16	5.82	42.53	13.27	24.84	61.88
Silver*	241	270	124	425	167	276	589
Copper	1.29	.81	1.57	.66	.93	.84	.45
Gold*	.90	1.11	.42	1.63	.73	1.02	2.31

\*ppm

**TABLE 4**  
**BALANCED MINERAL FLOWRATES (TPH)**

GRINDING CIRCUIT "B"					
	Sphalerite	Galena	Quartz	Micas	Pyrite
Rod Mill Disch.	25.80	16.31	30.32	11.83	119.34
Sec. Cyc o/f	25.80	16.31	30.32	11.83	119.34
Tert. Cyc o/f	25.80	16.31	30.32	11.83	119.34
Sec. Cyc u/f	23.60	16.23	10.48	3.60	176.08
Sec. Bm Disch.	61.51	42.30	27.30	9.37	458.87
Tert. Cyc u/f	61.91	41.73	48.34	14.11	427.75
Tert. Bm Disch.	46.95	31.64	36.65	10.70	324.34
	Chalcopyrite	Barite	Kaolinite	Pyrrhotite	Siderite
Rod Mill Disch.	.28	<del>30.71</del>	0.56	3.19	50.83
Sec. Cyc o/f	.28	30.71	0.56	3.19	50.83
Tert. Cyc o/f	.28	30.71	0.56	3.19	50.83
Sec. Cyc u/f	.30	25.62	.18	2.50	35.31
Sec. Bm Disch	.77	66.76	.47	6.52	92.03
Tert. Cyc u/f	.63	66.12	.91	4.72	103.21
Tert. Bm Disch	.47	50.14	.69	3.58	78.26
LEAD FLOTATION CIRCUIT					
	Sphalerite	Galena	Quartz	Micas	Pyrite
Rougher Feed	52.33	27.79	60.92	21.83	207.89
Rougher Conc.	27.88	29.95	2.88	1.02	49.75
Rougher Tail	63.84	9.56	63.81	22.66	234.95
Scavenger Conc.	15.87	5.19	3.24	1.23	28.70
Scavenger Tail	47.97	4.37	60.57	21.42	206.25
Cyclone U/F	21.76	38.86	.54	.21	45.10
Regrind Disch.	21.76	38.86	.54	.21	45.10
Cyclone O/F	27.88	29.95	2.88	1.02	49.75
CL 1 Conc	37.41	38.94	1.23	.70	34.04
CL 1 Tail	23.52	6.53	2.54	.62	48.11
CL 2 Conc	15.21	33.71	.87	.83	10.81
CL 2 Tail	33.05	15.51	.88	.30	32.40
CL 3 Tail	10.85	10.29	.52	.43	9.17
CL 3 Conc	<del>4.36</del>	<del>25.42</del>	.35	.40	1.64

TABLE 4 (Cont'd)

LEAD FLOTATION CIRCUIT					
	Chalcopyrite	Barite	Kaolinite	Pyrrhotite	Siderite
Rougher Feed	2.20	53.16	1.24	5.40	102.94
Rougher Conc.	.89	2.47	.05	1.25	16.85
Rougher Tail	4.05	53.60	1.28	6.32	110.07
Scavenger Conc.	1.89	1.07	.05	1.00	9.64
Scavenger Tail	2.16	52.52	1.23	5.32	100.43
Cyclone U/F	.58	1.96	.01	.37	8.22
Regrind Disch.	.58	1.96	.01	.37	8.22
Cyclone O/F	.89	2.47	.05	1.25	16.85
CL 1 Conc	.66	2.21	.03	1.14	15.70
CL 1 Tail	.84	1.83	.04	1.17	14.34
CL 2 Conc	.27	1.41	.01	.56	6.97
CL 2 Tail	.61	1.57	.02	1.06	13.20
CL 3 Tail	.22	.77	.01	.48	4.47
CL 3 Conc	.05	.64	.00	.08	2.51

**TABLE 5**  
**MODAL ANALYSES AND APPARENT SIZE DISTRIBUTIONS OF ORE MINERALS**  
**IN FIVE SAMPLES OF THIS ROD MILL FEED**

**SAMPLE 1**

Modal Analysis (Wt %)		Size fraction ( $\mu\text{m}$ )	Galena	Sphalerite	Pyrite	Chalcopyrite
Quartz	8.25	+212	.607	5.51	45.9	31.0
Micas	0.80	-212+150	2.01	6.97	11.8	28.5
Pyrite	43.11	-150+106	5.39	12.80	8.92	NIL
Chalcopyrite	0.15	-106+ 75	7.22	14.60	8.46	9.78
Barite	20.83	-75 + 53	12.1	15.4	7.35	3.21
Galena	6.11	-53 + 38	13.9	13.6	5.27	8.85
Sphalerite	10.62	-38 + 27	15.0	12.0	4.60	10.7
Kaolinite	NIL	-27 + 19	12.8	8.64	3.13	6.81
Pyrrhotite	0.29	-19 + 13	7.43	3.65	1.58	1.10
Siderite	9.83	-13 + 9	8.30	2.96	1.51	NIL
		- 9	15.17	3.76	1.51	NIL

**SAMPLE 2**

Modal Analysis (Wt %)		Size fraction ( $\mu\text{m}$ )	Galena	Sphalerite	Pyrite	Chalcopyrite
Quartz	NIL	+212	1.26	4.69	34.2	NIL
Micas	NIL	-212+150	4.28	4.36	11.6	NIL
Pyrite	38.69	-150+106	5.64	8.40	12.0	NIL
Chalcopyrite	NIL	-106+ 75	8.00	13.3	13.4	NIL
Barite	31.17	-75 + 53	11.2	12.9	9.43	NIL
Galena	13.39	-53 + 38	11.7	13.3	6.64	NIL
Sphalerite	12.07	-38 + 27	12.6	12.8	4.68	NIL
Kaolinite	NIL	-27 + 19	11.3	10.1	2.88	NIL
Pyrrhotite	NIL	-19 + 13	8.21	6.10	1.79	NIL
Siderite	4.68	-13 + 9	7.76	5.27	1.39	NIL
		- 9	17.93	8.77	2.06	NIL

