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PRELIMINARY GRAVITY BENEFICIATION OF TONSINA CHROMITE ORE

Alaska Mining Experiment Station
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SUMMARY

This report summarizes the results of preliminary beneficiation testing conducted on samples of chromite ore submitted by T. L. Pittman, Mining Engineer, from three masses of ultrabasic rock in the Tonsina area, northeast of Valdez, Alaska.

The data indicate that only higher-grade ore from Bernard Mountain is amenable to gravity concentration for the production of "Metallurgical grade" chromite concentrate. Plus 48 percent Cr_2O_3 products were made from Bernard Mountain intermediate-grade (11.3 percent Cr_2O_3) ore and from higher-grade (28.5 percent Cr_2O_3) float from Sheep Hill. The chrome to iron ratio of these products, however, did not exceed 2.0.

The chemical composition of the Chromium-bearing mineral limited the grade of concentrate obtainable from Dust Mountain ore and from Bernard Mountain low-grade (7.2 percent Cr_2O_3) ore. Concentrates made from these ores assayed only 37 to 40 percent Cr_2O_3 and had a chrome to iron ratio of only 1.2.

INTRODUCTION

The bulk of laboratory testing was conducted on two higher-grade composite samples. One was a composite of three channel samples cut across an ore-bearing zone on the western slope of Bernard Mountain; the other was a composite of three channel samples from an outcrop on Dust Mountain. Single supplementary table tests were made on a composite of three low-grade samples from the south ridge of Bernard Mountain, a low-grade sample from the north ridge of Bernard Mountain, and a float sample from Sheep Hill.

Because of the small quantity of material for testing, laboratory work was limited to simple gravity concentration procedures. Thus, the data obtained are only indicative and should not be construed to be the optimum results obtainable on these ores.

MARKETING SPECIFICATIONS

Chromite is marketed under three classifications; low-silica, high-iron "Chemical grade"; high-alumina, low-iron, "Refractory grade"; and high-chrome, low-iron "Metallurgical grade".

For the manufacture of chromium chemicals, friable material containing a minimum of 44 percent chromic oxide and a maximum of

4 percent silica usually is specified. Either "lump ore" or concentrate is acceptable to most purchasers.

Purchasers of ore intended for the manufacture of chromite refractories usually require "lump ore", not more than 20 percent of which shall pass a Tyler Standard 10-mesh screen. The chemical requirements for such material usually specify a chromic oxide content of not less than 30 percent and a combined chromic oxide plus alumina content of at least 60 percent; material containing more than 12 percent iron or more than 5 to 7 percent silica usually is not acceptable.

Most purchasers of ore intended for the manufacture of stainless steel and for other metallurgical uses require a minimum chromic oxide content of 48.0 percent and a maximum sulfur and phosphorus content of 0.05 percent and 0.02 percent, respectively. A chrome to iron ratio (Cr to Fe) of 3.0 : 1 is requested, but material with ratios as low as 2.8 : 1 usually is accepted at a lower price. Allowable silica content depends, to some extent, upon the purchaser's requirements, but normally 8 percent silica is the maximum permitted.

At the present time the United States Government is purchasing chromite ore and concentrates at incentive prices under the Minerals Stockpile Program. For domestic chromite delivered to Grants Pass, Oregon, the General Services Administration offers $115 per long dry ton of lump ore and $110 per long dry ton of fine ore or concentrates containing 48 percent chromic oxide and having a chrome to iron ratio of 3.0 : 1. A premium of $4.00 per ton is paid for each percentage point above 48 percent chromic oxide. A penalty of $3.00 per ton is charged for each 1 percent below 48 percent chromic oxide down to and including 42 percent. A penalty is also imposed for each 0.1 decrease in the chrome-iron ratio below 3.0 : 1 down to and including 2.0 : 1. A bonus is paid for each 0.1 increase in the chrome-iron ratio above 3.0 : 1 up to 3.5 : 1. The specifications further require that the silica content does not exceed 10 percent.

THE ORE

Physical Nature

Petrographic study indicated that the Bernard Ore is composed chiefly of antigorite with chromite and lesser amounts of olivine. The average grain size of the chromite was estimated to be about 60-mesh; the chromite is entirely locked with gangue in sizes coarser than 12 mesh and a small amount remains locked as fine as 325-mesh.

The Dust Mountain material is chiefly olivine, lesser antigorite and chromite, and minor amounts of magnetite. The chromium mineral is

coarser than in the Bernard Mountain ore; virtually all of the mineral is free in the minus 35-mesh fraction and only a minor amount is locked in grains finer than 100-mesh.

