UNITED STATES DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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War Minerals Report 167

CONCENTRATION OF OXIDE MANGANESE ORE FROM SHEEP MOUNTAIN PROPERTY DURKEE DISTRICT, BAKER CO OREGON

WASHINGTON: 1944

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WAR MINERALS REPORT

UNITED STATES DEPARTMENT OF THE INTERIOR — BUREAU OF MINES

W.M.R. 167 - Manganese February 1944

CONCENTRATION OF OXIDE MANGANESE ORE FROM SHEEP MOUNTAIN PROPERTY, DURKEE DISTRICT, OREGON

SUMMARY

This report is one of a series giving results of laboratory and pilot-plant investigations of concentration of Western manganese ores begun in December 1940. The data summarize results of laboratory investigation of concentration of oxide manganese ore from Sheep Mountain property, Durkee District, Oregon.

Manganese minerals were chiefly psilomelane and pyrolusite intimately associated with siliceous gangue. Owing to the intimate manganese-silica association, no 48-percent manganese products were obtained by ore-dressing methods. However, 70 percent of the manganese was recovered by simple gravity treatment in a plus 40-percent manganese product that would be marketable without sintering. Re-treatment of middlings increased recovery to 81 percent in a product that sintered to 46.7-percent manganese grade.

INTRODUCTION

Oxide manganese ore from the Sheep Mountain property was of intermediate grade (23.0 percent manganese) and contained silica as the major impurity. The deposit from which the ore was taken is known as the Sheep Mountain manganese property and is 8 miles west of Durkee, Oreg. Test work was done in the metallurgical laboratories of the Bureau of Mines at Salt Lake City, Utah,* on representative samples cut from a 290-pound shipment of crushed ore submitted by the Oregon State Department of Geology and Mineral Industries and reported to be typical of the Sheep Mountain deposit.

At the beginning of the investigation of manganese-ore beneficiation, the only product marketable to Metals Reserve Co. was "ferro-grade manganese, grade B," the requirements for which are as follows:

Assay, percent					
Mn min.	Fe max.	SiO_2 max.	P max.	Al_2O_3 max.	Zn max.
48.0	7.0	10.0	0.18	6.0	1.0

Since that time, the specifications have been gradually modified. As of May 15, 1943, manganese products are acceptable if they contain over 35 percent manganese and less than 3 percent zinc and 1 percent phosphorus. Prices are based upon material containing 48 percent manganese, 6.0 percent iron, and 11 percent silica plus alumina. Premiums are paid for manganese content in excess of 48 percent and iron content below 6 percent; penalties are imposed upon products containing less than 48 percent manganese, more than 6 percent iron, or more than 11 percent silica plus alumina.

Specifications for marketable manganese further require that 75.0 percent of the product be coarser than 20-mesh. Therefore, fine material, such as table and flotation concentrates, must be nodulized or sintered. In addition, carbonate manganese ores are

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* Metallurgical testing by R. R. Wells, metallurgist, and F. W. Rollins, laboratory mechanic.

not acceptable unless calcined. Sintering further concentrates the manganese by driving off oxygen, carbon dioxide, and other constituents. The impurities, such as silica, iron, alumina, and phosphorus, also are concentrated by sintering. Sintering was done to determine the chemical composition of the final product; the physical nature of the sinter was not studied, as commercial nodulizing or sintering of manganese concentrates is not included in this project.

THE ORE

Physical

Microscopic examination showed that the manganese content of this ore was represented by several of the oxide minerals of manganese, chiefly psilomelane and pyrolusite. The major impurity was silica, which occurred rather intimately associated with the manganese oxides. However, it was indicated that a portion of the ore consisted of relatively barren gangue, which could be liberated from the manganese minerals at coarse sizes.

Chemical

Chemical analysis of the ore from the Sheep Mountain property follows:

Analysis, percent

Mn	Insol.	SiO_2	Fe	CaO	S	Al_2O_3	MgO	Zn	Co	P	WO_3	Ba
23.0	54.8	49.0	1.6	1.2	Nil	3.8	0.10	Tr	0.01	0.042	Nil	Nil

Distribution of Manganese and Silica

A sample of ore as received was screen-sized wet without further crushing. Distribution of the manganese and silica is shown in table 1.

