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B.C. GARNET

A MAJOR NEW PRODUCT

A PROPOSAL TO THE

WESTERN DIVERSIFICATION PROGRAM

BY

POLESTAR EXPLORATION INC.

APRIL 15, 1989

1.0 SUMMARY

A supply crisis is developing in the Abrasive Blasting Industry. Abrasive blasting or "Sandblasting" is used to strip steel surfaces of millscale, old paint and/or rust.

The dust from Silica Sand, the "cheap" material of choice for generations can cause silicosis and is known to be a serious health risk (often fatal) to the human respiratory system. Silica is banned from use in many countries, in California and by the U.S. Military. All silica sand used for blasting in British Columbia is imported from the United States.

The major alternative abrasives, metal or coal slags, are by-products of copper and nickel smelters or boiler operations. These materials usually contain numerous heavy metals, often toxic elements and frequently corrosive chlorides. Slags cannot be used where the spent abrasives can enter the environment such as blasting on most bridges. Slags sell for about $100/ton in Vancouver. Fifty percent of consumed slags in B.C. and Alberta are imported from the U.S..

One mineral stands out as truly superior in all aspects as a blasting abrasive and that is garnet. Garnet is considerably heavier than silica and slags, is extremely hard, contains no free silica and is chemically totally safe.

Even though garnet is recognized as a superior abrasive throughout the industry, very little is produced for the blasting market since historically its cost has been prohibitive.

There is no garnet production in Canada. There are three producers in the Eastern U.S. and only one in the Western United States(Idaho). Garnet from Idaho sells in Vancouver for $39.60 per 100 lb bag or almost $800/ton (see Appendix 3b). What the industry needs is a consistent, reliable supply of garnet abrasive at a competitive price (in the $100/ton range).

Polestar Exploration Inc. has discovered and acquired two exceptionally large (over 5 million tons each) garnet deposits grading over 80% garnet.

The most favourable deposit is the ORO DENORO in Greenwood, B.C., which in addition to garnet, also contains some one million tons of mineralization grading 0.8% copper and 0.02 oz/t Gold. The presence of copper and gold will significantly reduce the costs of the garnet product to a level which is competitive with slags and silica.

The market for blasting abrasives is very large indeed. Most steel structures such as ships, oil storage tanks, bridges etc. need to be repainted on a 8-12 year cycle. Consumption of blasting abrasives in the U.S. alone is estimated at 5,000,000 tons per year. One ship, for example, requires 2,000 tons on the average.

Additional markets for garnet include roofing granules, water filtration, water jet cutting and various other abrasive uses.

The Company is soliciting funds for a detailed pre-production feasibility study, estimated to cost $550,000.00.

The cost of going into production is estimated at $1.7 million. The Company will raise these funds through equity financing.

Informal market enquiries over the past 6 months show that the need for a reliable safe abrasive like garnet is so great that the target of eventually conquering a major share of the market within 1,000 miles of the mine is definitely realistic.

The benefits to B.C. are the creation of an entirely new industry, a reduction in imports, an increase in exports, and the direct creation of 40 new jobs.

2.0 BACKGROUND

2.1 History of Development

Polestar Exploration Inc, as the name implies, was primarily an exploration company with a focus on base and precious metals. During 1988, Polestar personnel conducted research on B.C. skarn (contact metamorphic) deposits for their possible gold and copper content. Two of these skarns contained an exceptionally large and high grade garnet content. When the various uses for garnet were investigated, it was discovered that an enormous market existed for abrasive blasting media, and possibly filtration media and roofing granules as well. Research and experimentation have been in progress for the past 6 months.

2.2 Corporate Structure and Ownership

The Company was incorporated in 1983 and listed on the Vancouver Stock Exchange in November, 1986. Through equity financing the Company raised approximately two million dollars in 1987 and 1988 to conduct its exploration programs. Of 25,000,000 authorized shares, about 4.7 million are issued. The four directors collectively hold 749,596 shares. Another major shareholder is NIM with 964,917 shares. The rest of the outstanding shares are owned by private individuals.

2.3 Corporate Agents and References

Lawyers:	Bull, Housser & Tupper
Accountants:	Thorne Ernst & Whinney
Transfer Agent:	Montreal Trust
Bankers:	The Royal Bank of Canada
References:	Min-En Laboratories
	Bondar Clegg Labs
	Westmin Resources
	Esso Minerals Ltd.
	Almaden Resources Ltd.
	Gulderand Mining Corp.

3.0 PRODUCT

3.1 Description

A blasting abrasive is used to clean steel surfaces of mill scale or old paint and rust. The choice of abrasive determines the cleaning rate (labor costs) the cleaning quality, the abrasive cost, disposal costs and to a large extent the performance of the applied coating. Due to its consistent quality, high specific gravity and exceptional hardness garnet is recognized as a superior blasting abrasive throughout the industry (1, 4, 9, 10, 11, 12, 13, 15).

Garnet is one of the few abrasives that is specified and preferred by leading corrosion engineers, particularly on such specialized applications as (9):

- Rubber lining of tanks and vessels
- Suppression chambers of nuclear power projects
- Linings of scrubbers and stacks

The cutting rate of an abrasive is a function of velocity, mass, hardness, angularity, and particle size. Velocity is regulated by the air pressure at the nozzle, generally 100-120 lbs/square inch, causing particles to strike at about 450 miles per hour. Garnet is much heavier than most non-metallic minerals with a S.G. of 3.7-4.1 (silica has an S.G. of 2.7). Garnet is also exceptionally hard (H=7-7.5 on the MOH scale) topped only by such minerals as Topaz (H=8), Corundum (H=9), and Diamond (H=10).

Although garnet is a common mineral found in metamorphic rocks, large deposits containing over 30% garnet are extremely rare. Polestar has conducted extensive research on garnet deposits in Western Canada, particularly on contact metamorphic deposits known as Skarns. These are formed when hot intrusive magma reacts with limestone, producing a variety of silicates in the contact zone.

There are over 300 skarn deposits in B.C., all of which contain some garnet. The company has acquired 2 garnet skarn deposits of over 5 million tons each, containing in excess of 80% garnet. The most favourable of these is the ORO DENORO deposit in Greenwood, B.C. which also contains an estimated one million tons of Copper-Gold mineralization.

The garnet in the ORO DENORO is mostly of the Andradite variety (Ca_3 Fe_2 Si_3 O_{12}) with a hardness of 7 and S.G. of 3.8 (about 140 lbs per cubic foot). It crystallizes in the isometric system, forming dodecahedrons, trapezohedrons and cubic crystals of various colors, mostly amber, green and light brown. It crushes into sharp angled, chunky fragments ideally suited for aggressive blasting.

3.2 Competitors

Natural blasting abrasives in present use consist of Silica sand (65%), Slags (30%), and other mineral sands (5%). Canada does not produce garnet at the present time (6).

a) <u>Other Garnet Producers:</u> Even though garnet is superior, very little is used for sandblasting due to its high cost. Imported garnet from Emerald Creek, Idaho (the only western producer) sells in Vancouver for $39.60 per 100 lb bag (7) which is almost $800/ton. There are three Eastern U.S. producers. Barton Mines in New York, one of the largest garnet producers in the world, sells mostly to the sandpaper and glass polishing markets. Prices range to $2,000/ton. NYCO, N.Y. produces a grit containing garnet, diopside, and minor wollastenite as a by-product from a wollastenite mine. Industrial garnet extractives near Rangely, Maine markets a by-product of 80% feldspars and 10-15% garnet (6). They have developed a new product (see Appendix 3a), which sells for $220 U.S./ton, but is not available due to the mill being broken down. Imported Australian garnet sells for U.S.$200-260/ton in the Western U.S. (9).

b) <u>Silica Sand:</u> Sandblasting with silica creates excessive dust. Silica dust when breathed can cause silicosis, an often fatal disease. The average exposure time of sandblasters who have died from silicosis is 10 years. In some cases, exposure of as little as 1.5 years is sufficient to contact silicosis (2). For health reasons Silica has been banned in most countries, in California and by the U.S. Military (13). Yet, so few alternatives are available that 65% of U.S. Consumption is still Silica.

Silicon dioxide (SiO_2) or "free silica" is usually produced locally from beach and river deposits at a "low" price of $50-60/ton. However, in Vancouver all blasting sand is material was found to be very dusty, expensive and only available in the East (4).

Dupont produces "Starblast", also in the East, a Staurolite sand mixture (U.S. $100/ton) which still contains 5% free Silica and other impurities like Titanium minerals, Kyanite and Zircon. Starblast is mined as a by-product of a beach sand operation for ilmenite, a titanium ore. It comes in only one size and since the grains are rounded, it is inferior to sharp angled garnet in removing old paint and rust. Dupont markets this material aggressively even though it comes with elaborate health warnings regarding the silica content and in addition is toxic to eye contact (5) (also, see Appendix 3d).

Dupont claims that compared to Starblast, more than 6 times as much silica sand, almost 4 times as much coal slag, and more than 2 times as much copper slag are needed to clean the same area of metal (Appendix 3d).

3.3 Research and Development

The Oro Denoro garnet skarn is a mixture of several silicates, oxides and sulphides varying in concentration from one side of the deposit to another. The pre-production feasibility study will include research to develop a process that will separate the raw material into a sulphide concentrate (containing copper and precious metals) and a garnet grit suitable for sandblasting and to determine which part of the deposit should be processed and which part should be discarded as waste.

Montgomery Consultants has been retained to research the distribution of mineral concentrations through geostatistical methods. The Mining and Mineral Processing Department at the University of British Columbia will develop a flow sheet to effectively separate the various products.

Research to date has included several gravity concentrating experiments, mineral analyses and preliminary electrostatic, magnetic and flotation tests as well as actual blasting tests. Results have been encouraging. The next phase is a detailed study that will address the feasibility of all aspects of the project (see Appendix 2b).

3.4 Feasibility Study - Cost Estimate

1.	Supervision and Coordination One Engineer 6 months @ $8000/mo.	48,000
2.	Geological and Mineralogical analysis, geostatistics	40,000
3.	Additional drilling, surveying, mapping for garnet content, quality and grade	82,000
4.	Operating Cost Analysis	30,000
5.	a. Preliminary Research and Production Development (see proposal by U.B.C. Appendix 2b)	58,000
	b. Exhaustive Product Testing by S.G. Pinney & Assoc. in the U.S. to clear product by the California Air Resources Board and other agencies	42,000
6.	Environmental Impact Studies	70,000
7.	Mining and Processing Equipment Analysis	30,000
8.	Market Studies and Promotion (1 marketing consultant 6 mos. @ $8,000-48,000 per year Expenses - $25,000; Advertising, surveys etc. $27,000)	100,000
9.	Transportation Cost Analysis	20,000
10.	Discounted cash flow and return on investment analysis	30,000
	TOTAL:	$550,000

4.0 MARKETS

4.1 Customer Description (Abrasive Blasting)

Independent painting, or coatings and linings contractors form the bulk of the customers. In addition, large companies such as shipyards, steelmills, oil companies etc. handle their own sandblasting needs. A medium sized contractor was contacted in Seattle (1). Ty Long of Long Painting Co. informed the writer that his company typically blasts and paints 8-10 ships per year and that the average ship requires about 2,000 tons of abrasives. He has been using garnet for many years, but only on special projects due to the high cost of garnet. It is actually economical to collect the spent garnet, clean it, and reuse it again. Mr. Long indicated that if garnet was available at U.S. $100/ton, he would use garnet exclusively.

