TGS Report #48

HEAVY MINERALS FROM TEXAS GULF SULPHUR COMPANY AMINE TAILINGS

RML Report #1, August 1968 Progress Report

Minerals Research Laboratory
Lab. No. 3261 - Book 233, p. 49-105
by
Robert M. Lewis

Object

On March 5, 1968, approximately eight hundred pounds (wet weight) of amine tailings from the Texas Gulf Sulphur Company's phosphate plant at Aurora, North Carolina, was received at the Laboratory. The main objectives of this project were to determine the heavy mineral content of these tailings, recover the heavy minerals, and separate them into individual products.

Procedure

A representative sample of the material was obtained by riffling. Part of this sample was sent to Southern Testing and Research Laboratories for P_2O_5 analysis, and part was separated into floats and sinks by heavy liquid (sp. gr. 2.95). The head feed was found to contain 6.25 percent P_2O_5 and 4.0 percent heavy minerals.

The heavy minerals were concentrated by two types of gravity separators. In one test, a Humphreys spiral was used to upgrade the heavy minerals from 4.0 percent in the feed to 34.0 percent in the concentrate for a concentration ratio of 9 to 1. Forty-two percent of the heavy minerals were recovered in the spiral concentrate with thirty-four percent reporting as middlings. Eighty-four and six-tenths percent of the minerals in the concentrate were recovered as potential products by additional beneficiation. In another test, a Wilfley shaking table was used to upgrade the heavy minerals to 97 percent heavies by concentrating through several stages. Ninety-four percent of the heavy minerals were recovered in the table concentrate. Eighty-three and seven-tenths percent of these minerals were recovered as products by additional beneficiation. The total product recovered as a percent of heavy minerals in the amine tailings amounted to 78.7 percent.

The concentrate from the Humphreys spiral was dried in a gas-fired oven and then fed to an electrostatic separator. The bulk of the material reported to the thrown product, with the phosphate reporting to the middlings and a small amount of material reporting to the pinned product.

The middlings and pinned material were considered as waste. The thrown fraction was fed to a Stearns induced-roll magnet where two magnetic fractions and one nonmagnetic fraction were obtained. The magnetic fractions were upgraded by rerunning over the Stearns magnet to produce an ilmenite product, an associated titanium product, and a nonmagnetic product composed mostly of garnet. The nonmagnetics from the first pass over the magnet were repulped and fed to a shaking table for the removal of quartz and concentration of zircon. The quartz was discarded as waste, and the zircon concentrate was fed to the Stearns magnet for the removal of remaining magnetic minerals. A final electrostatic beneficiation of the zircon removed some remaining gangue minerals and produced a finished zircon product.

The concentrate produced from the amine tailings by the shaking table contained 97 percent heavy minerals which simplified the subsequent flowsheet. Eighty-three and seven-tenths percent of the heavy minerals was recovered as a final product. A zircon concentrate was produced by electrostatics and cleaned by magnetic separation. The remaining material was fed to a Stearns magnetic separator. Various machine settings were used in an effort to effect the desired separation. Observations of the products revealed the lack of a sharp separation. It became apparent that a possible reason for the lack of a sharp separation was the high operating ampere range (1.5-3.0) of the magnet. It was felt that the minimum (1.5 amps.) was still sufficient to cause the slightly magnetic minerals to report with the magnetics. In order to widen the operating range of the magnet to 0.0-3.0 amperes, the writer installed a powerstat to be used in conjunction with the existing rheostat. This increased the sharpness of the separation by allowing for operating in the lower ampere range and resulted in the products designated as ilmenite and black opaques. Near the end of the test work, the Laboratory received a Frantz Isodynamic magnetic separator which proved to be useful in checking on the purity of the products.

Results

The flowsheet used for processing the spiral concentrate is shown in Table 1. The distribution of the products as a percent of feed to dry separation is shown in the table along with the percent of predominant mineral. Grain counts were made of each product on the flowsheet by John Lawrence, a Laboratory technician. Mr. Jerry Bundy of the Division of Minerȧl Resources also provided data on mineral content and distribution as derived from grain counts of products and grain-mounted thin sections. This data is shown in Table 2 along with the distribution of products obtained from the processing of table concentrate. A material balance and chemical analyses of the products obtained from processing the table heavy mineral concentrate are shown in Table 3. The theoretical chemical composition of several comparable-type and marketed products are shown in Table 3.