TABLE 1. - Distribution of manganese and silica

Product	Weight, percent	Assay, percent		Distribution, percent	
		Mn	SiO_2	Mn	SiO_2
+3-mesh.	21.7	25.0	40.0	21.3	21.5
-3+6-mesh.	27.9	28.8	39.2	31.5	27.0
-6+10-mesh	14.6	26.6	39.2	15.3	14.2
-10+20-mesh.	12.7	27.8	41.4	13.9	13.1
-20+35-mesh.	6.3	28.0	38.2	7.0	6.0
-35+48-mesh.	2.2	27.0	36.6	2.3	2.0
-48+65-mesh.	1.9	25.6	39.0	1.9	1.8
-65+100-mesh	1.5	24.0	42.8	1.4	1.6
-100+200-mesh.	2.2	21.6	43.0	1.9	2.3
-200-mesh sand	4.2	12.8	50.6	2.1	5.2
-200-mesh slime.	4.8	7.7	44.0	1.4	5.3
Calculated head.	100.0	25.5	40.4	100.0	100.0

Table 1 shows that very little of the manganese is contained in the slime and that the distribution of silica follows closely that of manganese in all sizes above 200-mesh.

METHODS OF CONCENTRATION

Study of the foregoing data indicated that a portion of the gangue could be rejected at coarse sizes, but that a concentrate low in silica would be difficult to produce because of the close association of silica and manganese minerals.

The following methods were investigated as means of concentrating the Sheep Mountain ore:

1. Jigging and tabling.
2. Jigging and tabling with re-treatment of middlings.
3. Tabling of sized feed.
4. Flotation of manganese.
5. Flotation of silica.

Details of the ore-dressing methods employed follow, under separate headings.

Jigging and Tabling

A sample of the ore was crushed to minus 3/8-inch and sized on 6-mesh, 10-mesh, 20-mesh, 48-mesh, and 100-mesh screens. The minus 100-mesh fraction was deslimed by decantation. Each of the three coarsest fractions was jigged separately in a laboratory hydraulic jig to make a concentrate, middling, and tailing. The finer sand fractions were tabled separately to produce a concentrate, middling, and tailing.

Corresponding products from jigging and tabling were combined for assay. Results of this test are summarized in table 2:

TABLE 2. - Jigging and tabling

Product	Weight, percent	Assay, percent		Distribution, percent
		Mn	SiO_2	Mn
Combined jig concentrate	31.9	42.3	19.6	58.5
Combined table concentrate . . .	6.4	41.1	21.2	11.4
Jig middling	11.4	14.7	64.6	7.3
Combined table middling.	10.6	18.3	55.1	8.4
Combined jig tailing	23.2	7.9	73.0	8.0
Combined table tailing	10.7	9.9	67.2	4.6
Slime.	5.8	7.2	49.6	1.8
Calculated head.	100.0	23.1	47.8	100.0
Combined jig and table concentrates	38.3	42.1	19.9	69.9
Combined concentrates and jig middlings.	49.7	35.8	30.1	77.2

Results given in table 2 show that the combined gravity concentrates contained 69.9 percent of the manganese at 42.1 percent manganese grade. Addition of jig middling raised recovery of manganese to 77.2 percent in a product that assayed 35.8 percent manganese. As the products contained only 13 and 17 percent of minus 20-mesh material, respectively, they could be marketed directly without sintering.

Jigging and Tabling With Re-treatment of Middlings

An attempt to increase the recovery and grade was made by retreating the middling products of a jig-table test. A sample of the ore was crushed to minus 3-mesh and screen-sized on 6-mesh, 10-mesh, 20-mesh, 35-mesh, 48-mesh, 65-mesh, 100-mesh, and 200-mesh. The minus 200-mesh fraction was deslimed by decantation.

The minus 3- plus 6-mesh fraction was jigged in a laboratory pneumatic jig and a concentrate removed; the remaining product was crushed to minus 6-mesh and added to the next finer fraction, and this procedure was repeated for the next two fractions. The remainder of the sand fractions was tabled to make a concentrate, middling, and tailing, the middling being re-treated as described above.

The results of this test are shown in table 3, and results of sintering combined products are given in table 4.

TABLE 3. - Jigging and tabling with middling re-treatment

Product	Weight, percent	Assay percent Mn	Distribution, percent Mn
Combined jig concentrates	34.1	42.8	57.0
Combined table concentrates . . .	15.3	39.9	24.0
Combined tailings	37.7	9.3	13.7
Slime	12.9	10.4	5.3
Calculated head	100.0	25.5	100.0

TABLE 4. - Results of sintering

Sinter product	Assay, percent						
	Mn	Fe	SiO_2	P	Al_2O_3	Zn	$\frac{SiO_2}{Al_2O_3}$
Combined jig concentrates . . .	47.4	2.0	22.0	0.022	2.1	0.25	24.1
Combined table concentrates . .	45.0	1.8	26.5	.026	2.4	.26	28.9
Combined jig and table concentrates (calculated) . .	46.7	1.9	23.4	.023	2.2	.25	25.6
Base price marketing specifications.	48.0	6.0	--	Max. 1.0	--	Max. 3.0	11.0

Table 3 shows that a recovery of 57.0 percent of the manganese at a grade of 42.8 percent was obtained in combined jig concentrates. This product, being all plus 20-mesh, could be marketed directly without sintering. By adding the combined table concentrates, recovery was raised to 81.0 percent at a grade of 41.9 percent manganese. The combined concentrate would sinter to 46.7 percent manganese grade. Since the total product contained 31 percent minus 20-mesh material, sintering would be required to meet physical specifications for marketable manganese ore.

