

J.D. Wilson

Mar 20/91

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006500

IMAGE ANALYSIS OF VANGORDA PLANT PRODUCTS

**J.M.D. Wilson
Mineral Processing Laboratory**

February 1991

Project: 30.05.99

Cost Recovery

Job No.: 50264

CONFIDENTIAL

**MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 91-9 (CR)**

IMAGE ANALYSIS OF VANGORDA PLANT PRODUCTS

by

J.M.D. Wilson*

ABSTRACT

Image analysis was performed on samples of the feed, concentrates and tails taken from the Faro concentrator during processing of Vangorda ore. Mineral quantities, liberations and associations were measured of the important ore minerals in the samples. Galena and sphalerite are mostly liberated at a grind of 53 μm . Liberations of galena and sphalerite in the flotation feed are 91.3% and 83.1%, respectively. Grade is reduced in the lead and zinc concentrate by the presence of free gangue. Metal losses are mostly due to the presence of liberated galena and sphalerite in the tailings.

Keywords: Image analysis, lead-zinc ore, liberation, plant audit

* Physical Scientist, Process Mineralogy, Mineral Sciences Laboratories, CANMET, Department of Energy, Mines and Resources, Ottawa, Canada K1A 0G1.

INTRODUCTION

The complete flotation circuit of the Faro concentrator was sampled on December 15, 1990 during a plant trial with Vangorda ore. Samples were collected in buckets, filtered, dried, and split and a portion of each was forwarded to CANMET for mineralogical examination. Curragh Resources requested that only four samples, namely the feed, lead and zinc concentrates and tails be given priority on a cost recovery basis.

ANALYSIS

Each of the four samples were sieved at 106 μm (150 mesh), 75 μm (200 mesh), 53 μm (270 mesh) and 38 μm (400 mesh) in preparation for analysis by means of the MP-SEM-IPS image analysis system. Due to the fine-grained nature of the samples (Table 1) it was decided that only the feed and tails samples required analysis of individual sieve fractions. Therefore, polished sections were made of these samples for the sieve fractions +53 μm , -53+38 μm , and -38 μm . One polished section was made of each of the lead and zinc concentrates.

The major and minor minerals were identified by means of optical microscopy, X-ray diffraction, electron probe microanalysis using wavelength dispersive X-ray spectrometry and qualitative energy dispersive X-ray analysis. Image analysis was performed to determine mineral quantities, the apparent liberations of the galena, sphalerite and pyrite and their mineral associations. Special attention was paid to finding secondary copper and lead minerals by optical microscopy. The identification of these minerals is presently ongoing.

RESULTS

The size distributions of the samples are given in Table 1. The major and minor minerals identified in the samples are pyrite, quartz, siderite, illite, pyrrhotite, galena,

sphalerite, chalcopyrite, barite and chlorite. Trace amounts of covellite, marcasite, calcite, kaolinite, arsenopyrite, barytocalcite, celsian and other secondary Cu and Pb minerals were also observed. The quantities of the major and minor minerals in each polished section and sample are given in Table 2. It is found that covellite and other secondary copper and lead minerals tend to be recovered in the lead concentrate. Apparent liberation of sphalerite, galena and pyrite was measured in each polished section and is expressed as the mineral distribution by weight among the areal classes of ore particles in Table 3.

Mineral associations of the galena and the sphalerite were measured and are shown in Table 4. In this table the distribution data for each ore mineral in each sample consists of two lines. The upper line shows the distribution of the ore mineral among several types of particles. The first number in the upper line shows the quantity of ore mineral which is locked in ternary particles. Ternary particles are particles which contain the ore mineral and at least two other minerals. The next seven numbers in the upper line show the quantity of ore mineral locked with each other mineral in binary particles. Binary particles are particles which contain the ore mineral and only one other mineral. The last number in the upper line shows the quantity of free ore mineral. Free particles are simply ore particles with no other attached mineral. Thus the sum of the numbers in the upper line equals 100%. The lower line shows how the ore mineral in the ternary particles is distributed among the other minerals. The sum of the numbers in the lower line can add to more than the number in the "ternary" column in the upper line because any ore grain in a ternary particle can be classified more than once. By adding the numbers together columnwise the association of the ore mineral for a particular mineral may be determined.

DISCUSSION

Liberation

The term "liberated" is used to describe the proportion of ore mineral which is contained in particles of areal class 70% and greater. Such material may be considered

recoverable without any further grinding being necessary. "Free" is used to describe the proportion of ore mineral which is totally free of any other mineral.