Remarks

There are several features of this project which would classify it as a good potential by-product venture. The heavy mineral content of the feed (4.0 percent) is as high as that of an operating company which is presently producing heavy minerals successfully. The land preparation, mining, pumping, and desliming costs will have been absorbed by the phosphate operation, and this would result in a less costly operation than that of present producers. This would be a matter of bookkeeping, as the above costs would probably be proportioned between the phosphate and heavy mineral plants.

The approximate value of the products before deductions, based on assumed tonnages and operating time, would be as follows:

Ore tons per hour	- 1,200
Hours per year	- 6,864
Percent of ore reporting to amine tailings	- 5 percent
Percent heavy mineral in amine tailings	- 4 percent
Tons heavy mineral per year	- 16,474
Tons heavy minerals recovered @ 94%	- 15,486
Tons products recovered @ 83.7% x 94%	- 12,962

Product	Wt. %	Tons	$/Ton	$/Year
Ilmenite	64.4	9,974	25	249,350
Zircon	11.0	1,703	60	102,180
Black Opaques	8.3	1,285	25	32,125
Misc.	16.3	2,524	--	--
Total	100.0	15,486		$383,655

The test work was limited by the small amount of material available; however, it should be valuable in planning any future work. If the company desires to proceed further, about fifty tons of tailings could be beneficiated by gravity separation to produce about two tons of heavy mineral concentrate. The concentrate could be sent out for market studies as is, or separated into products and then sent to various companies. In the event that the company does not want to produce heavy minerals at present, the writer recommends that the heavy minerals be recovered from the amine tailings by gravity separators and stockpiled for future consideration.

Table 1

Plant Amine Tailings 4.0% H.M.
Spiral 1 Pass Concentrate 34.0% H.M.

Electrostatics

Product	Wt.%
Thrown	85.7
Mids	12.3
Pinned	2.0

Thrown 85.7 — Magnet

Product	Wt.%
#1 Mag.	7.88
#2 Mag.	13.20
Non Mag.	64.62

#1 Mag. 7.88 — Magnet

Sa.No.	Product	Wt.%	Compo.
1	#1 Mag.	3.53	96% Ilm.
2	#2 Mag.	3.88	89% Ilm.
3	Non Mag.	0.46	72% Ilm.

#2 Mag. 13.20 — Magnet

Sa.No.	Product	Wt.%	Compo.
4	#1 Mag.	5.43	90% Ilm.
5	#2 Mag.	3.55	67% Ilm.
6	Non Mag.	4.22	47% Ilm.

Non Mag. 64.62 — Shaking Table

Sa.No.	Product	Wt.%	Compo.
	Conc.	14.22	
13	Tails	50.44	89% Qtz.

Conc. 14.22 — Magnet

Sa.No.	Product	Wt.%	Compo.
14	#1 Mag.	2.46	70% Ilm.
15	#2 Mag.	6.87	57% Ilm
	Non Mag.	4.89	

Non Mag. 4.89 — Electrostatic

Sa.No.	Product	Wt.%	Compo.
16	Thrown	2.32	32% Ru.
17	Cl.Tail	1.64	75% Zr.
18	Zr.Conc.	0.93	86% Zr.

Mids 12.3 — Magnet

Sa.No.	Product	Wt.%	Compo.
7	#1 Mag.	0.86	53% Ilm.
8	#2 Mag.	0.75	32% Garnet
9	Non Mag.	10.69	86% Phos.

Pinned 2.0 — Magnet

Sa.No.	Product	Wt.%	Compo.
10	#1 Mag.	0.34	74% Ilm.
11	#2 Mag.	0.24	45% Ilm.
12	Non Mag.	1.42	39% Phos.

