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092GNW052 *
Mineral Hill

092GNW053
Wormy Lake

PRELIMINARY METALLURGICAL INVESTIGATION OF GARNET ORE

Prepared for:

TRI-SIL MINERALS INC.
P.O. Box 69
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Attention: Mr. Rudy Riepe

File Number: 8588
October 11, 1988

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1.0 INTRODUCTION

Preliminary metallurgical testing of samples of garnet ore has been conducted at the request of Mr. Rudy Riepe of Tri-Sil Minerals Inc. The analysis of the ores included:

1. Whole rock I.C.P. analysis.
2. Whole ore specific gravity analysis.
3. Comparative Bond Work Index determination.
4. Sink/float analysis.

The information and technical recommendations presented in this report are directed at evaluating the suitability of each ore for use as a sandblasting grit or, possibly, as a filtration media.

1.0 INTRODUCTION

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2.0 SUMMARY

The four garnet ore samples analyzed in this investigation all contained a high percentage of garnet. A sink/float analysis of each sample indicated over 98% of the material is heavier than specific gravity 2.96 (eliminating most silicate gangue). A whole rock I.C.P. analysis indicated high percentages of those elements which constitute garnet. The specific gravities of the whole ore fall within the range for garnet. Finally, microscopic examinations of the ground ores indicated a high garnet content, although the species of garnet vary within the ore.

Bacon, Donaldson and Associates was asked to conduct tests that would quantitatively determine the suitability of the ores for use as sandblasting grit or as a filtration media. The standard industry practice is to collect a large sample of properly sized garnet and use it in a full-scale sandblasting test. The sandblasting companies contacted do not perform specific tests to judge an ore's suitability. B.C. Research indicated that while there is an A.S.T.M. standard test to perform on sandblasting grit, it was rarely used and a full-scale test was again recommended. No information was available concerning industrial standards for garnet's use as a filtration media.

Pure garnet's specific gravity ranges between 3.56 and 4.32 depending on the composition. Sample 2 and 4 fall below this range. The reason for this is unclear, although it may be due to gasses trapped within aggregates of smaller crystals. The method of determining s.g.'s is extremely sensitive; little trapped air would be required to produce a significant lowering of the apparent specific gravity.

All the determined specific gravities fall at the lower end of the range of s.g's for pure garnet. This is consistent with the belief that most of the garnet in these ores is of the grossular variety. Grossular garnet has a specific gravity of 3.56.

3.4 Comparative Bond Work Index Determination

Each ore type was ground in a rod mill for 6 minutes under identical conditions. A sieve analysis on the grind products yielded the following results:

Sample 1	78.9% minus 200 mesh
Sample 2	56.0% minus 200 mesh
Sample 3	81.9% minus 200 mesh
Sample 4	42.9% minus 200 mesh

Experience with the BDA laboratory rod mill has provided an empirical relationship between grinding time to achieve X% minus 200 mesh and the Bond Work Index for an ore. Using this relationship, the approximate work indexes were indicated to be:

Sample 1	7.3 to 9.3
Sample 2	9.4 to 11.4
Sample 3	7.0 to 9.0
Sample 4	10.7 to 12.0

References indicate a typical garnet ore to have a Work Index of 12.4.

3.0 DISCUSSION

3.1 Sample Description

Four samples of garnet ore were received. Each sample was composed of coarse chunks (-15 cm) of massive garnet. The samples had distinctly different appearances, ranging from a pale yellow-brown color to black.

Table 3.1
Samples as Received

Sample No.	Client I.D.	Wt (g)	Color
1	Mineral Hill Brown	2482	Pale yellow-brown
2	Wormy Lake Road	2119	Dark red-brown
3	Wormy Lake A	1553	Light brown
4	Mineral Hill Black	3665	Black

3.2 Whole Rock I.C.P. Analysis

Sample 2 (Wormy Lake Road) and sample 3 (Wormy Lake A) were analyzed by Chemex Labs Ltd. (32 element whole rock I.C.P. analysis). Samples 1 and 4 had been analyzed prior to receipt by Bacon, Donaldson. Chemex's certificate of analysis is presented in Appendix I. A summary of the relevant elemental analysis for all four samples is listed in Table 3.2.