Data in Table 3 show that for the three sieve fractions +53 μm , -53+38 μm and -38 μm the liberation of galena in the plant feed is 30.0%, 91.1%, and 93.4% respectively. For sphalerite the corresponding liberations are 61.2%, 87.9%, and 86.3% respectively. This data indicates that both minerals are mostly liberated at 53 μm (270 mesh). The overall liberation of galena and sphalerite in the feed is 91.3% and 83.1%, respectively. This shows that liberation is excellent for galena but that sphalerite still requires further grinding. The proportion of liberated galena in the lead concentrate is very high, 99.7%, and that of sphalerite in the zinc concentrate is also high, 96.9%.

Grade

Lead concentrate

The data in Table 3 show that in the lead concentrate 99.7% of the galena is "liberated" and 96.2% is free. The small amount of locked galena is associated with barite and sphalerite but this contributes little to the lowering of the concentrate grade. This data supports the previous observation that liberation of galena is very good and indicates that grade is not being reduced by locking of galena.

The concentrate contains 10.4% sphalerite of which 96.6% is "liberated" and 72.1% is free. Most of the locked sphalerite (27.9% of the sphalerite) is not associated with galena but is associated with barite, pyrite and quartz.

The second major contaminant is pyrite which makes up 6.2% of the lead concentrate. 91.4% of the pyrite is "liberated" and 32.4% is free. It cannot be determined from the data how much of the pyrite is locked with sphalerite and how much is locked with other gangue minerals.

It is concluded that galena liberation in the lead concentrate is excellent, but that the concentrate contains over 10 wt% free sphalerite and pyrite and an additional amount of gangue not locked with galena. Therefore the grade of the lead concentrate could be improved by increasing selectivity for galena.

Zinc concentrate

The data in Table 3 show that in the zinc concentrate 96.9% of the sphalerite is "liberated" but only 60.9% is free. Data in Table 4 shows that a large proportion of the locked sphalerite (39.1% of the total sphalerite) is associated with barite and galena in roughly equal proportions. The zinc concentrate contains 4.2% galena of which 56.9% is free. The rest of the galena is locked with sphalerite and barite in ternary particles. This locking contributes to the lowering of the concentrate grade.

The concentrate also contains 6.4% pyrite of which 32.8% is free. It cannot be determined from the data how much of the pyrite is locked with spalerite.

In summary, liberation of sphalerite in the zinc concentrate is good but about 4 wt% of the zinc concentrate consists of free galena and pyrite.

Losses to tailings

Inasmuch as the image analyzer cannot resolve particles less than about 1 μm in diameter, all the discussion pertaining to lead and zinc losses in the tailings is based on particles larger than 1 μm . It is expected that the recovery of liberated lead and zinc particles in the slimes fraction will be much less than that of liberated lead and zinc grains in the non-slimes fraction.

Lead

Approximately half of the galena lost to tails is in the -38 μm sieve fraction and it is essentially all free. Half of the remaining galena in the +53 μm and -53+38 μm sieve fractions occurs as small locked grains in the low grade particle classes (0-20%). This galena is considered to be not recoverable. The other half of the remaining galena is either free or distributed in middling grade particle classes (20-99%). This "middling" galena is associated with barite.

It is concluded that about 75% of the observable galena lost to tailings is recoverable. An indeterminate proportion of the lead in the tailings is slimes and all the slimes are deemed unrecoverable. Therefore overall it is conservatively estimated that about 50% of the lead lost to tailings is recoverable.

Zinc

It is observed that 55.9% of the sphalerite in the tails is "liberated" but only 35.2% is free. Of the free sphalerite 76% is in the -38 μm fraction. The locked sphalerite is evenly distributed in the +38 and -38 μm sieve fractions. In the +53 μm fraction it is strongly associated with siderite where it is locked in particles of the 90-99.9% class. In the -38 μm fraction sphalerite is strongly associated with pyrite where it occurs in particles of the 0-60% class.

It is concluded that zinc losses may be reduced by improving efficiency of flotation.

CONCLUSIONS

1. Galena and sphalerite are mostly liberated at a grind of 53 μm .
2. Liberation is good for both galena and sphalerite in the mill products. Sphalerite is less well liberated than galena, contrary to observations on Faro ore in 1987.
3. Grade is reduced in both the lead and the zinc concentrates due to the presence of free gangue. Therefore, in both cases, grade could be improved by increasing selectivity.
4. Metal losses are mostly due to the presence of liberated galena and sphalerite in the tailings. Therefore losses might be reduced by improving flotation efficiency.