TABLE 5 (Cont'd)

## SAMPLE 3

Modal Analysis (Wt %)		Size fraction ( $\mu\text{m}$ )	Galena	Sphalerite	Pyrite	Chalcopyrite
Quartz	47.86	+212	NIL	9.54	18.9	31.7
Micas	1.75	-212+150	NIL	9.01	12.2	11.4
Pyrite	23.69	-150+106	NIL	13.1	12.6	12.8
Chalcopyrite	3.08	-106+ 75	NIL	11.1	10.7	10.5
Barite	NIL	-75 + 53	NIL	16.7	9.92	9.71
Galena	NIL	-53 + 38	NIL	12.6	9.26	8.79
Sphalerite	4.42	-38 + 27	NIL	12.5	8.12	8.19
Kaolinite	NIL	-27 + 19	NIL	7.59	6.83	5.38
Pyrrhotite	9.12	+ 13	NIL	2.95	3.24	1.42
Siderite	10.08	+ 9	NIL	2.23	3.93	.03
		- 9	NIL	2.78	4.36	NIL

## SAMPLE 4

Modal Analysis (Wt %)		Size fraction ( $\mu\text{m}$ )	Galena	Sphalerite	Pyrite	Chalcopyrite
Quartz	.12	+212	NIL	2.48	25.8	NIL
Micas	1.75	-212+150	.543	4.81	15.0	NIL
Pyrite	25.40	-150+106	NIL	9.51	14.5	NIL
Chalcopyrite	NIL	-106+ 75	.409	12.6	12.5	NIL
Barite	1.77	-75 + 53	3.13	18.4	9.75	NIL
Galena	1.46	-53 + 38	6.28	16.2	6.69	NIL
Sphalerite	12.21	-38 + 27	10.8	15.1	5.33	NIL
Kaolinite	NIL	-27 + 19	15.3	9.70	3.64	NIL
Pyrrhotite	1.70	-19 + 13	11.4	4.04	1.75	NIL
Siderite	55.57	-13 + 9	14.7	3.19	2.21	NIL
		- 9	37.5	3.91	2.83	NIL

TABLE 5 (Cont'd)

## SAMPLE 5

Modal Analysis (Wt %)		Size fraction ( $\mu\text{m}$ )	Galena	Sphalerite	Pyrite	Chalcopyrite
Quartz	48.61	+212	-	23.4	31.7	-
Micas	7.37	-212+150	-	13.7	18.1	-
Pyrite	23.16	-150+106	-	13.0	14.5	-
Chalcopyrite	NIL	-106+ 75	-	12.8	12.7	-
Barite	NIL	-75 + 53	-	11.8	8.78	-
Galena	NIL	-53 + 38	-	9.39	5.37	-
Sphalerite	16.23	-38 + 27	-	7.09	4.11	-
Kaolinite	NIL	-27 + 19	-	4.31	2.21	-
Pyrrhotite	NIL	-19 + 13	-	1.91	.87	-
Siderite	4.63	-13 + 9	-	1.24	.79	-
		- 9	-	1.34	.72	-

**TABLE 6**  
**COMPOSITION OF SPHALERITE**  
**(SCAV. TAILS)**

Av. Wt %					Av. Wt %				
Mn	Fe	Zn	S	Totals	Mn	Fe	Zn	S	Totals
0.1	7.7	58.7	34.2	100.7	0.7	10.4	54.1	33.5	98.7
0.1	9.4	56.8	33.0	99.3	0.2	10.6	55.3	33.6	99.7
0.6	10.4	54.5	33.1	98.6	3.2	11.1	50.9	33.7	98.9
0.6	10.3	54.4	33.6	98.9	0.2	8.8	56.9	33.4	99.3
0.4	10.1	55.2	33.6	99.3	1.9	9.3	54.8	33.3	99.3
1.6	10.0	55.3	33.7	100.6	1.2	9.1	55.5	33.4	99.2
1.5	9.9	55.1	33.5	100.0	1.4	9.1	55.4	33.7	99.6
0.2	7.2	59.4	33.6	100.4	1.2	9.0	55.9	33.5	99.6
0.1	7.0	59.7	33.1	99.9	1.8	10.6	53.0	33.6	99.0
0.7	9.4	56.6	33.4	100.1	0.1	6.5	59.5	33.4	99.5
2.5	10.8	52.7	33.7	99.7	1.8	9.3	55.2	33.6	99.9
1.8	10.4	54.1	33.6	99.9	1.3	9.5	55.4	33.6	99.8
2.0	9.9	54.0	33.6	99.5	2.5	10.7	52.6	33.6	99.4
0.3	8.5	57.2	33.7	99.7	1.2	9.6	55.6	33.5	99.9
1.8	10.2	54.9	33.5	100.4	0.5	10.0	57.3	34.2	102.0
0.5	10.6	54.6	33.5	99.2	2.5	10.5	52.1	33.5	98.6
2.3	10.5	53.3	33.3	99.4	0.1	4.8	62.3	33.1	100.3
0.1	7.9	59.5	34.0	101.5	0.0	4.7	61.6	33.2	99.5
1.9	10.1	52.9	33.5	98.4	2.0	10.9	52.6	33.9	99.4
1.5	10.0	54.1	33.4	99.0	1.3	9.3	55.9	34.3	100.8
1.1	10.7	54.7	33.5	100.0	1.5	10.0	54.3	33.7	99.5
1.2	10.3	54.2	33.8	99.5	3.0	11.0	51.6	33.8	99.4
1.5	9.7	54.1	33.6	98.9	1.2	9.8	55.0	33.4	99.4
1.9	9.5	55.6	34.5	101.5	2.0	9.4	55.1	33.8	100.3
0.1	9.7	56.3	33.6	99.7	1.4	9.0	55.1	33.6	99.1
0.4	8.4	56.4	33.3	98.5	0.8	10.5	54.7	33.8	99.8
1.8	8.7	56.2	34.4	101.1	1.5	9.8	55.2	33.4	99.9