4.2 The Abrasive Blasting Market

N.A.C.E., the National Association of Corrosion Engineers estimates that corrosion control costs the U.S. over 124 billion dollars per year (14). A crucial factor in preventing costly coating failures is proper surface preparation, which is accomplished by abrasive blasting.

The market for blasting abrasives is enormous. There are some 330,000 oil storage tanks in the free world, 17,500 ocean going ships, 10,000 military vessels, in addition to numerous other steel structures, such as bridges, trucks, earth moving equipment etc. Many of these structures have to be thoroughly stripped of all old paint and rust on a 8-12 year cycle. Prior to painting, all new steel has to be blasted to remove the mill scale, a tough oxidized layer. The consumption of abrasive blasting media in the U.S.. is estimated at 5 million tons per year of which 500,000-700,000 tons is consumed in the Western States and Canada (9).

The company should be able to produce garnet at a cost that would allow to ship the product to Asian markets as well as the U.S. and Canadian markets.

A major strength of the company is the huge size of its garnet deposits and therefore, its ability to supply the market with a safe, reliable, consistent product for a long time.

c) **Water Jet Cutting**

This new technology involves the cutting of concrete, steel, glass etc. with a high pressure (up to 80,000 PSI) water column assisted by fine grained abrasives.

Industrial water jet machines use about 400-500 pounds of abrasive per hour.

d) **Traditional Markets**

Garnet has been used in grinding wheels, lapping compounds and sandpaper. Barton Mines dominates these markets and the company has no intention of competing in this relatively small market (estimated at 20,000 tons/year) at this time. However, the company will produce a certain percentage of fines (minus 100 mesh) for which a market should exist.

4.4 Market for Magnetite

The Oro Denoro contains a percentage of Magnetite (to be determined). This by-product is relatively easy to remove. Magnetite is used as a heavy medium(mixed with water) in the coal purification process. Consumption is about 50,000 tons/year. The Cragmont mine has been supplying this market, but supplies are running out.

4.5 Price Sensitivity

The success of the project is relatively immune from a drop in end-use price level. The projected profit margins allow for considerable flexibility.

The anticipated production cost is so low that the company can sell a superior product at the same price as slags and silica and still make considerable profits.

5.0 MARKETING STRATEGY

5.1 Distribution Methods

The company intends to use established distributors to handle its abrasives. Most distributors employ an aggressive sales force to promote their products in each local area. This will simplify operations significantly.

Large clients such as shipyards, the U.S. Navy or oil companies may order abrasives in bulk directly from the producer.

A local distributor in Vancouver imports a large variety of industrial minerals by rail and has complete bagging and palletizing equipment on the premises. It may prove advantageous to use their facilities rather than packaging materials at the mine site (17).

5.2 Advertising and Promotional Plans

Polestar is a member of the Steel Structures Painting Council, the national U.S. organization made up of coatings manufacturers, contractors, abrasive suppliers and end users. The Council publishes the monthly Journal of Protective Coatings and Linings as well as numerous research reports, specifications and a directory of contractors and distributors listed by State.

The Company is also a member of NACE - the National Association of Corrosion Engineers, which has a chapter in Vancouver as well as in all major cities in North America. NACE publishes the Journal Materials Performance and organizes several yearly corrosion conferences around the world. One was recently held in Vancouver. The next major technical conference will be held in New Orleans on April 17-21, 1989.

In addition to advertising in the trade journals, Contractors and Distributors will be accessed by direct mail to promote the Company's products.

Polestar Exploration Inc. has formed a wholly owned subsidiary, named CRYSTAL PEAK GARNET CORPORATION. The product will be marketed under the name CRYSTAL GRIT. Trademark protection will be obtained in due time. The Company has retained the firm of S.G. Pinney and Associates, Corrosion Consultants with offices across the United States to help introduce Crystal Grit to the U.S. market.

Since California has the toughest environmental regulations, Mr. Don Hill, P.E. of S.G. Pinney's office in Los Angeles will arrange for the testing of Crystal Grit by the California Air Resources board. Once accepted in California the rest of the U.S market should present no regulatory delays.

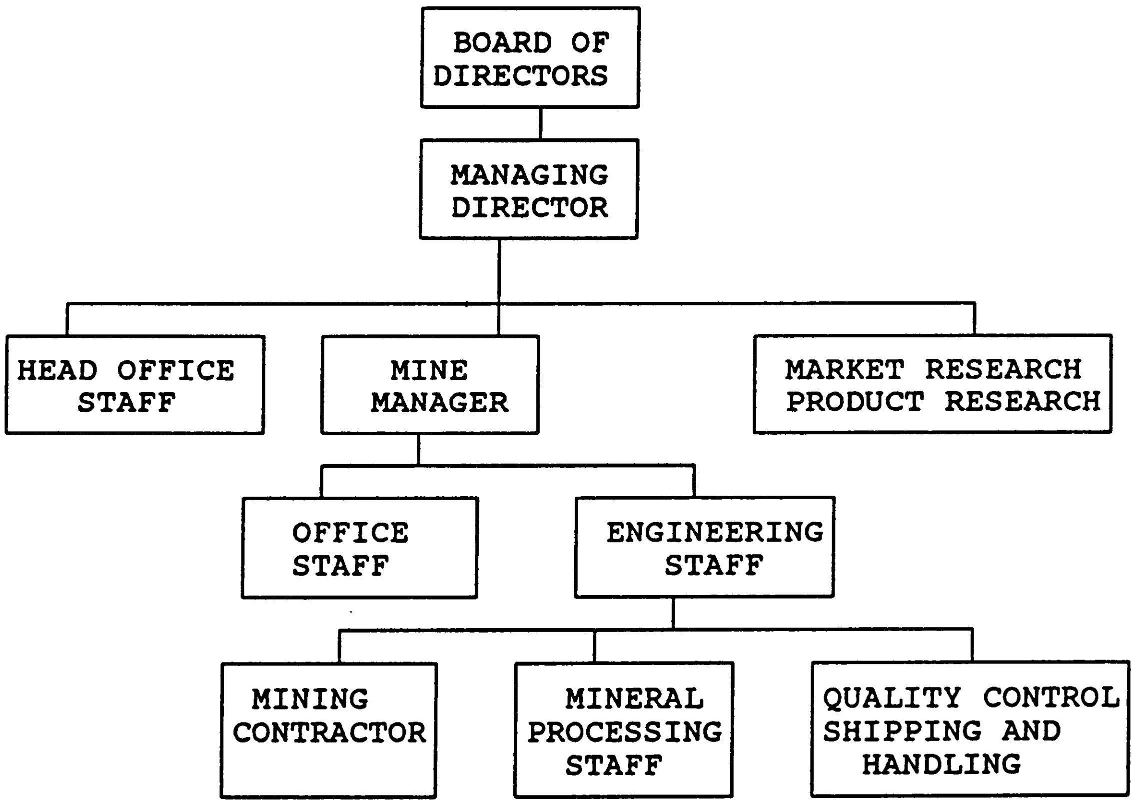
5.3 Credit and Warranty Policies

The industry norm is net 30 days and 1.5% interest per month. Most sales will be to well established, large distributors and payment delays are not anticipated.

The product will be intensively tested and warranties can be covered by regular liability insurance coverage.

6.0 ORGANIZATION

6.1 Organization Chart



7.0 OPERATIONS AND PLANT

7.1 The Town of Greenwood, B.C.

The Oro Denoro Garnet deposit is located on Hwy 3, 18 road Km. NE of Greenwood, B.C. and 24 Km. NW of Grandforks. Greenwood (500 km east of Vancouver) was one of the first copper mining towns in B.C. when the Granby Mining Company operated the Phoenix Mine. This mine has not operated for over 10 years but Noranda has acquired the property and may be doing more work.

The district has always seen a fluctuating level of exploration and mining activity, although at the present time only the Skylark, a small gold mine is operating.

The skilled labor situation in South-Central B.C. is excellent, as are the availability of equipment and general services. Sources of employment are limited to some logging and a lumber mill in Midway. There is a higher than average level of unemployment; therefore, a new employer would be viewed positively by the community (see Appendix 5).

7.2 The Oro Denoro Garnet/Copper Deposit

This property was intensively explored for Copper in the sixties and early seventies by several major companies including WestCoast Resources, Noranda, Furukawa and Granby. The unusual garnet content was ignored at the time.

Several reserve studies were completed (16) a conservative estimate suggests 1.0 million tons grading 0.8% Copper and 0.02 oz/t Gold and over 5 million tons of garnet (80% or better).

The planned feasibility study will include detailed geostatistics to improve these estimates.

The Oro Denoro is ideally located for a low-cost open pit quarrying operation. The Burlington Northern Railroad passes just 16 km south of the property and power is available at Eholt, 4 km north of the property. Low elevations (3,800 feet) and reasonably mild climate allow for year-round operations.

Freight cost by rail are (US)$22.00/ton to Vancouver, $18.00/ton to Seattle;

$26.00/ton to Portland and $40.00/ton to San Francisco. Bulk ocean shipments could be made from Vancouver or Seattle.

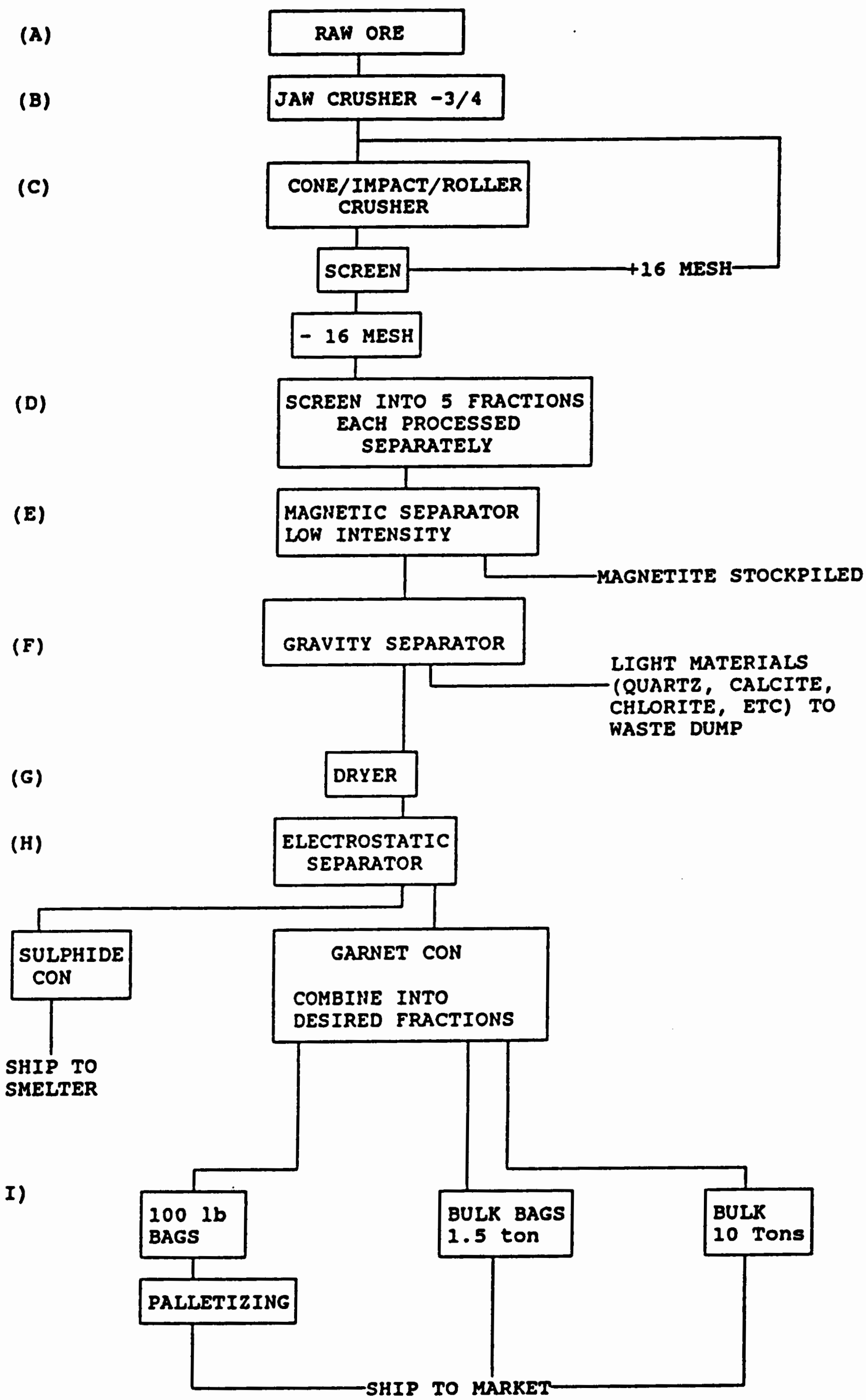
Another favourable feature is that the deposit is located on a hill with negligible overburden and minimal waste.