The sample from Sheep Hill is similar to ore from Bernard Mountain and mainly consists of chromite and antigorite with a minor amount of olivine.

Subsequent work has shown that the mineral referred to as chromite is, in reality, a chromium-bearing spinel. The chemical composition of the mineral varied widely in the samples submitted and ranges from material high in chromium and containing relatively low amounts of iron to material that contains almost equal amounts of chromium and iron.

TABLE 3 - Tabling Bernard Mountain higher-grade ore, minus 65-mesh

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Concentrate	27.84	53.4	13.2	3.1	62.7	2.77
Middling	10.44	36.8	10.3	15.2	16.2	2.45
Tailing	32.32	5.2	4.4	37.2	7.1	
Slime	29.40	11.3	6.0	31.4	14.0	
Calc. head	100.00	23.7	7.9	23.7	100.0	
Comb. conc. and midd.	38.28	48.9	12.4	6.4	78.9	2.70

TABLE 4 - Tabling Bernard Mountain Higher-grade ore, minus 48-mesh with middling re-treatment

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Comb. Conc	39.39	51.4	12.8	5.1	83.0	2.75
Midd. 1	6.56	23.8	7.8	25.9	6.4	2.09
Midd. 2	11.89	10.1	5.3	33.4	4.9	
Comb. tail	31.32	1.7	3.4	40.2	2.2	
Slime	10.84	8.0	5.6	34.0	3.5	
Calc. head	100.00	24.4	7.9	24.0	100.00	
Conc. plus Midd 1	45.95	47.5	12.1	8.1	89.4	2.69

Preliminary tests indicated that 80 to 88 percent of the chromium in Bernard Mountain higher-grade ore can be recovered in a concentrate assaying more than 48.0 percent Cr_2O_3 and having a chrome to iron ratio of about 2.7 to 1.

Three tabling techniques were tried on the Dust Mountain ore; none were successful. Best results, shown in table 5, were obtained by stage-crushing ore to 20-mesh tabling and re-treating the middling product at 35-mesh and again at 65-mesh. Magnetite was removed from the combined concentrate by wet magnetic separation.

TABLE 5 - Tabling Dust Mountain ore, minus 20-mesh with middling re-treatment

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Concentrate	43.68	36.7	21.4	3.8	67.7	1.17
Middling	12.94	24.1	16.7	15.6	13.2	
Tailing	26.13	8.1	10.0	30.3	8.9	
Slime	17.17	14.1	12.6	23.7	10.2	
Magnetite	.08	--	31.0	--	---	
Calc. head	100.00	23.7	16.3	15.7	100.00	

Chemical Nature

Partial chemical analyses of the samples tested are shown in table 1. Semi-quantitative spectrographic analyses of Dust Mountain and Bernard Mountain intermediate-grade composites are shown in table 2.

TABLE 1 - Chemical Analysis

Sample	Assay, percent Cr_2O_3	Fe	SiO_2	MgO	Al_2O_3	Ni	Oz. per ton Au	Ag	Pt
Bernard Mtn. higher grade	25.1	8.4	22.8	28.0	3.0	0.26	*0.02	0.12	*0.02
Bernard Mtn. low grade	7.2	9.5	35.2						
Bernard Mtn. low grade	11.3	8.8	31.1						
Sheep Hill	28.5	17.0	18.6						
Dust Mtn.	22.8	16.2	16.9	23.4	12.2	0.23	*0.02	0.41	*0.02

* less than

TABLE 2 - Spectrographic Analysis

	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Ge	Hg
Bernard Mtn.	-	C	-	-	F	-	-	-	G	-	E	A	F	A	-	-	-
Dust Mtn.	-	A	-	-	F	-	-	-	E	-	D	A	F	A	-	-	-

	In	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Pd	Pt	Sb	Si	Sn	Sr	Ta
Bernard Mtn.	-	-	A	D	E	-	-	D	-	E	-	-	-	A	-	-	-
Dust Mtn.	-	-	A	D	E	-	-	D	-	E	-	-	-	A	-	-	-

	Te	Ti	V	W	Zn	Zr
Bernard Mtn.	-	E	D	-	-	-
Dust Mtn.	-	D	C	-	-	E

Concentration

A screen analysis was made on a portion of the higher-grade Bernard Mountain sample. The results substantiated the liberation data of the petrographic study; results did not, however, show marked concentration of chromium in any sized fraction.