Average of 54 analyses = Mn(1.2), Fe(9.5), Zn(55.4), S(33.6) = 99.7 wt%

**TABLE 6 (Cont'd)**  
**IN FINAL LEAD CONCENTRATE**

Av. Wt %					Av. Wt %				
Mn	Fe	Zn	S	Totals	Mn	Fe	Zn	S	Totals
2.6	10.0	53.7	33.8	100.1	2.2	8.6	54.8	33.5	99.1
1.0	8.2	56.6	33.2	99.0	1.1	8.8	56.1	33.7	99.7
1.6	9.3	56.2	33.8	100.9	1.6	9.5	54.2	33.7	99.0
0.2	9.3	55.2	34.0	98.7	0.4	8.8	58.4	33.7	101.3
2.6	10.4	54.1	34.1	101.2	1.9	9.4	54.6	34.0	99.9
2.8	9.7	52.8	33.7	99.0	2.7	9.5	55.5	33.9	101.6
0.3	5.1	60.6	33.3	99.3	1.6	8.8	54.8	33.4	98.6
5.6	9.4	50.3	34.0	99.3	1.1	9.5	54.8	33.7	99.1
1.3	8.3	56.7	33.5	99.8	0.3	8.7	56.7	33.4	99.1
1.2	9.2	55.1	34.0	99.5	1.2	8.8	55.9	33.4	99.3
1.6	10.3	53.9	33.8	99.6	0.1	9.5	56.7	33.5	99.8
1.3	8.5	55.9	33.4	99.1	1.3	8.8	56.0	33.8	99.9
0.5	8.5	57.7	33.8	100.5	1.9	9.7	55.9	34.0	101.5
2.2	9.0	55.5	34.0	100.7	0.5	9.5	56.4	34.0	100.4
1.1	9.4	55.5	33.7	99.7	1.4	9.6	54.7	33.5	99.2
1.6	8.8	54.3	34.1	98.8	5.0	11.3	49.6	33.7	99.6
0.1	9.0	56.4	33.5	99.0	1.9	8.8	55.8	34.3	100.8
1.7	8.8	55.1	33.7	99.3	0.2	7.1	58.6	33.6	99.5
0.8	8.0	56.8	33.4	99.0	0.4	10.5	54.9	33.5	99.3
1.5	9.2	57.1	33.8	101.6	1.4	9.6	55.4	34.1	100.5
0.2	9.2	55.7	34.5	99.6	3.0	11.2	51.7	34.0	99.9
1.7	8.8	56.0	33.8	100.3	2.7	10.1	53.5	34.2	100.5
1.6	9.5	54.8	33.7	99.6	0.2	11.1	54.6	33.4	99.3
4.1	10.0	50.9	33.7	98.7	1.6	9.9	54.7	33.4	99.6
2.8	9.5	52.7	34.1	99.1	1.3	10.0	54.7	33.7	99.7
0.2	7.5	58.5	33.5	99.7	5.0	10.9	49.4	33.8	99.1
2.6	9.1	53.4	33.9	99.0	2.1	9.9	53.9	33.3	99.2
4.9	10.0	51.1	34.0	100.0	2.2	10.8	52.4	34.3	99.7
0.1	8.5	56.7	33.7	99.0	0.7	8.5	56.8	33.9	99.9
0.6	9.2	55.4	33.7	98.9	0.1	8.7	57.7	33.8	100.3
1.8	8.8	54.4	33.8	98.8	2.2	9.1	55.5	33.6	100.4
1.8	8.6	55.0	33.9	99.3	0.5	8.4	57.6	33.2	99.7
2.1	9.1	53.9	34.0	99.1	0.4	8.4	57.7	33.9	100.4
3.2	9.0	53.2	34.0	99.4	1.6	8.9	54.6	34.5	99.6
2.7	9.3	54.1	33.6	99.7	1.6	9.7	54.1	33.8	99.2
2.0	9.7	54.4	34.0	100.1					

**TABLE 7**  
**AVERAGE AND RANGE IN COMPOSITION OF SPHALERITE IN FINAL CONC AND SCAV. TAILS**

Element	PbCl <sub>3</sub> (-75+38 μm) 71 grains			Scav. Tails (-75+38 μm) 54 grains		
	Av. Wt %	Mol	Range in Wt %	Av. Wt %	Mol	Range in Wt %
Mn	1.7	.031	0.1 to 5.6	1.2	.022	0.0 - 3.2
Fe	9.2	.165	5.1 to 11.3	9.5	.170	4.7 - 11.1
Zn	55.0	.841	49.4 to 60.6	55.4	.847	50.9 - 62.3
S	33.8	1.054	33.2 to 34.5	33.6	1.048	33.0 - 34.5
	99.7			99.7		

Formulae: [(Zn<sub>.80</sub>Fe<sub>.16</sub>Mn<sub>.03</sub>)<sub>.99</sub>S<sub>1.01</sub>]

[(Zn<sub>.81</sub>Fe<sub>.16</sub>Mn<sub>.02</sub>)<sub>.99</sub>S<sub>1.00</sub>]