Two old railroad grades pass right by the workings, which consist of 2 old drifts, a crosscut and some small open pits.

7.3 Production Process

Research to date suggests that a purely physical extraction process using a combination of gravity, magnetic and electrostatic methods will be effective. The intent is to use no chemicals whatsoever thus reducing environmental impact to an absolute minimum. The Department of Mining and Mineral Processing at the University of British Columbia has expressed a serious interest in developing the process on a contract basis.

Until the feasibility study is completed the following flow chart is subject to modification.


(A)
RAW ORE
(B)
JAW CRUSHER -3/4
(C)
CONE/IMPACT/ROLLER CRUSHER
SCREEN
+16 MESH
- 16 MESH
(D)
SCREEN INTO 5 FRACTIONS EACH PROCESSED SEPARATELY
(E)
MAGNETIC SEPARATOR LOW INTENSITY
MAGNETITE STOCKPILED
(F)
GRAVITY SEPARATOR
LIGHT MATERIALS (QUARTZ, CALCITE, CHLORITE, ETC) TO WASTE DUMP
(G)
DRYER
(H)
ELECTROSTATIC SEPARATOR
SULPHIDE CON
SHIP TO SMELTER
GARNET CON
COMBINE INTO DESIRED FRACTIONS
I)
100 lb BAGS
PALLETIZING
BULK BAGS 1.5 ton
BULK 10 Tons
SHIP TO MARKET

A) The actual mining of the material is subcontracted. This will simplify the operation and reduce the capital requirements significantly. Initial production is estimated at 500 tons/day.

B) Jaw crushing to -3/4"

C) Closed circuit crushing to -16 mesh. Initial indications are that impact crushing liberates more sulphides into the finer fractions which facilitates separating the coarser fractions. A double roll crusher may perform better yet. The +16 mesh material is recirculated and the -16 mesh fraction is continuously removed in order to keep the amount of fines to a minimum. The most popular size blasting grit is -16 +40 mesh (about 0.5 -1.0 mm).

D) The material is screened into 5 closely sized fractions to facilitate subsequent separation. Tentatively: 16-24, 24-32, 32-40, 40-60 and -60. Separation is easier for the finer fractions. Each fraction is now processed separately.

E) Low intensity magnetic separation takes out the magnetite, to be stockpiled. There is a small market for magnetite in the coal industry.

F) Gravity separation using spirals, jigs, tables or combinations thereof. All water is settled and recirculated. Consumption should be minimal. All light materials with S.G. less than 3.0 are removed (Quartz, Calcite, Chlorite etc.) to tailings pond.

G,H) Drying and Electrostatic separation of garnet and sulphides. Curiously, garnet is one of the least conductive materials found in nature, possibly only topped by asbestos. Since sulphides are fairly conductive, this stage should produce a sulphide concentrate to be shipped to a copper smelter (either Utah, Flin Flon, Manitoba, or Japan).

I) The various fractions of garnet are now combined into several end products and packaged into 3 different containers: 100 lb double wall paper bags, 1.5 ton bulk bags or large bulk containers. The 100 lb bags are placed on pallets and wrapped in plastic for shipment and waterproof storage.

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METALLURGICAL INVESTIGATION OF POLESTAR GARNET ORE

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File Number: M89-082
March 21, 1989

Dr. W. G. Bacon, P.Eng.

1.0 INTRODUCTION

A preliminary metallurgical investigation has been conducted on a large sample of garnet ore provided by Polestar Exploration Ltd. The intent of this investigation was to study the ore to develop a metallurgical process that would produce a relatively pure garnet product suitable for sandblasting and/or other industrial uses. In addition, the copper mineralization in the ore was sufficient to warrant investigating the feasibility of producing a by-product copper concentrate.

Throughout this project communications were maintained with Mr. Robert Wolfe of Polestar Exploration Ltd. All tests were planned jointly and results were discussed before proceeding with the next phase of the investigation.

2.0 SUMMARY

2.1 Sample Preparation

The raw garnet ore was stage crushed from +15 cm to -10 mesh. Closed circuit crushing and screening with conventional jaw and cone crushers was employed to minimize the production of fines. Despite these measures, approximately 20% of the crushed material was -100 mesh. In terms of the garnet content, this 20% fraction likely represents a loss. Further investigation should be devoted to minimizing the production of fines during crushing. This could involve the use of impact crushers or roll crushers. A second alternative would be to investigate the market potential of this fine fraction.

The crushing operation produced' a well liberated product.

2.2 Gravity Separation

Gravity separation worked well on the finer size fractions. Concentrates were produced containing up to 70% sulphide (visual volume estimate). The coarse fraction, however, did not respond well to gravity separation by either a table or a jig. The similarity in specific gravity between the garnet and the sulphide minerals results in this poor efficiency. Closer sizing of the material would likely improve this separation.

It is not believed that a gravity concentrate can be produced containing chalcopyrite. The range of specific gravity for chalcopyrite overlaps that of garnet.

2.3 Electrostatic Separation

The results of the tests using a laboratory scale Carpco electrostatic separator indicate potential for this method. It was the first method that produced a copper-sulphide concentrate. Recovery was poor, but a significant improvement in copper grade was made in the finer fractions. A second encouraging aspect of electrostatic separation is that the success of this method is supported by theory: chalcopyrite and pyrite are strong conducting minerals while garnet is one of the most non-conducting minerals in existence.

Some problems encountered in the electrostatic separation tests included:

1. Extremely fine particles coating on drum (reducing separation efficiency)
2. Poor recovery
3. Very poor separation in coarse size range

Further investigation of the potential for electrostatic separation is recommended. It is further recommended that this testwork be done by a firm with a strong background in electrostatic separation. BD&A can suggest several firms.

3.0 DISCUSSION

This investigation began with a request for Bacon, Donaldson & Assoc. to propose a metallurgical flowsheet that would produce a garnet concentrate and a by-product sulphide concentrate from a garnet ore. This was done but the proposed flowsheet was never tested. As the investigation progressed, the focus of the study shifted from producing a final flowsheet for the ore to gathering a data base of metallurgical information from which future studies can progress.

This investigation included:

1. Preparation of size fractions from the coarse garnet sample.
2. Heavy liquid analysis of size fractions.
3. Electrostatic separation.
4. Gravity separation of coarsest size fraction.
5. Hydrochloric acid and attrition tests.
6. Scanning Electron Microscopy of garnet grains.

In addition, BD&A attended a sandblasting demonstration of Polestar Exploration's garnet product. In this test a rough gravity-separated garnet product was compared to industry standard sandblasting media. The test was conducted by B.C. Hydro Ltd.

Throughout this investigation, use was made of optical microscopy to examine the products of all tests. Because of the nature of the material, standard methods of assaying could not be used to judge the effectiveness of many tests conducted. Visual examination was the most practical alternative.

3.1 Sample Preparation

On January 17, 1989, Bacon, Donaldson & Associates received 336 kg of +15 cm garnet ore. The processing instructions called for the preparation of various size fractions with a minimum production of fines.

The ore was first crushed in a 6" x 12" Pacific jaw crusher, then crushed again in a small laboratory-scale jaw crusher. The lab-scale jaw crusher discharge was screened at 10 mesh. The undersize was saved while the oversize was put through a laboratory-scale cone crusher. The cone crusher discharge was again screened at 10 mesh to remove fines. Oversize was cone crushed again. This closed-circuit cone-crushing screening procedure was repeated until the sample was -10 mesh. A flowsheet of the sample preparation procedure is shown in Figure 1.

When the entire sample was minus 10 mesh, it was wet screened using a Sweco to produce the following size fractions:

- 10	+ 30	mesh
- 30	+ 60	mesh
- 60	+100	mesh
-100		mesh (fines)

Despite efforts to minimize the production of fines, approximately 60 kg of -100 mesh material was produced. Some of it could not be saved as the extremely fine material washed away during wet screening.

3.2 Sample Description

The size fractions were examined microscopically and assayed for copper and total sulphur. The assay results are presented in Table 3.1. The cone-crusher discharge was assayed separately for comparison.