Table 1. Size Distributions (wt%)

Samples	#1	#20	#46	#49
Sieve Size (μm)	Tert Grind Cyc. o/f	Lead Conc.	Zinc Conc.	Final Tails
+106	2.63	-	-	5.23
-106+75	3.64	-	.26	5.28
-75+53	7.65	.15	1.25	8.29
-53+38	13.97	1.04	6.22	14.92
-38	72.11	98.81	92.27	66.28

Table 2. Mineral Quantities (wt%)

	Quartz	Illite	Pyrite	Chalcopyrite	Barite	Galena	Sphalerite	Arsenopyrite	Pyrrhotite	Siderite
Lead Conc.	3.51	2.70	6.16	0.09	0.68	68.46	10.42	0.18	2.76	5.03
Zinc Conc.	2.37	0.33	6.40	1.97	0.97	4.16	77.81	0.01	2.10	3.88
Feed +53 μm	29.39	2.97	32.36	0.25	7.76	1.43	7.29	0.04	5.00	13.50
+38 μm	10.71	1.28	46.45	0.26	13.11	2.50	6.93	0.16	7.20	11.40
-38 μm	10.08	1.15	43.37	0.27	9.69	8.38	7.74	0.42	5.72	13.18
Total	12.86	1.42	42.27	0.26	9.90	6.59	7.57	0.33	5.83	12.98
Tails +53 μm	26.80	3.98	34.02	0.14	5.79	0.68	1.50	0.24	7.29	19.55
+38 μm	12.94	6.62	57.22	0.01	11.05	0.59	0.84	0.23	4.98	5.53
-38 μm	12.30	3.00	55.26	0.03	10.50	0.30	0.86	1.25	5.39	11.10
Total	15.12	3.72	51.56	0.05	9.70	0.41	0.98	0.91	5.68	11.86

Table 3. Vangorda Liberations (wt%)

		Particle Classes %										
		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-99	FREE
<i>pre-activated</i> Lead Conc.	Galena	0.03	0.01	0.02	0.05	0.02	0.05	0.08	0.18	0.75	2.59	96.20
	Sphalerite	0.28	0.41	0.31	0.24	0.54	0.77	0.87	1.35	2.75	20.40	72.10
	Pyrite	0.35	0.35	1.32	1.28	1.20	1.96	2.14	3.81	13.50	41.70	32.40
Zinc Conc.	Galena	7.65	11.90	2.31	4.14	0.78	1.41	9.94	1.52	3.48	0.00	56.90
	Sphalerite	0.07	0.16	0.39	0.05	0.60	0.28	1.56	1.61	6.88	27.50	60.90
	Pyrite	1.14	3.47	1.30	1.08	4.38	2.82	15.60	1.71	23.50	12.20	32.80
Feed +53 μm	Galena	28.80	15.60	13.30	6.24	5.53	0.00	0.62	0.04	0.13	18.00	11.80
	Sphalerite	2.23	3.35	5.84	7.11	5.64	6.78	7.87	6.56	9.72	18.80	26.10
	Pyrite	0.59	1.11	1.44	2.30	4.25	4.86	5.01	2.16	2.29	27.60	48.40
Feed +38 μm	Galena	2.84	3.19	2.15	0.00	0.72	0.04	0.02	2.66	1.31	32.80	54.30
	Sphalerite	0.77	1.67	1.74	0.23	3.83	1.86	2.01	2.32	5.66	31.90	48.00
	Pyrite	0.19	0.55	0.49	1.11	1.05	1.56	1.14	3.09	5.94	24.10	60.80
Feed -38 μm	Galena	0.80	0.75	1.38	0.67	1.49	0.30	1.23	0.73	3.94	22.90	65.80
	Sphalerite	1.89	5.02	0.74	1.65	1.74	1.40	1.31	2.31	4.29	21.80	57.90
	Pyrite	0.49	0.26	0.34	0.24	0.47	1.15	1.17	1.84	6.40	34.30	53.40
Total	Galena	1.75	1.33	1.78	0.80	1.57	0.28	1.15	0.81	3.69	23.28	63.56
	Sphalerite	1.79	4.37	1.55	2.20	2.53	2.18	2.28	2.88	5.19	22.69	52.37
	Pyrite	0.45	0.39	0.48	0.59	0.96	1.61	1.57	2.07	5.89	32.02	54.00
Tails +53 μm	Galena	45.50	9.83	5.99	0.93	0.00	1.51	1.46	0.86	15.20	0.44	18.30
	Sphalerite	10.40	9.30	8.42	1.25	4.99	4.82	1.03	3.06	2.76	43.70	10.30
	Pyrite	0.70	1.71	1.72	2.50	3.00	2.80	4.17	5.09	7.47	40.40	30.40
Tails +38 μm	Galena	4.84	1.67	1.61	2.21	2.88	1.35	0.21	1.94	1.88	9.54	71.90
	Sphalerite	4.55	4.43	1.49	1.51	2.86	2.74	0.26	5.78	5.96	28.10	42.40
	Pyrite	0.13	0.27	0.47	0.57	0.82	1.50	1.50	2.38	3.41	24.40	64.60
Tails -38 μm	Galena	1.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.10
	Sphalerite	9.94	3.63	5.88	15.40	0.00	15.90	1.01	0.00	1.87	0.31	46.00
	Pyrite	0.14	0.23	0.18	0.19	0.15	0.43	0.18	0.46	1.19	11.50	85.30
Total	Galena	15.97	3.39	2.19	0.75	0.61	0.75	0.49	0.68	5.09	2.16	67.93
	Sphalerite	9.38	5.37	6.05	9.54	1.81	11.02	0.92	1.62	2.65	16.39	35.24
	Pyrite	0.21	0.42	0.42	0.54	0.61	0.90	0.90	1.35	2.34	17.22	75.06