**TABLE 8**  
**SILVER CONTENT OF Pbs IN FINAL LEAD CONCENTRATE**

745	1216	1130	1195	1121	1008	1105	1005	684
843	428	661	831	1214	1175	719	638	955
1025	986	1093	800	885	876	1456	1106	834
743	863	1026	1166	784	228**	592	777	784
1021	830	544	567	931	962	931	1276	763
998	905	888	1339	1167	535	1106	789	
771	733	660	294	798	1042	987	1049	
762	850	1028	1089	1222	882	855	767	
1076	1242	1105	989	513	1275	642	1124	
472	821	1151	524	983	1281	488	537	
803	1160	960	922	1446*	447	947	980	
874	859	936	295	856	557	339	628	

@All values are in ppm Ag

\*Highest silver value

\*\*Lowest silver value

**TABLE 9**  
**GRINDING CIRCUIT LIBERATION ANALYSIS (TPH)**

Particle size ( $\mu\text{m}$ )	Rod Mill Discharge	SEC CYo/f	TERT CYo/f	SEC CYu/f	SECBMD	TERT CYu/f	TERT BMD
<b>SPHALERITE - LIBERATED</b>							
+300	1.17	0.10	NIL	2.26	1.18	0.17	.07
-300+150	1.12	1.35	.07	4.51	4.74	2.93	1.65
-150+ 75	2.45	3.35	1.94	5.93	6.83	11.24	9.83
-75 + 38	2.31	4.14	5.26	4.09	5.93	8.03	9.14
- 38	4.97	8.53	14.64	7.19	10.75	6.40	12.51
<b>TOTAL</b>	12.02	17.47	21.91	23.98	29.43	28.77	33.20
<b>SPHALERITE - MIDDLINGS</b>							
+300	5.46	0.25	NIL	9.41	4.21	0.55	0.30
-300+150	1.02	0.90	.05	5.87	5.75	1.77	0.92
-150+ 75	0.70	1.66	0.89	4.10	5.05	4.61	3.85
-75 + 38	0.47	.78	1.09	1.37	1.68	2.34	2.65
- 38	0.47	1.57	1.24	0.86	1.97	1.75	1.41
<b>TOTAL</b>	8.12	5.16	3.27	21.61	18.66	11.02	9.13
<b>SPHALERITE - TAILINGS</b>							
+300	4.37	0.28	0.01	8.43	4.34	.34	.06
-300+150	.55	.50	.05	4.40	4.35	.73	.28
-150+ 75	.36	1.10	.27	1.90	2.65	2.72	1.89
-75 + 38	.13	.28	.36	.35	.50	.60	.67
- 38	.21	.39	.42	.23	.42	.47	.50
<b>TOTAL</b>	5.62	2.55	1.11	15.31	12.26	4.86	3.40
<b>GALENA - LIBERATED</b>							
+300	.28	.02	NIL	.57	.31	.03	NIL
-300+150	.45	.04	.01	1.42	1.01	.10	.06
-150+ 75	.79	.78	.25	8.24	8.23	1.98	1.45
- 75+ 38	1.11	2.98	.94	4.62	6.50	10.13	8.09
- 38	3.91	7.04	11.09	4.30	7.42	8.58	12.64
<b>TOTAL</b>	6.54	10.86	12.29	19.15	23.47	20.82	22.24

TABLE 9 (Cont'd)

Particle size ( $\mu\text{m}$ )	Rod Mill Discharge	SEC CYo/f	TERT CYo/f	SEC CYu/f	SECMD	TERT CYu/f	TERT BMD
GALENA - MIDDINGS							
+300	2.02	.01	NIL	2.94	.93	.02	.01
-300+150	.43	.16	NIL	1.72	1.44	.18	.03
-150+ 75	.50	.92	.36	2.35	2.77	1.35	.78
-75 + 38	.36	1.20	.71	.65	1.49	2.35	1.86
- 38	.32	.83	.88	.55	1.06	1.21	1.26
<b>TOTAL</b>	3.63	3.12	1.95	8.21	7.69	5.11	3.94
GALENA - TAILINGS							
+300	4.17	.11	NIL	7.25	3.19	.17	.05
-300+150	.67	.45	.03	3.22	3.00	.89	.47
-150+ 75	.49	.73	.43	2.41	2.64	2.03	1.74
-75 + 38	.23	.45	.63	.32	.54	.82	.99
- 38	.18	.52	.72	.18	.52	.40	.61
<b>TOTAL</b>	5.74	2.26	1.81	13.38	9.89	4.31	3.86

**TABLE 10**  
**LEAD FLOTATION CIRCUIT LIBERATION ANALYSIS (TPH)**

Particle size ( $\mu\text{m}$ )	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
SPHALERITE - LIBERATED (70-100 area % sphalerite in particles)							
+75	6.07	1.03	6.34	1.05	5.28	2.02	1.30
-75+38	13.63	6.05	13.24	3.03	10.21	7.33	4.16
-38	23.03	5.35	33.19	8.97	24.22	5.70	10.08
<b>TOTAL</b>	42.73	22.43	52.77	13.05	39.71	15.05	15.54
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.31	.51	.25	.25	.45	.19	.06
-75+38	2.88	8.69	2.63	2.00	8.45	1.75	.25
-38	19.73	21.36	16.54	10.09	18.16	6.90	3.20
<b>TOTAL</b>	22.92	30.56	19.42	12.34	27.06	8.84	3.51
SPHALERITE - MIDDINGS (20-70 area % sphalerite in particles)							
	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
+75	1.49	.42	1.48	.34	1.13	.72	.37
-75+38	2.42	1.77	2.03	.85	1.18	2.88	1.69
-38	2.16	2.37	2.95	1.26	1.69	2.52	2.81
<b>TOTAL</b>	6.07	4.56	6.46	2.45	4.00	6.12	4.87
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.07	.16	.06	.05	.15	.04	.01
-75+38	0.58	1.90	.53	.46	1.85	.41	.05
-38	2.66	4.15	1.90	2.02	3.38	1.26	.76
<b>TOTAL</b>	3.31	6.21	2.49	2.53	5.38	1.71	.82