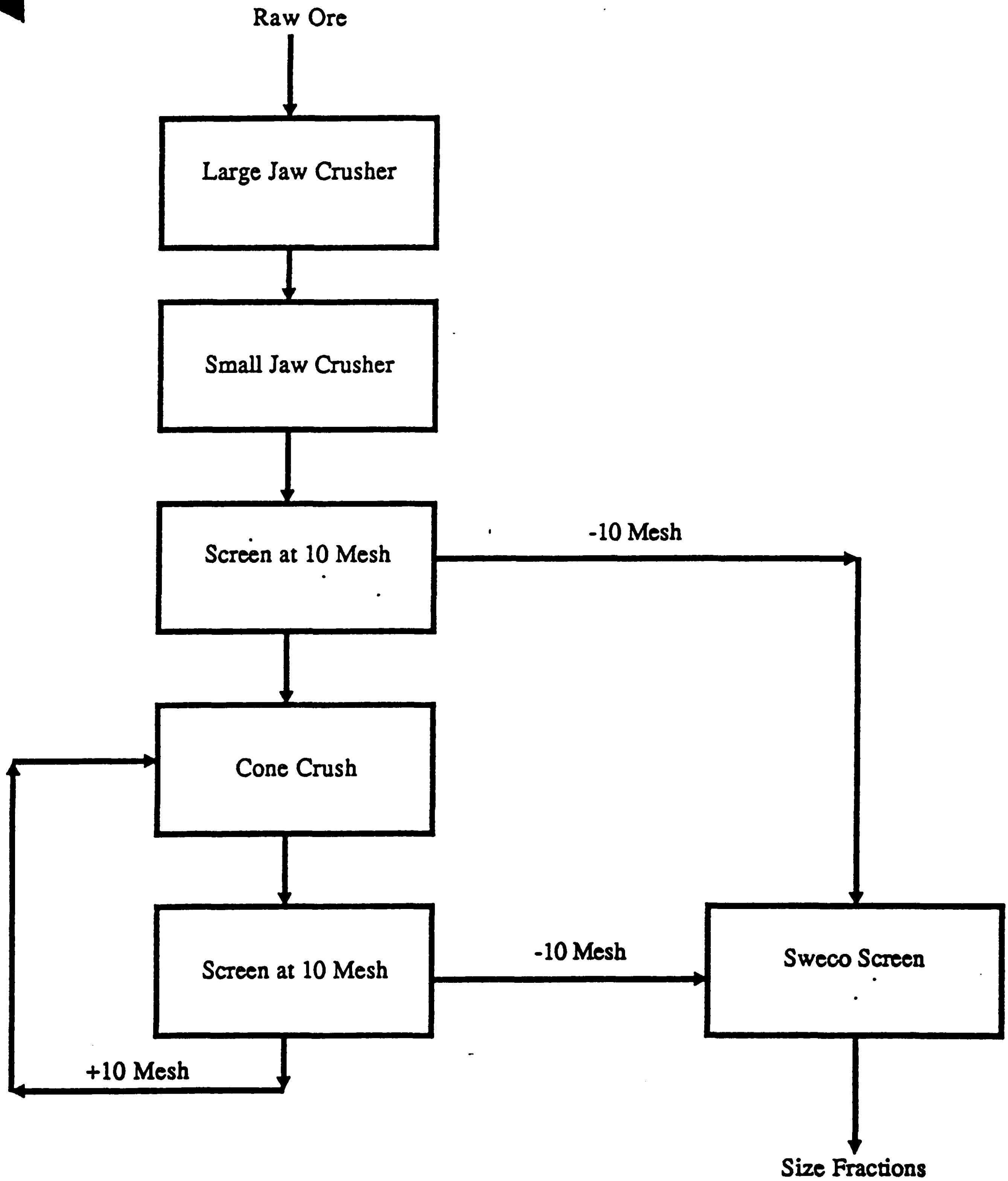


Figure 1: Closed circuit screening of garnet ore

Table 3.1

Head Analysis

Size Fraction (mesh)		Assay Cu %	S^{TOTAL} %
- 10	+ 30	0.02	0.15
- 30	+ 60	0.03	0.17
- 60	+100	0.05	0.25
-100		0.06	0.28
Cone Crusher Discharge		0.02	0.19

During microscopic examination, it was apparent that there was a high degree of liberation in all size fractions; few middlings were found. Magnetite was the exception. Magnetite appeared to be widely distributed in the form of small, disseminated inclusions in garnet crystals. These inclusions were often present in large enough quantities to cause the garnet grain to respond to a hand magnet.

The sample appeared to be about 90 to 95% garnet. The garnet itself ranged from an abundant pale green/brown variety to less common bright red and yellow crystals. Several copper minerals were identified including chalcopyrite, bornite and minor copper oxides. The main sulphide mineral is pyrite. Other gangue minerals include quartz and calcite. Figure 2 shows a collection of handpicked particles which indicate the varied composition of this ore.

3.3 Heavy Liquid Analysis

As a preliminary analysis of the size fractions, samples were submitted to Cominco Laboratories Ltd. for heavy liquid analysis. This procedure involves vigorously mixing the sample in a heavy liquid (in this case tetrabromoethane of specific gravity 2.96) then allowing the mixture to sit. The solids will separate according to their specific gravity. The specific

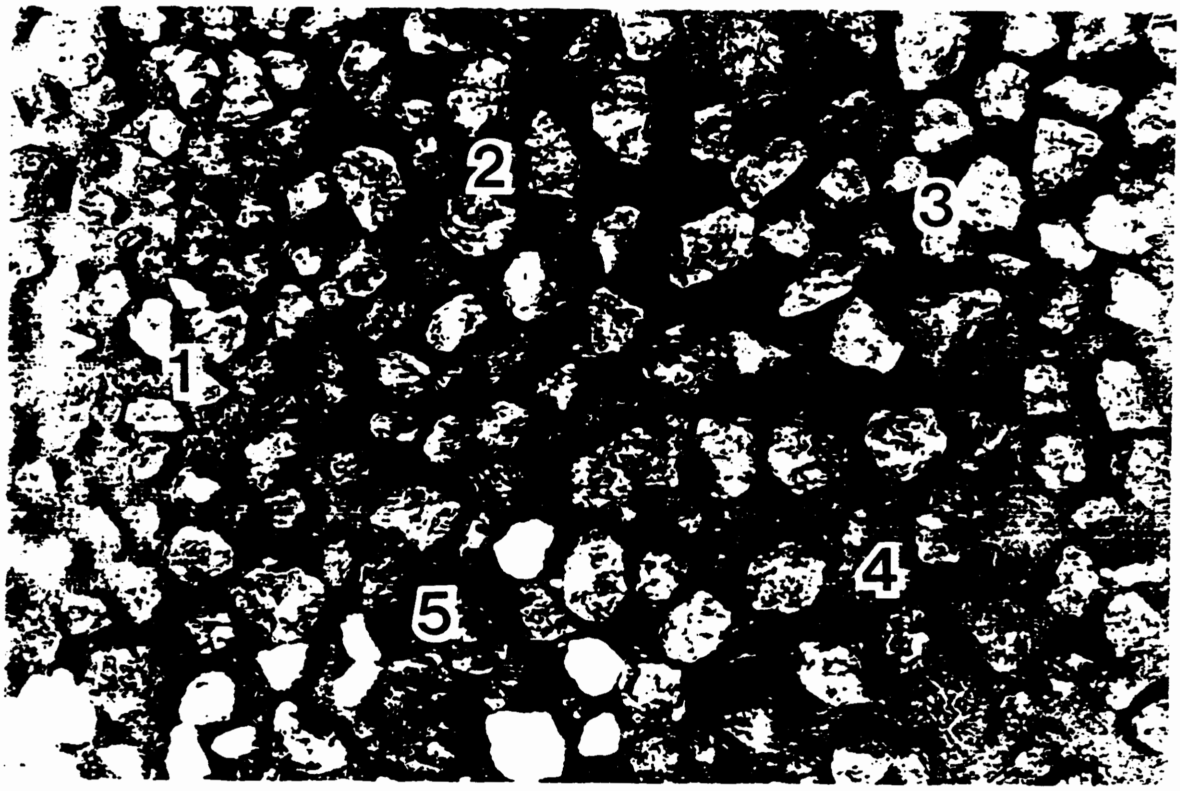


FIGURE 2. Hand-picked particles from Polestar garnet ore. The particles were chosen because they represent the full range of material found in the ore. Starting from the left and moving clockwise from Area 1 to Area 4 the garnet becomes dirtier and less identifiable. Area 5 shows some of the common impurities in the ore. The white minerals are quartz and calcite, while the sulphides are pyrite, chalcopyrite and bornite.

gravity of tetrabromoethane is high enough to cause most of the common silicate gangue minerals to float. The heavier garnet and sulphides will sink.

This test provides information about the percentages of light gangue minerals occurring in the ore. Furthermore, by testing different size fractions, there is an indication of the degree of liberation.

The results of the sink-float analysis are presented below in Table 3.2.

Table 3.2

Sink-Float Analysis

Size Fraction			Total Weight Tested (g)	% Float (s.g. > 2.96)
- 10	+ 30	mesh	Not tested (too coarse)	-
- 30	+ 60	mesh	341.1	2.4
- 60	+100	mesh	344.5	4.2
-100		mesh	212.6	4.2

Microscopically, the material that floated was calcite and quartz with minor garnet middlings. This analysis also indicates that the coarse size fractions are not as well liberated as the fine fractions.

3.4 Electrostatic Separation

Three large scale electrostatic separation tests were conducted on the ore. The dried and sized material was passed over the Carpco laboratory scale electrostatic separator shown in Figure 3. Adjustments to the instrument were made in progress until an optimum separation was achieved.

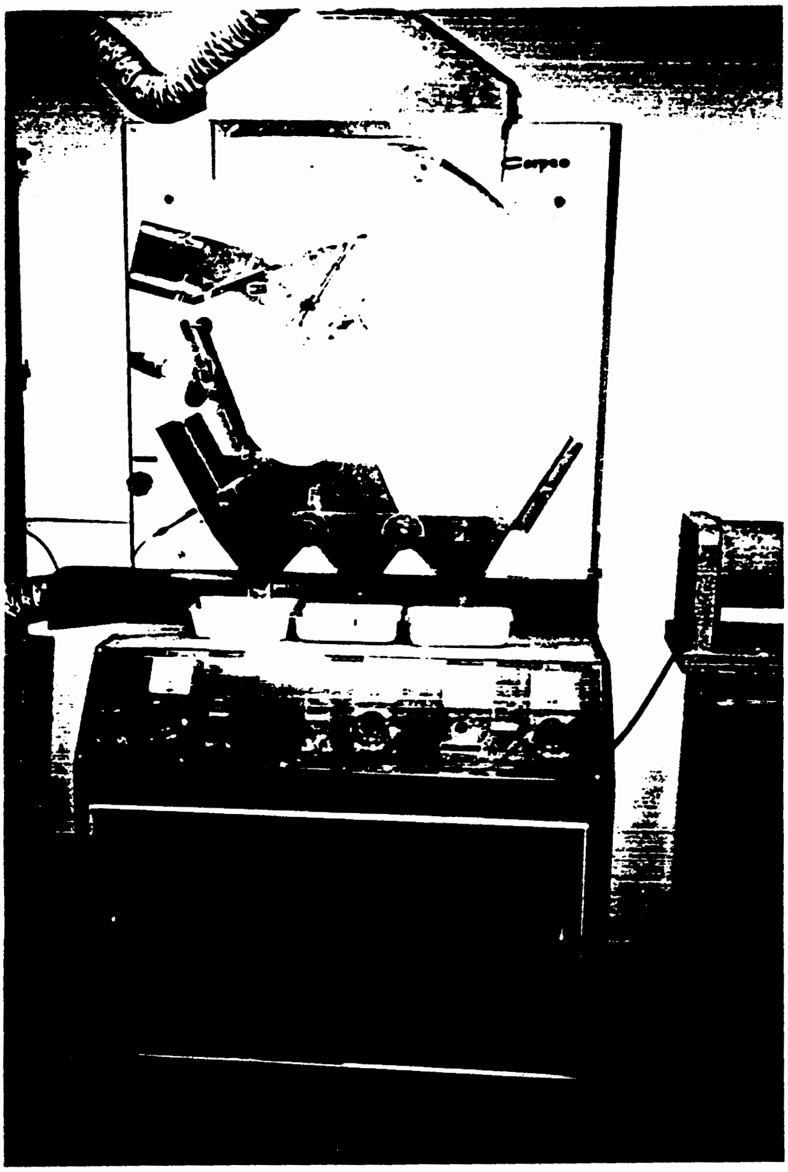


FIGURE 3. The laboratory scale Carpco electrostatic separator (located at the University of British Columbia). This photo shows the approximate arrangement of electrodes and splitters used in the BD&A testwork.