Table 3.2
Whole Rock I.C.P. Summary

Element	Weight % of Total Sample			
	Sample 1	Sample 2	Sample 3	Sample 4
Mg	0.11	0.58	0.02	0.07
Al	1.27	1.18	1.38	1.35
Ca	8.16	14.35	8.49	7.61
Mn	0.13	0.17	0.39	0.17
Fe	1.90	11.95	3.20	3.04

The elements listed in Table 3.2 are those which are present in the various mineral phases of garnet. A pure garnet crystal could have up to 18% Mg (pyrope), 13% Al (pyrope), 27% Ca (grossular), 33% Mn (spessartite), and 34% Fe (almandine). The low percentages determined in Chemex's analysis do not necessarily reflect the actual weight percent of each element in the sample. The I.C.P procedure is recognized to be approximate for Al, Ca, and Mg. Fe and Mn determinations are accurate.

If the percentages for Mn and Fe are assumed to be correct, and the other percentages are considered at least proportionally correct, then the bulk of the garnet is indicated to be of the grossular variety ($Ca_3Al_2Si_3O_{12}$). This is the most common garnet.

It should be remembered that pure grossular is a rare occurrence and extensive solid solution exists between the various pure end members. Solid solution is indicated to be prevalent in all samples by the significant percentages of Mg, Mn and Fe. There is the possiblity that the samples were not completely homogeneous. Optical microscopy revealed that none of the samples was homogeneous.

3.3 Whole Ore Specific Gravity Determination

Standard specific gravity tests were conducted on pulverized fractions from each sample. The samples were tested in duplicate and the results are summarized in Table 3.3.

Table 3.3
Specific Gravities

Sample No.	Client I.D.	Average s.g. of Whole Ore
1	Mineral Hill Brown	3.58
2	Wormy Lake Road	3.47
3	Wormy Lake A	3.57
4	Mineral Hill Black	3.53

3.5 Microscopic Examination of Samples

As indicated by the test grind results, there is a distinct difference in the apparent hardness of the samples. The size analysis of the test grinds (Appendix II) and an examination of the ground products by stereo microscopy leads to the following discussion.

Sample 1 appeared uniform. The small, clear-yellow garnet particles were all closely sized. Their physical appearance was consistent. There was a scattering of darker particles, perhaps one in a thousand, but these appeared to be of the same size as the bulk of the pale crystals. The larger particles that were present appeared to be aggregates of many smaller particles.

The sieve analysis of the ground product (sample 1) did not follow a standard size distribution. There was a relatively large percentage of material in the -100 +150 mesh size range while the bulk of the material is -200 mesh.

The sieve analysis and the microscopic observations, plus the low work index, suggest that the material may break down in stages. The first stage would be the relatively easy breaking up of the large aggregates and the second stage would be the more difficult grinding of the individual garnet particles.

A microscopic examination of sample 2 provided more information. This sample appeared less uniform. Both the size range of the particles and their physical appearance varied greatly. The individual particles ranged in color from a pale red, through dark red, to similar black speckles observed in sample 1. The darker crystals were generally larger than the pale ones and did not appear to be aggregates of smaller pieces. Aggregates of the pale red pieces, however, were abundant. The sieve analysis exhibited a similar type of distribution to that of sample 1 except that there was a greater percentage of coarse pieces. The reason for the distribution of sizes is similar to that hypothesized for sample 1. However, the higher "Work Index" appears to be associated with the presence of the larger dark red crystals; possibly a harder variety of garnet.

Sample 3 was composed of pale yellow pieces which were noticeably darker than those of sample 1. The familiar small dark specks were observed again but were less abundant than in the other samples. The size range of particles was much wider than sample 1, but the pieces were smaller with few large aggregates. The sieve analysis for this product supports this observation and results in the most normal size distribution of any of the samples. It appears that the aggregates were mush easier to break up than in the other samples and they all but disappeared in 6 minutes of grinding. This sample had the lowest "Work Index" of the four.

Sample 4 appears an even grey-black with the naked eye. Microscopically, however, the sample was composed of particles of dark red garnet and pale red/colourless garnet in an approximately 1:1 ratio. There was a large spread in the size range. The biggest particles were the dark red crystals, appearing black when they were relatively large. When these particles were broken they appeared more red but were still distinct from the paler pieces. The colourless and pale red pieces were significantly smaller and appeared similar to those observed in sample 2. The sieve analysis for this products showed a heavy concentration in the coarse size range. The coarse size range mostly contained the dark-red garnet. It appears that a higher "Work Index" is related to the presence of darker red garnets.