Table 4. Vangorda Mineral Associations (wt%)

			Ternary Particles	Binary Particles							FREE
				Siderite	Quartz	Illite	Pyrite	Chalcopyrite	Barite	Sphalerite/ Galena	
Lead Conc.	Galena	Ternary dist.	0.05	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	3.66 0.05	0.07 0.04	96.20
	Sphalerite	Ternary dist.	26.10	0.23 3.85	0.00 0.16	0.00 1.37	0.12 5.67	0.42 2.35	0.90 8.32	0.13 4.39	72.10
Zinc Conc.	Galena	Ternary dist.	39.60	0.00 1.08	0.00 0.00	0.00 0.80	0.00 0.22	0.00 0.00	3.48 39.60	0.03 38.86	56.90
	Sphalerite	Ternary dist.	35.60	1.45 2.78	0.00 0.23	0.00 1.16	0.02 2.71	0.34 2.62	1.68 13.99	0.01 12.19	60.90
Feed +53 μm	Galena	Ternary dist.	44.70	3.08 21.93	1.93 3.04	0.00 2.48	4.73 13.02	0.00 0.22	1.11 7.31	32.70 39.27	11.80
	Sphalerite	Ternary dist.	41.00	3.50 14.70	2.26 6.10	0.00 1.64	4.69 18.81	0.00 0.86	3.55 14.47	18.90 25.42	26.10
Feed +38 μm	Galena	Ternary dist.	7.71	0.01 1.77	0.00 0.00	0.00 0.00	0.00 1.17	0.00 0.12	35.60 6.57	2.41 6.84	54.30
	Sphalerite	Ternary dist.	41.70	1.88 3.30	0.00 0.82	0.00 0.00	0.65 7.17	0.00 3.33	7.13 14.56	0.63 12.70	48.00
Feed -38 μm	Galena	Ternary dist.	8.09	0.00 1.04	0.00 0.40	0.00 0.00	0.00 0.26	0.00 0.43	26.00 8.09	0.15 7.91	65.80
	Sphalerite	Ternary dist.	33.00	1.67 8.78	0.00 4.49	0.00 3.95	0.02 8.70	0.32 5.40	7.13 17.07	0.04 11.84	57.90
Feed Total	Galena	Ternary dist.	9.18	0.09 1.71	0.06 0.46	0.00 0.07	0.14 0.69	0.00 0.41	25.76 7.99	1.25 8.80	63.56
	Sphalerite	Ternary dist.	35.19	1.94 8.87	0.30 4.24	0.00 3.13	0.73 9.86	0.24 4.53	6.65 16.40	2.65 13.77	52.37

Table 4. Vangorda Mineral Associations (wt%) (Cont'd)

			Binary Particles								
			Ternary Particles	Siderite	Quartz	Illite	Pyrite	Chalcopyrite	Barite	Sphalerite/ Galena	FREE
Tails +53 μm	Galena	Ternary dist.	59.56	6.78 49.93	2.94 10.61	0.07 14.15	3.88 26.14	0.00 5.11	0.77 18.58	7.70 20.15	18.30
	Sphalerite	Ternary dist.	67.40	10.90 57.03	0.08 6.03	0.00 16.07	2.48 18.24	0.08 17.27	7.67 19.75	1.13 31.11	10.30
Tails +38 μm	Galena	Ternary dist.	10.30	0.00 2.99	0.00 0.04	0.00 1.99	0.00 0.77	0.00 0.00	17.80 9.69	0.00 6.05	71.90
	Sphalerite	Ternary dist.	49.50	0.31 3.02	0.00 1.16	0.00 2.32	1.05 5.62	0.00 5.50	6.81 15.78	0.00 10.95	42.40
Tails -38 μm	Galena	Ternary dist.	1.89	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 0.00	0.00 1.89	0.00 1.89	98.10
	Sphalerite	Ternary dist.	50.20	0.00 0.00	0.00 0.00	0.00 0.00	0.72 33.07	0.00 0.00	3.12 16.04	0.00 1.09	46.00
Tails Total	Galena	Ternary dist.	21.46	2.09 16.03	0.91 3.28	0.02 4.79	1.20 8.23	0.00 1.58	4.02 8.69	2.37 8.40	67.93
	Sphalerite	Ternary dist.	55.08	3.19 16.85	0.02 1.89	0.00 4.94	1.27 25.27	0.02 5.69	4.91 17.08	0.33 11.02	35.23