Three products were collected per run; a sulphide product (conductor), middlings, and a garnet product (non-conductor). Due to time constraints, a scavenging run was conducted on only one of the size fractions. A mass balance and some assays are presented in Table 3.3.

Table 3.3

Electrostatic Separation Summary

Size Fraction		Product	Product Weight (g)	(%)	Copper Assay %
- 10	+ 30	Conductor	3452	18	very low grade
		Middlings	5553	30	
		Non-conductor	9665	52	
- 30	+ 60	Rougher Conductor	38	0.2	2.40
		Rougher Middlings	76	0.4	
		Scavenger Conductor	74	0.4	1.80
		Scavenger Middlings	243	1.2	
		Scavenger Non-conductor	19969	97.8	
- 60	+100	Conductor	64	0.4	2.16
		Middlings	133	0.8	
		Non-conductor	17053	98.8	

The results indicate that the electrostatic separation did not separate all the sulphide minerals from the garnet. Based on the head grades presented in Section 3.2 of this report, the estimated copper recoveries were approximately 36% (rougher plus scavenger) for the -30 +60 mesh fraction, and 16% for the -60 +100 mesh fraction. The coarsest fraction produced very little sulphide separation and no copper assay was performed.

Despite poor recoveries, the results are encouraging. The copper grade of the sulphide products was increased from 50 to 80 times compared to the copper grade of the feed. This is the highest ratio of concentration for copper achieved in this test program.

Several problems were encountered during electrostatic separation. There was a large portion of fine particles present in the feed. These particles tended to coat the drum and noticeably lower the separation efficiency. To combat this the machine was shut down and cleaned frequently. Separation was noticeably improved immediately after cleaning. This behaviour suggests that very careful washing and screening of the feed material could improve electrostatic separation results.

Mineral conductivity tables indicate garnet to be one of the most non-conducting minerals in existence. Conversely, chalcopyrite and pyrite are highly conducting. Microscopic analysis shows the sulphide particles to be well liberated from the garnet. These facts all suggest that electrostatic separation of the sulphides from the garnet should be possible. The results of our tests are very preliminary in nature. It is believed that improvements could be achieved through further testwork.

3.5 Gravity Separation

Most of the impurities in this ore have a significantly different specific gravity than garnet:

Quartz	s.g.	=	2.65
Calcite	s.g.	=	2.7
Garnet	s.g.	=	3.56-4.32
Chalcopyrite	s.g.	=	4.1-4.3
Pyrite	s.g.	=	4.9-5.2

This indicates that it should be possible to remove most of the impurities by careful gravity separation.

The shaking table is a very effective gravity separation device for material in an approximate size range of 20 to 200 mesh. Coarser and finer materials are processed less effectively or require special equipment. If the difference in specific gravity of the materials to be separated is great, then the need for closely sized feed is less. If the difference is small, then size and shape effects become significant and separation efficiency is reduced.

Gravity separation tests using a Diester table were conducted on samples of Polestar's garnet ore. The tests were conducted in Greenwood, B.C. by VADCO Mine and Mill Services. The partial results and test products were shipped to Vancouver for further evaluation by BD&A.

The specific results of the tabling tests were presented to Polestar Exploration by VADCO and will only be discussed qualitatively in this report. The coarse size fractions (-6 +10 mesh and -10 +18 mesh) responded poorly or not at all to gravity separation by the shaking table. This material is too coarse for efficient separation with a shaking table. An intermediate fraction (-18 +40 mesh) gave better results and it is reasonable to expect successful results with this size fraction once scavenging and cleaning steps are incorporated. The finest fraction (-40 mesh) responded well to gravity separation by tabling.

Our microscopic examination of the test products confirmed VADCO's estimation of the sulphide content of the various products, with the exception of the -10 +18 mesh sulphide conc: VADCO estimated 20% sulphides, while 5% seems more reasonable. It is important to note, however, that the sulphide concentrate produced by tabling was mostly pyrite and did not appear to be significantly higher in copper sulphides than the feed (no assays were taken). This is as expected given the similar specific gravities of garnet and chalcopyrite.

A jig is a more effective gravity separation device for coarse material. Again, close sizing is required to ensure proper separation between materials with small differences in specific gravity.

One jigging test was conducted on a coarse sample of Polestar Exploration's garnet ore. A 2500 g sample of -10 +30 mesh material was jigged. Rougher and scavenger products were combined and then cleaned in a subsequent pass through the jig. The cleaner product shows only minimal up-grading in pyrite content, grading approximately 5% pyrite. This is the same up-grading that was achieved by VADCO's tabling of the -10 +18 mesh product. From these results it is evident that gravity concentration of a coarse fraction of this ore is very difficult. The difference in specific gravities between garnet and pyrite is not great enough to allow high separation efficiency.

The main method of improving this is to prepare the feed with a much smaller size range. This would minimize dimensional effects.

3.6 Garnet Analysis

A large sample of processed garnet product was requested by Polestar Exploration for use in a sandblasting demonstration. To this point, gravity concentration by tabling was demonstrated to be the most effective method of removing the sulphide impurities. As VADCO had already tabled large amounts of similar garnet ore, it was suggested that rather than tabling several more samples, VADCO's products be sent to Vancouver and prepared for the demonstration.

When VADCO's material arrived at BD&A, it was necessary to re-table the -40 mesh material as the original table middlings and garnet product had been combined before shipping. This material tabled well and a high purity sulphide concentrate was removed. All products were dried in preparation for the demonstration.

On February 14, a sandblasting demonstration was conducted by B.C. Hydro at their research facilities in Surrey, B.C. Several products were tested:

1.	Industrial media:	20 x 30 silica sand
2.	Industrial media:	copper slag
3.	Polestar Exploration media:	-10 +18 mesh VADCO table product
4.	Polestar Exploration media:	-10 +30 mesh Brown Garnet Ore

The testing itself will not be discussed here except to say that the VADCO garnet product performed comparably with the industrial media, while the brown garnet performed significantly better. Samples were collected of each media for laboratory analysis. Pictures of each media are presented in Figures 4 to 8. It can be seen from the pictures that the media are extremely varied; particle size, shape and surface features are all different.

A comparison of the two garnet ores is summarized below in Table 3.4.

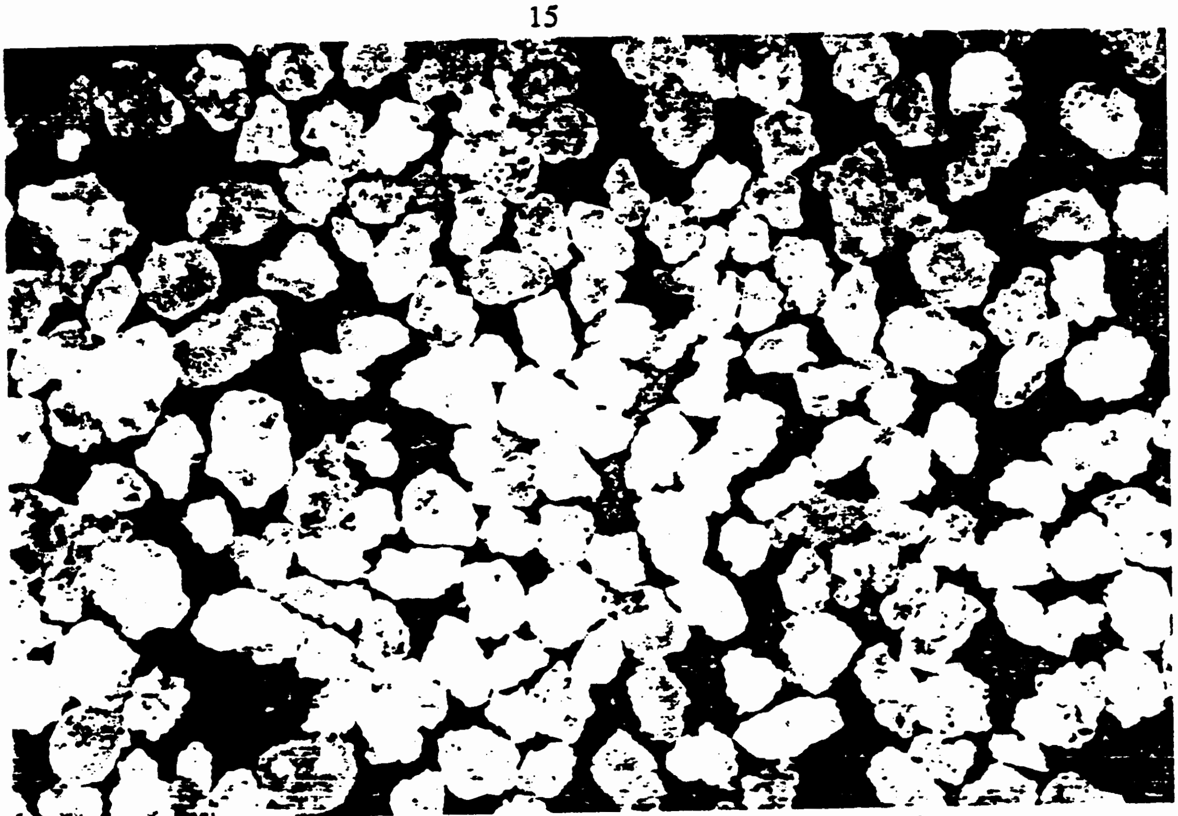


FIGURE 4. Industrial sandblasting media: 20x30 silica sand.

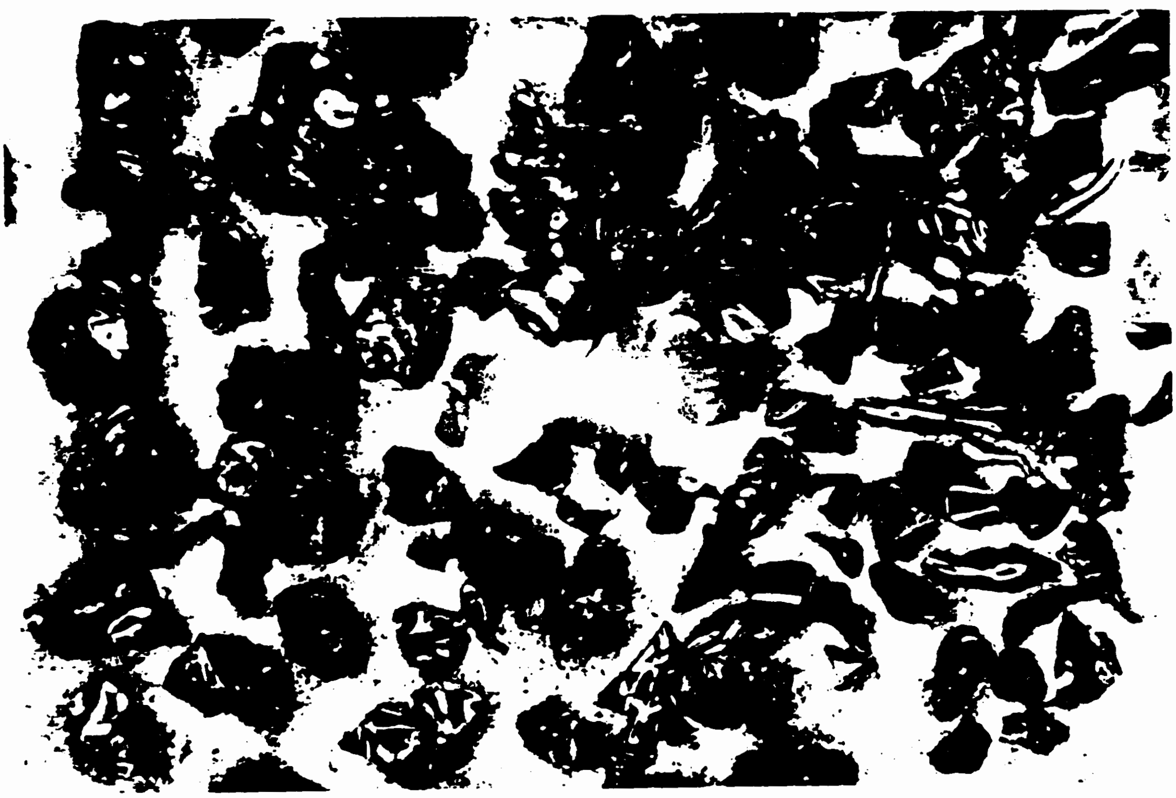


FIGURE 5. Industrial sandblasting media: copper slag.