TABLE 10 (Cont'd)

SPHALERITE - TAILINGS (0-20 area % sphalerite in particles)							
	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
+75	.47	.06	.49	.06	.43	.12	.08
-75+38	.61	.33	.58	.16	.42	.57	.39
-38	.89	.63	1.10	.30	.80	.30	.28
<b>TOTAL</b>	1.97	1.02	2.17	.52	1.65	.99	.75
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.02	.02	.02	.01	.02	.01	NIL
-75+38	.15	.26	.13	.06	.25	.04	.01
-38	.61	.36	.54	.26	.28	.18	.08
<b>TOTAL</b>	.78	.64	.69	.33	.55	.23	.09
GALENA - LIBERATED (70-100 area % galena in particles)							
	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
+75	.21	.16	.17	.09	.09	.31	.21
-75+38	3.01	3.05	.56	.24	.32	6.55	4.34
-38	17.99	20.10	2.62	2.36	.26	25.54	26.79
<b>TOTAL</b>	21.21	23.31	3.35	2.69	.67	32.40	31.34
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.05	.11	.03	.05	.09	.03	.02
-75+38	.84	4.13	.36	2.17	3.64	1.69	.48
-38	21.35	26.25	2.37	25.51	7.28	6.53	18.97
<b>TOTAL</b>	22.24	30.49	2.76	27.73	11.01	8.25	19.47

TABLE 10 (Cont'd)

GALENA - MIDLINGS (20-70 area % galena in particles)							
	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
+75	.31	.20	.35	.17	.18	.34	.23
-75+38	.95	1.34	.59	.35	.25	2.46	1.95
-38	1.70	2.47	.34	.31	.03	2.11	2.73
<b>TOTAL</b>	2.96	4.01	1.28	.83	.46	4.91	4.91
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.09	.24	.07	.10	.23	.09	.01
-75+38	.84	1.38	.64	.77	1.18	.58	.19
-38	3.09	2.94	.80	3.10	.65	.81	2.29
<b>TOTAL</b>	4.02	4.56	1.51	3.97	2.06	1.48	2.49
GALENA - TAILINGS (0-20 area % galena in particles)							
	Ro Feed	Ro Conc	Ro Tail	Sc Conc	Sc Tail	CY u/f	Regrind Disch
+75	1.08	.15	1.35	.28	1.06	.17	.17
-75+38	1.08	.53	1.57	.45	1.12	.80	.96
-38	.77	1.81	1.22	.65	.57	.40	.56
<b>TOTAL</b>	2.93	2.49	4.14	1.38	2.75	1.37	1.69
	CY o/f	CL1 Conc	CL1 Tail	CL2 Conc	CL2 Tail	CL3 Tail	CL3 Conc
+75	.15	.17	.14	.06	.16	.05	.01
-75+38	.69	1.12	.58	.36	1.00	.25	.11
-38	1.96	1.50	1.61	.60	1.14	.25	.35
<b>TOTAL</b>	2.80	2.79	2.33	1.02	2.30	.55	.47

**TABLE 11**  
**RECOVERY OF GALENA IN THE LIBERATION CLASSES BY SIEVE SIZE**  
**IN SELECTED STREAMS (AS % OF FLOTATION UNIT FEED)**

	Tailings (0-20 area %)	Liberated (70-100 area %)	Middlings (20-70 area %)
<b>Pb Rougher Concentrate</b>			
+75 $\mu\text{m}$	48	36	10
-75+38 $\mu\text{m}$	84	69	25
-38 $\mu\text{m}$	87	88	60
<b>Pb Scavenger Concentrate</b>			
+75 $\mu\text{m}$	53	32	21
-75+38 $\mu\text{m}$	43	59	29
-38 $\mu\text{m}$	90	91	53
<b>Pb Ro Conc.</b> <b>(per Rougher-Scavenger together)</b>			
+75 $\mu\text{m}$	67	53	12
-75+38 $\mu\text{m}$	91	84	32
-38 $\mu\text{m}$	99	98	76
<b>Pb Final Conc.</b> <b>(per CL1-CL2-CL3 together)</b>			
+75 $\mu\text{m}$	40	11	7
-75+38 $\mu\text{m}$	57	23	16
-38 $\mu\text{m}$	89	74	18

**TABLE 12**  
**LIBERATION IN GRINDING CIRCUIT "B" AND THE LEAD FLOTATION CIRCUIT (%)**

GRINDING CIRCUIT "B"	Galena	Sphalerite
RM Discharge	41	47
Sec. Cyc o/f	67	69
Tert Cyc o/f	<del>77</del>	<del>83</del>
Sec. Cyc u/f	47	39
Sec. BMD	57	49
Tert Cy u/f	69	64
Tert BMD	74	73
LEAD FLOTATION CIRCUIT		
Rougher Feed	<del>76</del>	84
Rougher Conc.	<del>78</del>	80
Rougher Tail	35	86
Scavenger Conc.	52	81
Scavenger Tail	15	88
Cyclone U/F	83	68
Regrind Discharge	81	73
Cyclone O/F	74	85
Cleaner 1 Conc.	78	82
Cleaner 1 Tail	42	86
Cleaner 2 Conc.	82	81
Cleaner 2 Tail	71	82
Cleaner 3 Tail	80	82
Cleaner 3 Conc.	<del>83</del>	79

**TABLE 13**  
**DISTRIBUTION OF GALENA AMONG BINARY AND TERNARY<sup>+</sup> PARTICLES**  
**IN EACH SIEVE FRACTION IN EACH STREAM (WT %)**