Samples for testing were roll-crushed to minus 10-mesh. Portions were treated in the laboratory attrition scrubber for five minutes and the pulp was deslimed by decantation prior to subsequent grinding of the sand fraction for tabling. The original slime fraction contained four to six percent of the total weight of the samples and usually contained approximately one-third as much chromic oxide as the original feed. The slime fraction was combined with the final table slimes for calculation.

A sample of Bernard Mountain higher-grade ore was stage-ground to pass a 65-mesh seive and was tabled to yield a concentrate, middling, tailing and slime. A hydraulic cone classifier was used to feed the material to the laboratory shaking table. A second test on this ore involved tabling at minus 48-mesh with re-treatment of the middlings reground to pass 65-mesh. Results are shown in tables 3 and 4.

The grade of product obtainable by treatment of Dust Mountain ore was limited by the low-chromium content of the chrome-bearing mineral. The highest grade product obtained from this ore assayed only 37.3 percent Cr_2O_3, 21.6 percent Fe, 10.8 percent MgO, 17.8 percent Al_2O_3 and 2.6. Such material does not meet marketing specifications for "Metallurgical grade", "Refractory grade" or "Chemical grade" chromite.

Supplemental tabling tests were made on a composite of low-grade samples and a slightly higher-grade sample from Bernard Mountain and on a sample of intermediate-grade float from Sheep Hill. For each test, minus 10-mesh ore was scrubbed and deslimed; the sands were stage-ground to minus 65-mesh, hydraulically sized and tabled without re-treatment of middling. Results are shown in tables 6, 7 and 8.

TABLE 6 - Tabling, Bernard Mountain low-grade composite, minus 65-mesh

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Concentrate	8.75	39.1	21.8	4.9	44.5	1.23
Middling	22.60	12.5	12.4	29.7	36.7	
Tailing	44.49	1.41	6.6	41.6	8.1	
Slime	24.16	3.41	7.5	36.3	10.7	
Calc. head	100.00	7.7	9.5	34.2	100.0	

TABLE 7 - Tabling Bernard Mountain low-grade ore, minus 65-mesh

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Concentrate	10.40	52.4	18.5	2.0	47.0	1.94
Middling	11.16	28.1	12.7	20.2	27.1	1.51
Tailing	47.18	2.94	5.9	37.5	12.0	
Slime	31.26	5.17	7.3	34.3	13.9	
Calc. head	100.00	11.6	8.4	30.9	100.0	
Comb. conc. and midd.	21.56	39.8	15.5	11.4		1.75

TABLE 8 - Tabling Sheep Hill Ore, minus 65-mesh.

Product	Weight, percent	Assay, percent Cr_2O_3	Fe	SiO_2	Distribution, percent Cr_2O_3	Cr/Fe
Concentrate	24.37	51.2	17.6	2.1	42.1	1.99
Middling	21.21	44.2	15.7	7.6	31.7	1.92
Tailing	25.87	10.0	7.5	33.2	8.7	
Slime	28.55	18.1	10.2	26.4	17.5	
Calc. head	100.00	29.6	12.5	18.3	100.0	
Comb. conc. and middling	45.58	47.9	16.7	4.7	73.8	1.99

Table concentration of 7.2 percent Cr_2O_3 Bernard Mountain ore recovered only 44.5 percent of the total chromium in a concentrate that assayed 39.1 percent Cr_2O_3 and that had a chrome to iron ratio of 1.23. The highest grade fraction made from this ore assayed only 40.6 percent Cr_2O_3, 22.9 percent Fe, and 2.4 percent SiO_2.

The 11.3 percent Cr_2O_3 sample from Bernard Mountain was tabled to recover 47 percent of the chromium in a concentrate that assayed 52.4 percent Cr_2O_3. The ratio of chrome to iron, however, was only 1.94, below the 2.0 purchase minimum. This material would have possible value as "Chemical grade" chromite (minimum 44.0 percent Cr_2O_3, maximum 5.0 percent SiO_2) or could be blended with a low-iron product to meet the chrome to iron ratio of "Metallurgical grade" specifications.

By tabling Sheep Hill float ore, 73.8 percent of the chromium was recovered at 47.9 percent Cr_2O_3 grade. As with the previous sample, however, the iron content of the mineral was high; the chrome to iron ratio was only 1.96.

CONCLUSIONS

1. The iron content of the chrome-bearing mineral - hence, the chrome to iron ratio of finished concentrate - varied widely in the samples tested.

2. Only the higher-grade material from Bernard Mountain was readily amenable to gravity concentration for the production of "Metallurgical grade" concentrate.

3. Intensive field exploration and additional laboratory work would be required to determine the potential of the Tonsina deposits.

s/s R. R. Wells
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