FIGURE 6. Polestar Exploration sandblasting media: -10+18 mesh VADCO table product.

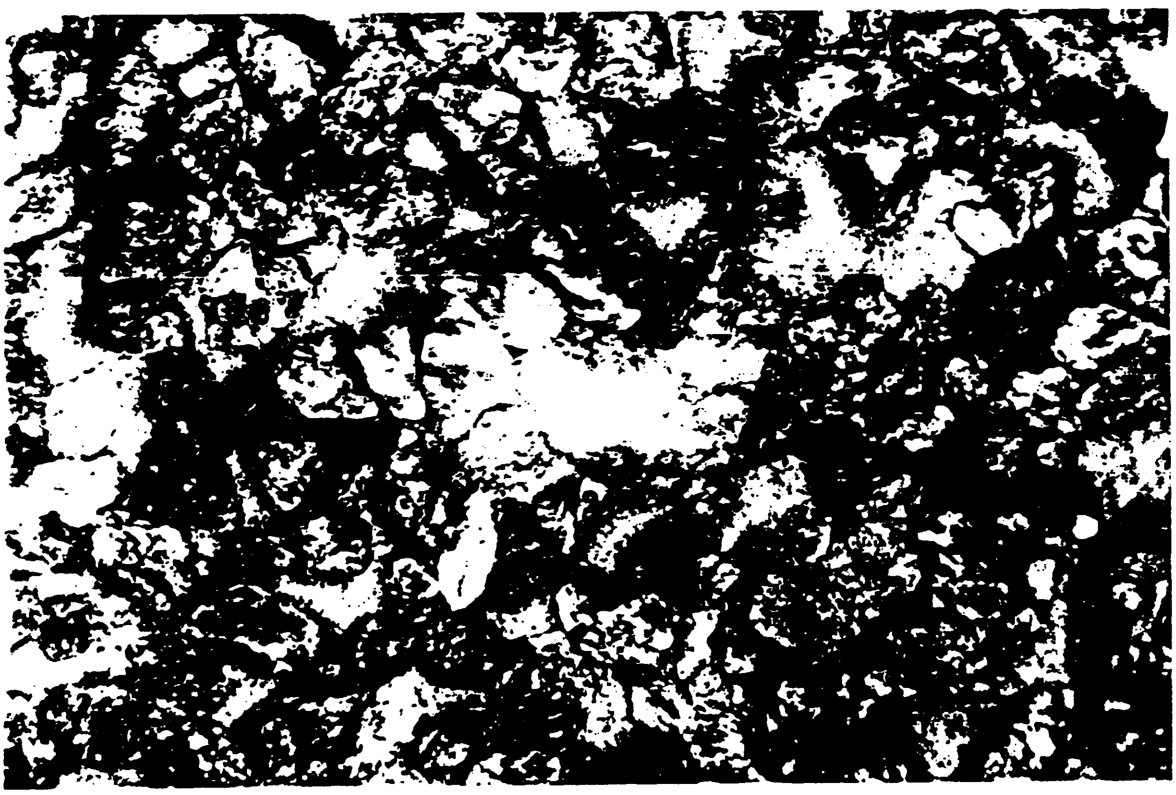


FIGURE 7. Polestar Exploration sandblasting media: -10+30 mesh brown garnet ore.

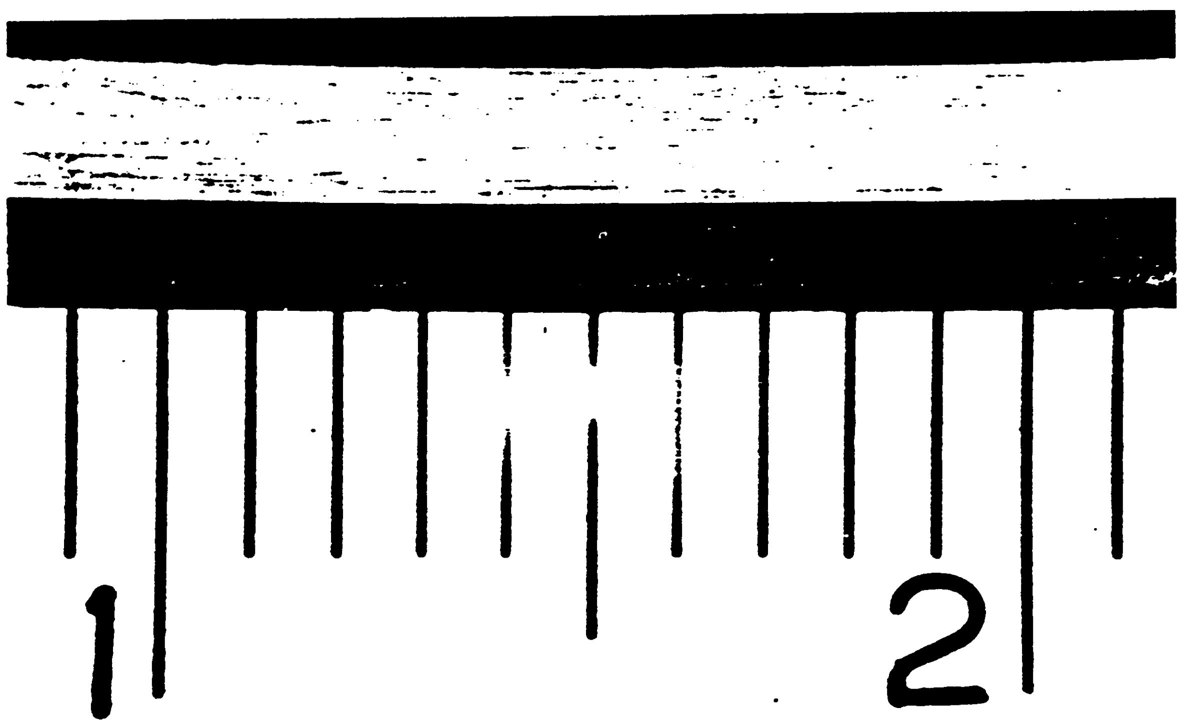


FIGURE 8. Scale for Figures 4 to 7. Each division equals 1 mm (ie, distance from "1" to "2" is 1.0 cm).

Table 3.4

Comparison of Polestar Garnet Ores

Brown Garnet Ore (Non-Sulphide)			Green Garnet Ore (Sulphide)		
-	Figure 7		-	Figure 6	
-	dark, red-brown overall colour		-	pale, green-red-brown overall colour	
-	some very dark brown-black garnet present (~10%)		-	rare dark brown-black garnet present (~2%)	
-	very clean material (no coating, very shiny)		-	dirty material (grainy white coating on almost everything)	
-	impurities: (liberated)	quartz (~1/300) calcite (~1/300) magnetite (~1/50)	-	impurities: (liberated)	quartz (~1/100) calcite (~1/100) magnetite (~1/200)
-	calcite:	- occurs as liberated grains - acid test on random garnet sample produces reaction only on <u>specific</u> grains	-	calcite:	- abundant non-visible occurrence - acid test on random garnet sample produces short, violent reaction throughput

There are some important differences between the two ores. The significance of the presence of very dark garnet in the brown sample is that this colour garnet can indicate the presence of almandine or pyrope garnet which usually have a higher hardness than the common grossular variety (usually pale green to pale brown). However, colour is not a very reliable guide to the composition of garnets and should not be used alone as a diagnostic tool.

Another important difference between the two ores in the "dirtiness" of the green garnet ore. The surface of the grains is covered with a very fine-grained white powder. This coating was not appreciably reduced by wet screening and tabling. During acid tests on the two ores the brown garnet produced a reaction only on <u>specific</u>, readily identifiable grains of calcite. Acid tests on the green garnet, however, produced short, violent reactions throughout the sample. Because of this behaviour, it was thought that the white coating on the green garnet may have been the cause of the reaction.

To further investigate the nature of the white coating on the garnet, several tests were performed:

1. 2 hour HCl test
2. 24 hour HCl test
3. 24 hour attrition test

The HCl tests involved placing 100.0 g of dry -10 +30 mesh raw garnet ore in a beaker and adding 100.0 ml of 25% hydrochloric acid. The mixture was stirred occasionally over the duration of the tests. The 24 hour test involved a solution change after 2 hours. Both tests were run in duplicate and the averaged results are shown in Table 3.5.

Table 3.5

Acid Testing of Garnet Ore

Test Duration (hrs)	Starting Dry Weight (g)	Ending Dry Weight (g)	Weight Loss %
2	100.00	96.55	3.45
24	100.00	95.40	4.60

The solutions of both the 2 hour and 24 hour tests had a distinct green colour. This was due to the dissolution of iron containing minerals: magnetite, pyrrhotite, some native iron. This is not believed to have contributed significantly to the weight loss. The bulk of the weight loss is thought to be attributable to calcite dissolution.

The surfaces of the garnet were <u>not</u> cleaned by the action of the hydrochloric acid. In fact, they looked slightly less clean than before.

The attrition test involved placing 1000.00 g of dry -10 +30 mesh raw garnet ore in a bucket and diluting it to 70% solids with water. A large propeller was used to agitate the mixture for 24 hours. After 24 hours the slurry was screened at 48 mesh with both the oversize, and undersize dried and weighed.

The results indicated a 5.0% weight loss on the feed. The surface of the garnet grains were cleaned by the inter-particle scouring action (attrition). Figures 9 and 10 show the difference between the dirty, raw garnet and the attritioned, clean garnet. Not only has the surface been cleaned, but a significant amount of rounding of the edges has also taken place. It is not known whether the full 24 hours was required to produce this effect.