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Sp	
Pb Ro Feed									
+75 $\mu\text{m}$	66.3	1.06	11.3	NIL	4.83	1.69	.386	12.2	2.20
-	-	59	49	3	44	10	10	34	-
-75+38 $\mu\text{m}$	25.6	3.99	NIL	NIL	4.97	NIL	11.3	19.4	34.8
-	-	24	6	6	9	NIL	18	14	-
-38 $\mu\text{m}$	12.5	9.26	NIL	.44	.3	NIL	23.4	3.80	50.2
-	-	10	.4	3.3	.8	.2	8	6	-
Pb Ro Conc.									
+75 $\mu\text{m}$	54.5	7.35	.99	.112	7.33	NIL	.458	21.8	7.47
-	-	45	6	2	27	2	11	40	-
-75+38 $\mu\text{m}$	34.6	5.44	NIL	NIL	7.23	NIL	2.43	15.1	34.9
-	-	26	2	3	18	2	13	25	-
-38 $\mu\text{m}$	27.2	2.62	NIL	NIL	1.75	NIL	23.6	3.63	41.1
-	-	18	NIL	4	11	2	22	18	-
Pb Ro Tail									
+75 $\mu\text{m}$	64.5	8.10	NIL	NIL	3.79	NIL	NIL	5.63	17.5
-	-	60	9	3	32	4	23	37	-
-75+38 $\mu\text{m}$	63.9	4.87	NIL	NIL	10.8	NIL	NIL	16.0	3.57
-	-	61	NIL	NIL	44	3	35	34	-
-38 $\mu\text{m}$	49.4	.788	NIL	NIL	NIL	NIL	28.2	NIL	21.5
-	-	44	NIL	3	14	NIL	38	10	-
Pb Sc Conc		?							
+75 $\mu\text{m}$	58.5	63.4	1.23	NIL	9.74	NIL	NIL	20.1	3.58
-	-	46	4	2	33	4	8	42	-
-75+38 $\mu\text{m}$	54.7	5.33	NIL	NIL	6.89	NIL	2	13.5	17.1
-	-	44	3	4	28	5	18	38	-
-38 $\mu\text{m}$	34.3	4.88	NIL	NIL	4.27	NIL	9.45	8.67	38.4
-	-	27	NIL	8	11	3	18	21	-

TABLE 13 (Cont'd)

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Sp	
Pb Sc. Tail									
+75 $\mu\text{m}$	72.6	5.57	3.57	NIL	4.23	NIL	.6	5.88	7.30
-	-	63	14	7	46	3	12	42	-
-75+38 $\mu\text{m}$	76.7	4.95	1.28	NIL	7.74	NIL	3.24	2.14	3.98
-	-	71	3	19	45	4	24	51	-
-38 $\mu\text{m}$	51.8	12.5	NIL	NIL	NIL	NIL	7.11	NIL	28.6
-	-	50	NIL	36	9	8	8	10	-
Pb CY U/F									
+75 $\mu\text{m}$	54.6	4.96	NIL	NIL	9.74	NIL	.2	22.6	7.88
-	-	41	5	3	31	4	10	39	-
-75+38 $\mu\text{m}$	30.7	3.52	NIL	NIL	7.66	NIL	3.98	10.5	43.7
-	-	22	1	2	20	2	9	20	-
-38 $\mu\text{m}$	20.8	3.36	NIL	NIL	2.47	NIL	25.7	1.05	46.7
-	-	27	NIL	2	11	1	25	13	-
Pb Regr. Disch									
+75 $\mu\text{m}$	60.4	5.22	.4	.3	8.33	NIL	.2	16.1	8.99
-	-	52	5	4	31	3	11	42	-
-75+38 $\mu\text{m}$	42.3	2.41	NIL	NIL	4.31	NIL	18.4	4.97	27.6
-	-	32	NIL	1	20	8	23	26	-
-38 $\mu\text{m}$	30.5	6.92	NIL	NIL	1.63	NIL	2.4	2.09	34.5
-	-	24	NIL	5	9	1.1	28	13	-
Pb CYC O/F									
+75 $\mu\text{m}$	52.1	9.65	11.5	NIL	8.5	NIL	NIL	8.14	9.97
-	-	44	13	4	23	1	4	22	-
-75+38 $\mu\text{m}$	68.4	1	NIL	NIL	.3	NIL	20	2.32	7.94
-	-	64	NIL	18	42	20	58	41	-
-38 $\mu\text{m}$	27.2	3.69	NIL	1	3.1	NIL	18.0	3.05	44.2
-	-	25	.5	4	10	1	15	13	-

TABLE 13 (Cont'd)

Stream + Sieve Fraction	Ternary+ Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Sp	
Pb CL1 Conc									
+75 $\mu\text{m}$	60.7	4.84	.4	NIL	8.17	NIL	1.82	17.0	7.14
-	-	50	4	1	25	1	13	43	-
-75+38 $\mu\text{m}$	34.7	5.95	NIL	NIL	4.6	NIL	8.81	13.2	32.1
-	-	26	.7	.6	16	2	14	25	-
-38 $\mu\text{m}$	25.6	4.52	NIL	NIL	2.84	NIL	24.7	4.26	38.1
-	-	21	.5	4	10	1	16	15	-
Pb CL1 Tail									
+75 $\mu\text{m}$	56.1	7.94	.68	.2	7.37	NIL	2.25	12.1	13.3
-	-	49	5	4	29	NIL	12	35	-
-75+38 $\mu\text{m}$	59.3	9.06	NIL	NIL	4.73	NIL	4.59	10.2	12.1
-	-	53	4	6	30	4	20	42	-
-38 $\mu\text{m}$	52.3	14.6	NIL	1	1.72	.2	14.6	3.21	12.5
-	-	45	.8	6	27	2	33	32	-
Pb CL2 Conc									
+75 $\mu\text{m}$	58.0	.84	NIL	NIL	3.57	NIL	3.31	30.4	3.66
-	-	54	NIL	1	25	1	11	41	-
-75+38 $\mu\text{m}$	23.5	6.84	.6	NIL	4.4	NIL	4.19	20.1	40.5
-	-	16	1	2	10	1	8	17	-
-38 $\mu\text{m}$	29.0	3.17	NIL	.4	1.26	NIL	27.3	4.09	34.8
-	-	23	NIL	3	7	1	23	16	-
Pb CL2 Tail									
+75 $\mu\text{m}$	57.5	6.90	.8	.4	5.56	.2	.7	19.8	8.17
-	-	47	5	6	26	4	11	43	-
-75+38 $\mu\text{m}$	42.4	.5	NIL	NIL	NIL	NIL	13.8	1.34	41.9
-	-	21	2	5	16	5	41	34	-
-38 $\mu\text{m}$	18.1	NIL	NIL	NIL	.6	NIL	31.6	1.66	47.9
-	-	11	NIL	2	8	1	18	13	-