3.6 Sink/Float Analysis

A sample of ground material from each ore type was sent to Cominco Laboratories for a sink/float analysis. The process involves slurrying the sample in a heavy liquid, in this case tetrabromoethane of specific gravity 2.96, then allowing the solids to stratify according to their specific gravity. Those minerals with an s.g less than 2.96 (most silicate gangue) float and those with an s.g greater than 2.96 sink (not necessarily pure garnet). Table 3.4 summarizes the results of these tests.

Table 3.4
Sink/Float Analysis

Sample No.	Client I.D.	% Sink (s.g > 2.96)
1	Mineral Hill Brown	99.7
2	Wormy Lake Road	98.7
3	Wormy Lake A	99.4
4	Mineral Hill Black	99.6

The floated gangue particles were quartz and wollastonite. The wollastonite particles were long, column-like shards of colourless crystals. They were abundant in sample 3 and occasionally visible in the other whole ore samples. The wollastonite, a calcium silicate, was positively identified by examining it using a scanning electron microscope (see Appendix III).

APPENDIX I

Whole Rock I.C.P. Analysis

Chemex Labs Ltd.

Analytical Chemists • Geochemists • Registered Assayers

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Page No. : 1-A
Tot. Pages: 1
Date : 12-SEP-88
Invoice # : I-8822961
P.O. # : 50332

CERTIFICATE OF ANALYSIS A8822961

SAMPLE DESCRIPTION	PREP CODE		Al %	Ag ppm	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	Hg ppm	K %	La ppm	Mg %	Mn ppm	Mo ppm
#2	214	238	1.18	3.8	35	< 10	< 0.5	< 2	14.35	3.0	9	17	88	11.95	< 10	< 1	< 0.01	< 10	0.58	1725	1
#3	214	238	1.33	0.4	115	< 10	< 0.5	< 2	8.49	< 0.5	5	57	3	3.20	< 10	2	< 0.01	< 10	0.02	3880	< 1

CERTIFICATION : B. Caudle

Chemex Labs Ltd.

Analytical Chemists • Geochemists • Registered Assayers

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Page No. : 1-B
Tot. Pages: 1
Date : 12-SEP-88
Invoice # : I-88-2961
P.O. # : 50332

CERTIFICATE OF ANALYSIS A8822961

SAMPLE DESCRIPTION	PREP CODE		Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sr ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
#2	214	238	< 0.01	31	400	42	5	3	28	0.01	10	< 10	113	35	223
#3	214	238	< 0.01	5	5040	10	< 5	2	13	0.02	< 10	< 10	36	5	38

APPENDIX II

Size Analysis of Ground Samples

SIZE DISTRIBUTION

SAMPLE NO. 8588 - 1 (MINERAL HILL BROWN)

1 Kg Ground 6 min at 65% solids

Size Fraction (mesh)	Individual Percentage Retained %	Cumulative Percentage Passing %
+ 65	0	100.0
- 65 + 100	0.7	99.3
- 100 + 150	13.8	85.5
- 150 + 200	6.6	78.9
- 200 + 325	53.6	25.3
- 325	25.3	

SIZE DISTRIBUTION

SAMPLE NO. 8588 - 2 (WORMY LAKE ROAD)

1 Kg Ground 6 min at 65% solids

Size Fraction (mesh)	Individual Percentage Retained %	Cumulative Percentage Passing %
+ 65	5.2	94.8
- 65 + 100	17.6	77.2
- 100 + 150	15.8	61.4
- 150 + 200	5.4	56.0
- 200 + 325	26.2	29.8
- 325	29.8	

SIZE DISTRIBUTION

SAMPLE NO. 8588 - 3 (WORMY LAKE A)

1 Kg Ground 6 min at 65% solids

Size Fraction (mesh)	Individual Percentage Retained %	Cumulative Percentage Passing %
+ 65	0	100.0
- 65 + 100	0	100.0
- 100 + 150	1.2	98.8
- 150 + 200	16.9	81.9
- 200 + 325	45.0	36.9
- 325	36.9	

SIZE DISTRIBUTION

SAMPLE NO. 8588 - 4 (MINERAL HILL BLACK)

1 Kg Ground 6 min at 65% solids

Size Fraction (mesh)	Individual Percentage Retained %	Cumulative Percentage Passing %
+ 65	17.7	82.7
- 65 + 100	18.4	63.9
- 100 + 150	12.9	51.0
- 150 + 200	8.1	42.9
- 200 + 325	18.7	24.2
- 325	24.2	

APPENDIX III

Scanning Electron Microscope Analysis
Of Unidentified Gangue Particle

Ca
Si
Ca