As a final analysis, samples of cleaned and dirty samples were mounted side by side and submitted for scanning electron microscopy (SEM). A comparison was made between the clean and dirty areas on the surface. Figures 11 and 12 contrast the surface of a clean and dirty garnet grain at a magnification of 180X. The indicated area on the dirty grain (plus a second area, not shown) were zoomed in on for further analysis. Figures 13 and 14 show dirty areas at a magnification of 1700X. These pictures show sub-micronsized particles adhering to the surface of the garnet grain. X-ray energy dispersive analysis of the sub-micronsized grains (Appendix I) indicates them to be calcium-iron-silicates, ie, garnet.

A variety of ways to remove these adhering particles to improve the surface appearance of the garnet has been suggested. These include:

- attrition for less than 24 hours
- surface reagents (e.g., soap)
- ultrasonic cleaning

It is not known whether a clean surface would improve the end-use behaviour of a garnet ore. Clean garnet may leave less residue behind during sandblasting; a problem encountered with the green garnet during the sandblasting demonstration (however, the problem may not be attributable to the dirty coating on the garnet). Further investigation would be beneficial.

FIGURE 9. Polestar garnet ore (-10+30 mesh) before attrition test. Garnet surfaces are coated with white "powder".

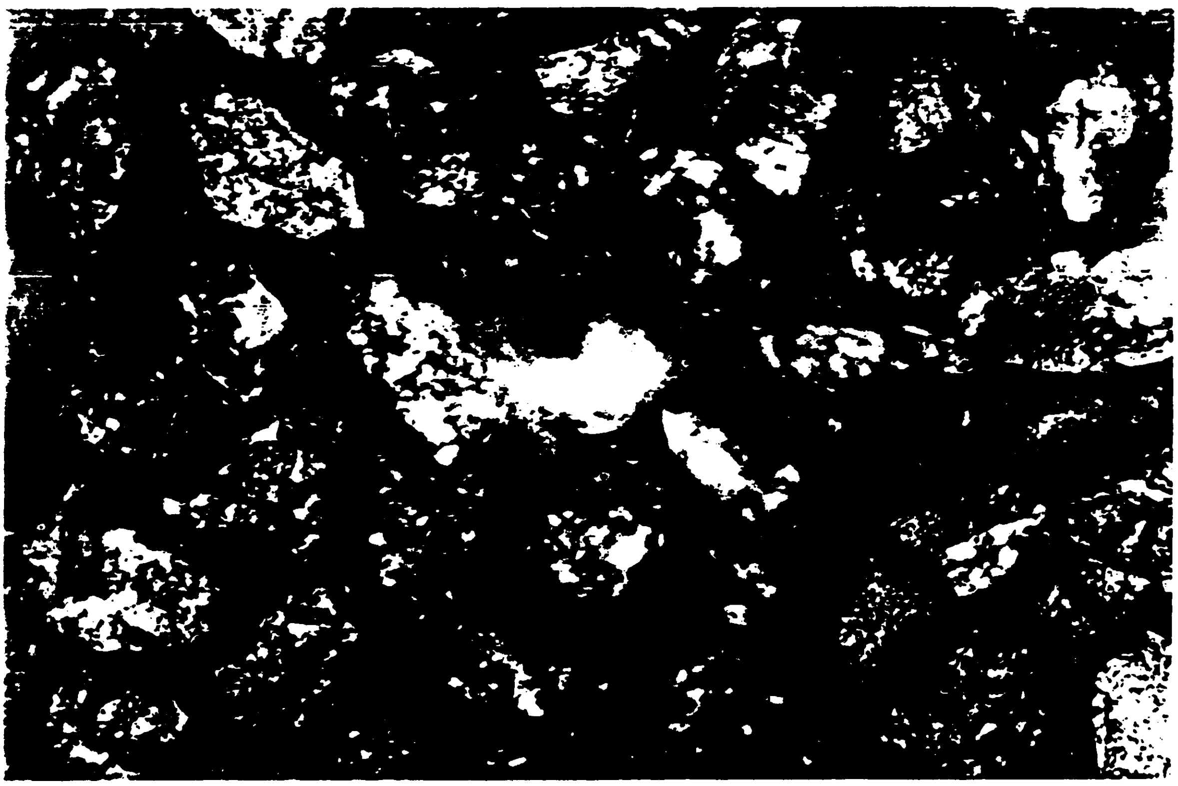


FIGURE 10. Polestar garnet ore (-10+30 mesh) after 24 hours attrition test. Garnet surfaces are clean and slightly rounded.

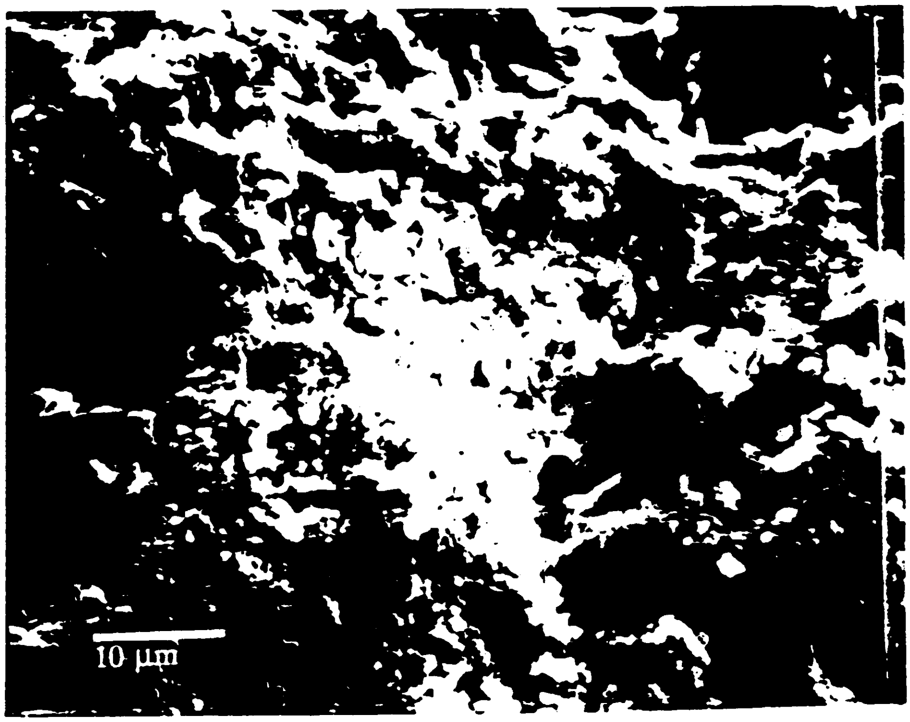


FIGURE 13. Further analysis of Area 1 in Figure 11. SEM photo of dirty area at a magnification of 1700X shows submicron-sized particles adhering to surface. Energy dispersive analysis of particles (Appendix I) identifies the particles as garnet.

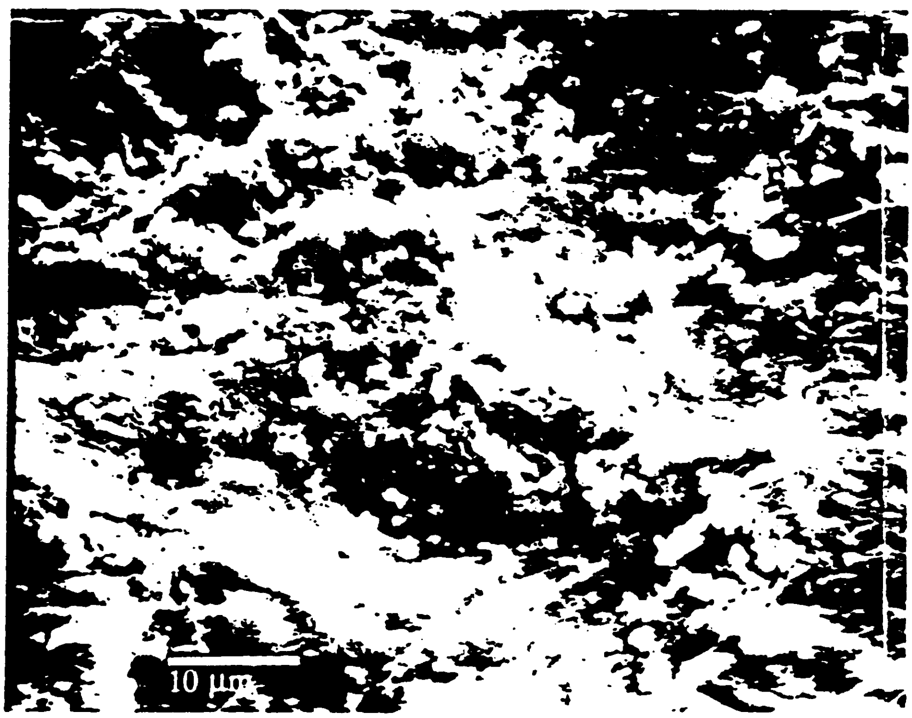


FIGURE 14. SEM photo of separate dirty area at a magnification of 1700X. Energy dispersive analysis of submicron-sized grains (Appendix I) identifies them as garnet.

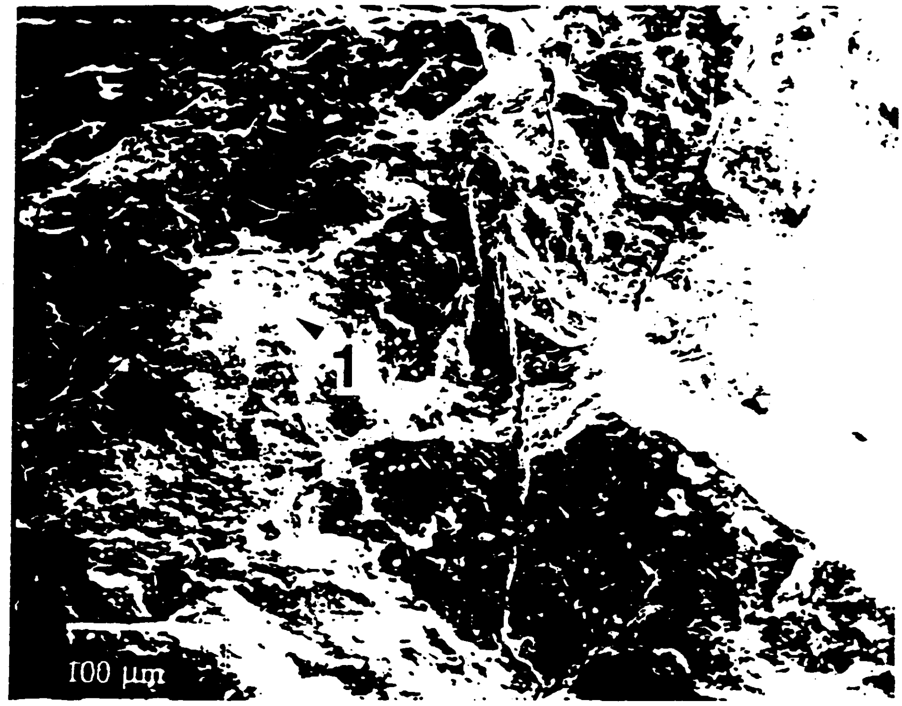


FIGURE 11. Surface of dirty garnet grain. Photo taken with scanning electron microscope at a magnification of 180X. Area 1 was zoomed in on for further analysis.