TABLE 13 (Cont'd)

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Sp	
Pb CL3 Tail									
+75 $\mu\text{m}$	44.2	9.23	.5	NIL	6.38	NIL	1.66	23.5	14.4
-	-	35	1	.4	18	1	9	33	-
-75+38 $\mu\text{m}$	26.6	5.67	NIL	NIL	5.36	NIL	8.29	12.9	41.0
-	-	21	.6	2	13	.6	14	16	-
-38 $\mu\text{m}$	17.7	NIL	NIL	NIL	NIL	NIL	33.0	.5	48.7
-	-	11	.3	.4	6	1	18	13	-
Pb CL3 Conc									
+75 $\mu\text{m}$	20.4	5.43	NIL	NIL	3.86	NIL	1.95	18	50.1
-	-	19	.3	1	7	.3	4	16	-
-75+38 $\mu\text{m}$	23.1	4.5	NIL	NIL	1.17	NIL	12.8	11.6	46.8
-	-	16	1	3	6	1	14	14	-
-38 $\mu\text{m}$	16.1	5.99	NIL	NIL	.4	NIL	24.6	1.62	51.2
-	-	13	.3	1	2	.3	14	7	-

**TABLE 14**  
**DISTRIBUTION OF SPHALERITE AMONG BINARY AND TERNARY<sup>+</sup> PARTICLES IN EACH SIEVE**  
**FRACTION IN EACH STREAM (WT %)**

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Galena	
Pb Ro Feed									
+75 $\mu\text{m}$	58.0	5.58	7.08	NIL	.41	1.27	2.28	4.92	20.5
-	-	45	29	3	23	27	4	31	-
-75+38 $\mu\text{m}$	26.2	17.7	NIL	NIL	.654	3.48	2.25	7.36	42.4
-	-	23	3	6	10	6	6	14	-
-38 $\mu\text{m}$	24.6	14.2	NIL	1	.4	4.49	4.49	1.69	46.3
-	-	21	2	4	6	8	8	12	-
Pb Ro Conc									
+75 $\mu\text{m}$	47.8	1.36	NIL	.227	.905	NIL	.319	39.7	9.61
-	-	37	2	1	20	3	8	47	-
-75+38 $\mu\text{m}$	48	3.82	NIL	NIL	1	NIL	NIL	30.9	15.3
-	-	37	2	4	22	7	8	46	-
-38 $\mu\text{m}$	60.0	10.9	NIL	NIL	2.57	1.72	1.70	5.37	17.7
-	-	47	NIL	10	30	9	37	40	-
Pb Ro Tail									
+75 $\mu\text{m}$	38.6	8.13	.47	NIL	2.93	2.04	2.8	10.7	34.3
-	-	33	2	2	24	4	10	32	-
-75+38 $\mu\text{m}$	33.8	12.5	NIL	NIL	3.66	3.51	3.41	13.8	29.4
-	-	31	2	2	16	7	10	20	-
-38 $\mu\text{m}$	44.9	26.3	NIL	NIL	3.28	1	1.68	1.80	20.9
-	-	44	3	6	33	9	17	10	-
Pb Sc Conc									
+75 $\mu\text{m}$	52.0	4.96	NIL	NIL	1	1.78	NIL	30.2	9.95
-	-	38	3	2	20	5	8	51	-
-75+38 $\mu\text{m}$	42.9	5.48	NIL	NIL	2.08	4.11	NIL	23.1	21.7
-	-	31	NIL	2	18	9	8	37	-
-38 $\mu\text{m}$	35.6	12.3	NIL	NIL	2.39	5.9	1	5.76	36.7
-	-	27	NIL	6	12	14	10	18	-

TABLE 14 (Cont'd)