Tabling Sized Feed

To determine whether high-grade concentrates could be produced by finer grinding before gravity treatment, a table test was run on ore that had been stage-ground to minus 48-mesh, deslimed, and the sands screen-sized to three fractions. A recovery of 73.8 percent of the manganese was obtained in a combined product that assayed 38.0 percent manganese and 27.2 percent silica. As the results were inferior to the jig-table tests previously described, details of the test are not included in this report. It is evident that after the relatively coarse barren portion of the gangue is rejected, further liberation of silica from manganese oxides would involve excessively fine grinding.

Flotation of Manganese

A few preliminary tests were run on deslimed and undeslimed ore at various screen sizes in attempts to separate manganese from gangue by flotation. Only the test giving the best results is described in detail.

A sample of minus 10-mesh ore was stage-ground to minus 65 mesh and deslimed by decantation. A rougher manganese concentrate was floated and subsequently cleaned to make two cleaner concentrates, a cleaner tailing, and a rougher tailing. The slimes, being low in manganese tenor, were not treated. Flotation was conducted in a mechanically agitated laboratory cell with Salt Lake City tap water. Sodium silicate and sulfuric acid were used as conditioners, and a water emulsion of oleic acid stabilized with Emulsol X-1 was used as frother-collector.

Results of this test are given in table 5. Reagent consumption is shown in table 6.

TABLE 5. - Flotation of manganese

Product	Weight, percent	Assay, percent Mn	Assay, percent SiO_2	Distribution, percent Mn
Cleaner concentrate No. 1 . .	24.8	42.4	18.4	44.1
Cleaner concentrate No. 2 . .	7.8	37.0	27.6	12.0
Cleaner tailing	21.5	18.8	55.2	16.9
Rougher tailing	31.8	13.4	67.8	17.9
Slime	14.1	15.2	44.6	9.1
Calculated head	100.0	23.8	43.2	100.0
Combined cleaner concentrate.	32.6	41.1	20.6	56.1

TABLE 6. - Reagent consumption

		Reagent, pounds per ton of ore			
Operation	pH	Sodium silicate	Sulfuric acid	Oleic acid	Emulsol X-1
Rougher	6.8	4.5	3.2	1.6	0.32
Cleaner No. 1 . . .	6.4	3.0	2.0	---	--
Cleaner No. 2 . . .	6.4	.8	.8	0.16	0.03
Total	--	8.3	6.0	1.76	0.35

As is evident, no low-silica products were obtained by flotation of manganese even when fine grinding is employed. In general, results were inferior to those obtained by coarse gravity concentration.

Flotation of Silica

Tests were run in the attempt to float silica from sized fractions of deslimed ore with a cationic reagent, thus leaving manganese minerals in the tailing. The best test gave a recovery of 58.1 percent at a grade of 39.7 percent manganese. The addition of marginal silica concentrates raised the recovery to 73.4 percent and lowered the grade to 36.2 percent manganese. These two products would sinter to 44.7 percent and 40.8 percent manganese, respectively. Since results were inferior to those obtained by gravity methods, no further details will be given.

General Discussion

Although slightly lower recovery and grade was obtained by rejecting gravity middlings instead of re-treating them, the reduced grinding cost and elimination of an expensive nodulizing or sintering step probably would make middling rejection preferred for commercial concentration of Sheep Mountain manganese ore.

CONCLUSIONS

1. Manganese oxide ore from the Sheep Mountain property contained a portion of the siliceous gangue so closely associated with the manganese minerals that concentrates low in silica were not produced by ore-dressing methods. However, enough coarse barren gangue was present to permit effective gravity treatment for the production of intermediate-grade concentrates.

2. Jigging and tabling of minus 3/8-inch ore with no middling re-treatment recovered 69.9 percent of the manganese at a grade of 42.1 percent, or 77.2 percent at a grade of 35.8 percent manganese. Both products met present marketing specifications directly without sintering.

3. Jigging and tabling, with re-treatment of middlings, recovered 81.0 percent of the manganese in a product that, when sintered, assayed 46.7 percent manganese.

4. Concentrates obtained by fatty-acid flotation of manganese from deslimed ore contained only 56.1 percent of the total manganese in a product that would sinter to plus 44 percent manganese.

5. Silica flotation from sized fractions of deslimed ore recovered only 58.1 percent of the manganese at a grade of 39.7 percent of 73.4 percent at a grade of 36.2 percent manganese. These products sintered to 44.7 percent and 40.8 percent manganese, respectively.

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