Test Flow Sheet

Table 2-A

Composition of Products Obtained from Spiral Concentrate as Shown in Table 1

Sample No. (Table 1)	Sp. Conc. Wt.% Dist.	Composition[1] Ilm.	Ru. & Garnet	Zr.	Misc.	Qtz.	Phos.	Units Ilm.	Ru. & Garnet	Zr.	Misc.	Qtz.	Phos.
1	3.53	96	-	2	-	-	2	3.39	-	.07	-	-	.07
2	3.88	89	1	6	2	-	2	3.45	.04	.23	.08	-	.08
3	0.46	72	4	2	4	17	-	0.33	.02	.01	.02	.08	-
4	5.43	90	7	1	1	1	-	4.89	.38	.05	.05	.05	-
5	3.55	67	17	7	6	3	-	2.38	.60	.25	.21	.11	-
6	4.22	47	14	4	6	29	-	1.98	.59	.17	.25	1.22	-
7	0.86	53	28	3	7	2	7	0.46	.24	.03	.06	.02	.06
8	0.75	25	32	11	9	8	15	0.19	.24	.08	.07	.06	.11
9	10.69	3	4	1	1	5	86	0.32	.43	.11	.11	.53	9.19
10	0.34	74	12	1	3	10	-	0.25	.04	-	.01	.03	-
11	0.24	45	19	5	12	10	9	0.11	.05	.01	.03	.02	.02
12	1.42	7	4	6	6	38	39	0.10	.06	.09	.09	.54	.55
13	50.41	3	2	1	1	89	4	1.51	1.01	.50	.50	44.86	2.02
14	2.46	70	13	8	4	5	-	1.72	.32	.20	.10	.12	-
15	6.87	57	11	14	16	2	-	3.92	0.76	.96	1.10	.14	-
16	2.32	26	32	17	8	-	17	0.60	0.74	.39	.19	-	.39
17	1.64	10	7	75	3	-	5	0.16	0.11	1.23	.05	-	.08
18	0.93	7	3	86	1	-	3	0.07	0.03	.80	-	-	.03
	100.00							25.83	5.66	5.18	2.92	47.78	12.60

(1) Grain count by John Lawrence.

Table 2-B

Distribution of Heavy Minerals in Spiral Concentrate

Mineral	H.M. Units	Wt.%[1]	Wt.%[2]
Ilmenite	25.83	65.2	56.2
Black Opaques	-	-	-
Zircon	5.18	13.1	12.5
Rutile	} 5.66	} 14.3	3.3
Garnet			13.9
Brown Misc.	2.92	7.4	14.1
Total	39.59	100.0	100.0

(1) Grain count by John Lawrence. (2) Grain count by Jerry Bundy.

Table 2-C

Distribution of Products from Table Concentrate

Product	Wt.%
Ilmenite	64.4
Black Opaques	8.3
Zircon	11.0
Rutile	-
Garnet	8.4
Brown Misc.	7.9
Total	100.0

Table 3

Material Balance and Chemical Analyses of Heavy Mineral Products from Table Concentrate

Product	Wt. %	TiO_2	ZrO_2	Fe_2O_3	Al_2O_3	SiO_2
Ilmenite	64.4	51.73	0.58	37.75	-	-
Zircon	11.0	6.85	52.28	0.33	-	-
Garnet	8.4	11.14	-	17.45	-	16.50
Black Opaques	8.3	57.08	-	10.87	3.76	3.10
Brown Misc.	7.9	15.74	-	13.73	20.89	17.80
Total	100.0	38.98	6.12	27.80	1.96	3.06
Head Feed		35.02	7.43	26.17	2.59	3.30

Theoretical Chemical Analyses

Product	TiO_2	ZrO_2	Fe_2O_3	FeO	Al_2O_3	SiO_2
Ilmenite ($FeO \cdot TiO_2$)	52.7			47.3		
Zircon ($Zr \cdot SiO_4$)		67.2				32.8
Garnet ($3FeO \cdot Al_2O_3 \cdot 3SiO_2$)			43.3		20.5	36.2
Rutile ($Fe \cdot TiO_3$)	90.0		0.0-10.0			

Marketed Products

	TiO_2	ZrO_2	Fe_2O_3	FeO	Fe
Ilmenite (Jax., Fla.)	60.3		26.3	5.6	22.7
Leucoxene (Trail Ridge, Fla.)	82.1		9.0	1.6	7.5
Rutile (Jax., Fla.)	94.2		1.71		1.2
Zircon (Jax., Fla.)		60.0			