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Galena	
Pb Sc Tail									
+75 $\mu\text{m}$	39.0	16.8	.4	NIL	3.33	.7	.9	8.51	30.4
-	-	31	3	4	20	3	7	26	-
-75+38 $\mu\text{m}$	30.7	11.1	1.75	1.38	7.154	5.06	1	1.37	40.6
-	-	28	1	6	16	7	5	14	-
-38 $\mu\text{m}$	33.0	24.1	NIL	1	2.66	NIL	.4	NIL	38.8
-	-	32	13	17	28	17	14	3	-
Pb CY U/F									
+75 $\mu\text{m}$	51.9	2.89	NIL	NIL	.6	.8	.3	38.3	5.07
-	-	37	NIL	1	20	9	9	50	-
-75+38 $\mu\text{m}$	51.5	4.03	NIL	NIL	2.47	1.37	NIL	29.8	10.6
-	-	31	NIL	NIL	26	9	11	49	-
-38 $\mu\text{m}$	66.6	9.41	NIL	NIL	1	.5	.6	7.55	14.4
-	-	46	NIL	5	31	17	35	58	-
Pb Reqr. Disch									
+75 $\mu\text{m}$	54.8	3.36	NIL	NIL	.6	.3	NIL	35.2	5.52
-	-	28	NIL	NIL	11	3	4	33	-
-75+38 $\mu\text{m}$	63.8	5.90	NIL	NIL	1.78	.2	.1	18.0	10.0
-	-	58	NIL	2	32	6	15	55	-
-38 $\mu\text{m}$	56.6	15.5	NIL	NIL	1.95	1.28	.3	5.37	19.0
-	-	49	NIL	9	29	22	20	37	-
Pb CYC O/F									
+75 $\mu\text{m}$	42.6	7.99	NIL	NIL	.9	NIL	NIL	35.4	13.0
-	-	38	.7	NIL	11	1	2.7	41	-
-75+38 $\mu\text{m}$	89.9	4.72	NIL	NIL	.5	NIL	NIL	1	3.7
-	-	89	NIL	21	81	39	49	49	-
-38 $\mu\text{m}$	52.3	15.6	NIL	NIL	2.71	NIL	1	8.6	19.5
-	-	46	NIL	9	23	13	15	42	-

TABLE 14 (Cont'd)

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Galena	
Pb CL1 Conc									
+75 $\mu\text{m}$	53.2	3.40	NIL	NIL	1.0	NIL	NIL	34.6	7.44
-	-	14	NIL	NIL	14	3	8	53	-
-75+38 $\mu\text{m}$	54	3.99	NIL	NIL	.5	.9	.4	29.9	10.2
-	-	43	.5	.7	18	6	11	51	-
-38 $\mu\text{m}$	62.2	11.7	NIL	NIL	1.3	1.76	NIL	14.1	8.87
-	-	51	NIL	10	24	9	26	55	-
Pb CL1 Tail									
+75 $\mu\text{m}$	47.8	7.33	NIL	NIL	.36	NIL	.2	24.3	19.8
-	-	42	.8	1	15	NIL	7	45	-
-75+38 $\mu\text{m}$	46.9	13.2	NIL	NIL	2.75	.5	NIL	20.3	16.3
-	-	41	.5	3	22	3	5	42	-
-38 $\mu\text{m}$	48.6	16.9	NIL	NIL	1	2.31	1	7.56	22.6
-	-	41	NIL	7	21	8	17	33	-
Pb CL2 Conc									
+75 $\mu\text{m}$	48.4	1.39	NIL	NIL	1.05	NIL	NIL	39.0	10.2
-	-	42	NIL	NIL	9	5	7	48	-
-75+38 $\mu\text{m}$	39.5	2.93	NIL	NIL	.7	.2	.5	43.2	12.9
-	-	26	NIL	2	10	3	7	39	-
-38 $\mu\text{m}$	60.5	7.61	NIL	NIL	2.03	.5	.8	12.7	15.9
-	-	50	NIL	6	23	7	33	50	-
Pb CL2 Tail									
+75 $\mu\text{m}$	54.0	2.26	NIL	NIL	NIL	NIL	.2	36.9	6.14
-	-	44	1	4	19	4	10	53	-
-75+38 $\mu\text{m}$	63.6	4.67	NIL	NIL	1.78	1.78	5.3	2.52	20.3
-	-	32	2	5	31	18	50	43	-
-38 $\mu\text{m}$	62.2	10.8	NIL	NIL	2.49	1	6.42	3.39	13.8
-	-	49	NIL	5	41	7	42	30	-

TABLE 14 (Cont'd)

Stream + Sieve Fraction	Ternary <sup>+</sup> Particles	Binary Particles							Free
		Sid	Qtz	Micas	Py	Cp	Ba	Galena	
Pb CL3 Tail									
+75 $\mu\text{m}$	43.6	2.45	NIL	NIL	1.08	NIL	NIL	41.5	11.2
-	-	33	.7	1	14	2	6	43	-
-75+38 $\mu\text{m}$	40.6	4.85	NIL	NIL	.8	.4	.5	31.4	21.4
-	-	31	NIL	2	13	3	12	38	-
-38 $\mu\text{m}$	51.4	10.4	NIL	NIL	8.64	1.91	1.10	.3	26.2
-	-	35	NIL	6	29	10	35	26	-
Pb CL3 Conc									
+75 $\mu\text{m}$	40.9	6.59	NIL	NIL	NIL	2.28	NIL	36.1	14.1
-	-	36	1	2	10	NIL	19	36	-
-75+38 $\mu\text{m}$	36.2	5.57	NIL	NIL	.9	.56	.6	41.2	14.9
-	-	25	.9	1.5	7	6	11	32	-
-38 $\mu\text{m}$	45.9	12.3	NIL	NIL	NIL	.5	2.	14.1	24.9
-	-	36	NIL	3	11	1	30	40	-

**TABLE 15**  
**QUANTITATIVE COMPOSITION OF THE ELECTRUM IN THE Pb SCAV. TAILS**

Element	Av. wt %	Range in wt %
Ag	37.3	34.6-40.8
Au	62.1	58.0-65.4
<b>TOTAL</b>	99.4	

**TABLE 16**  
**ESTIMATED LEAD AND ZINC SLIMES IN SELECTED STREAMS**

Stream	Lead		Zinc	
	TPH	% of total lead in stream	TPH	% of total zinc in stream
Rod Mill Discharge	.51	3.5	NIL	NIL
Sec. CYC O/F	1.7	12	1.0	7
Tert. CYC O/F	6.8	48*	1.9	13
Rougher Feed	2.2	9	2.8	10
Final Conc.	1.7	8	.28	12
Scavenger Tail	2.3	61	3.2	12
Regrind CYC O/F	2.6	10	2.5	16

\*Spurious result?