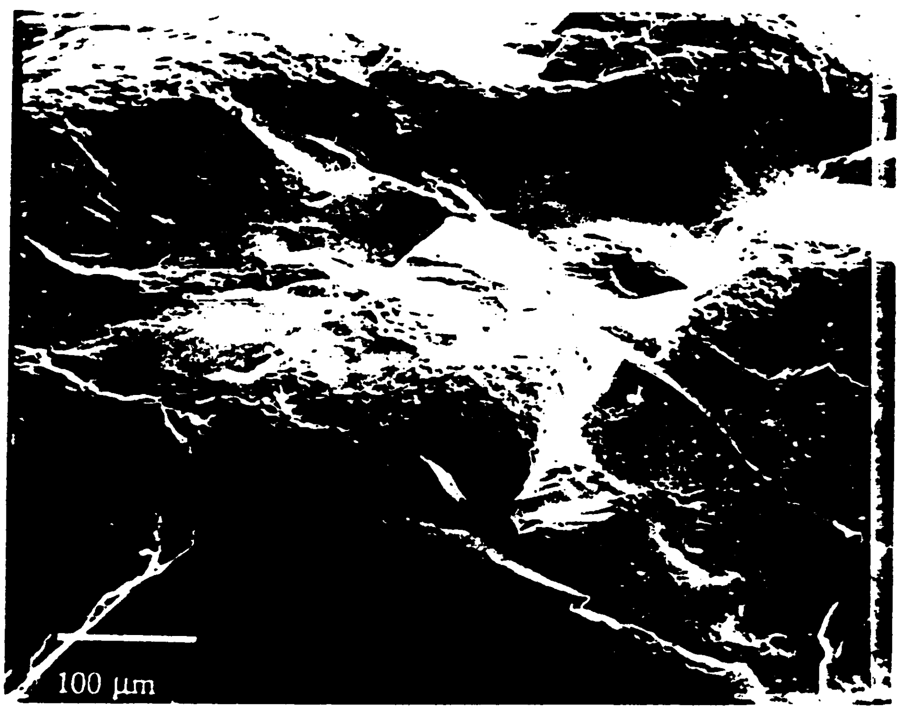


FIGURE 12. Surface of clean (attritioned) garnet grain. Photo taken with scanning electron microscope at a magnification of 180X.

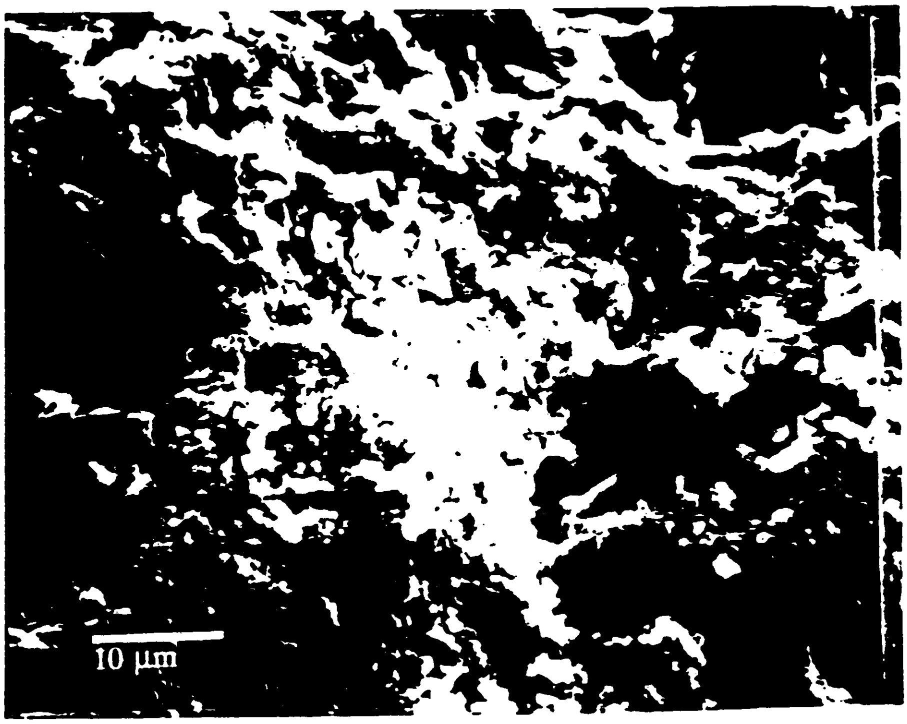


FIGURE 13. Further analysis of Area 1 in Figure 11. SEM photo of dirty area at a magnification of 1700X shows submicron-sized particles adhering to surface. Energy dispersive analysis of particles (Appendix I) identifies the particles as garnet.

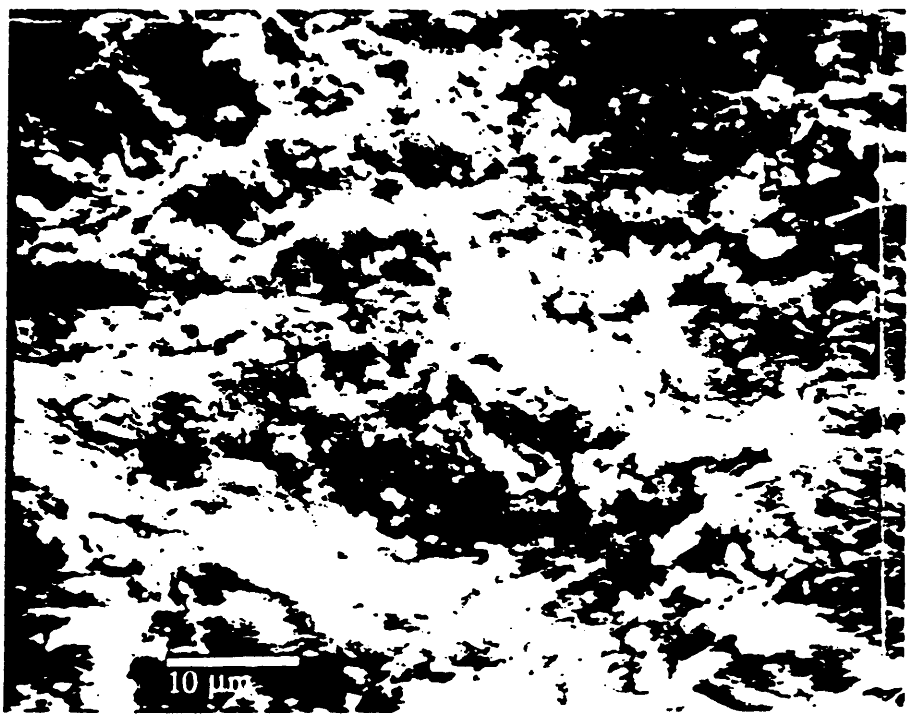


FIGURE 14. SEM photo of separate dirty area at a magnification of 1700X. Energy dispersive analysis of submicron-sized grains (Appendix I) identifies them as garnet.

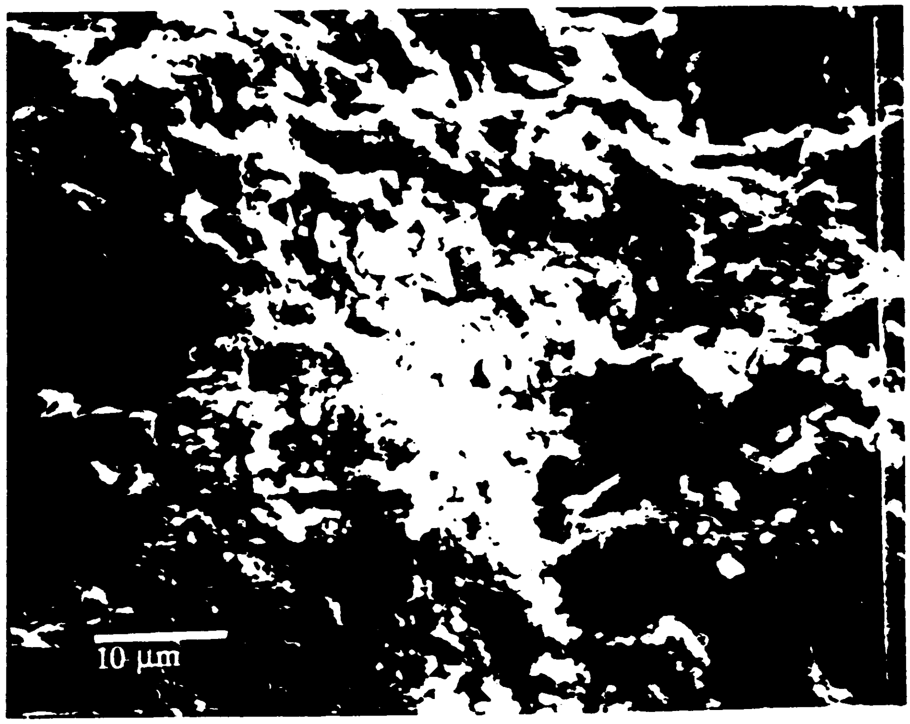


FIGURE 13. Further analysis of Area 1 in Figure 11. SEM photo of dirty area at a magnification of 1700X shows submicron-sized particles adhering to surface. Energy dispersive analysis of particles (Appendix I) identifies the particles as garnet.

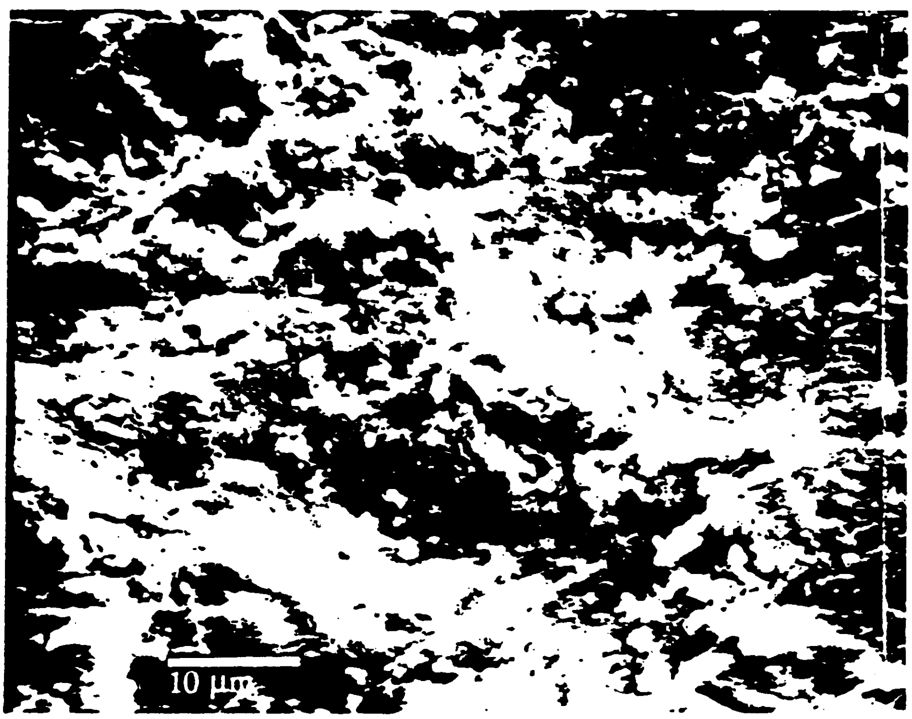
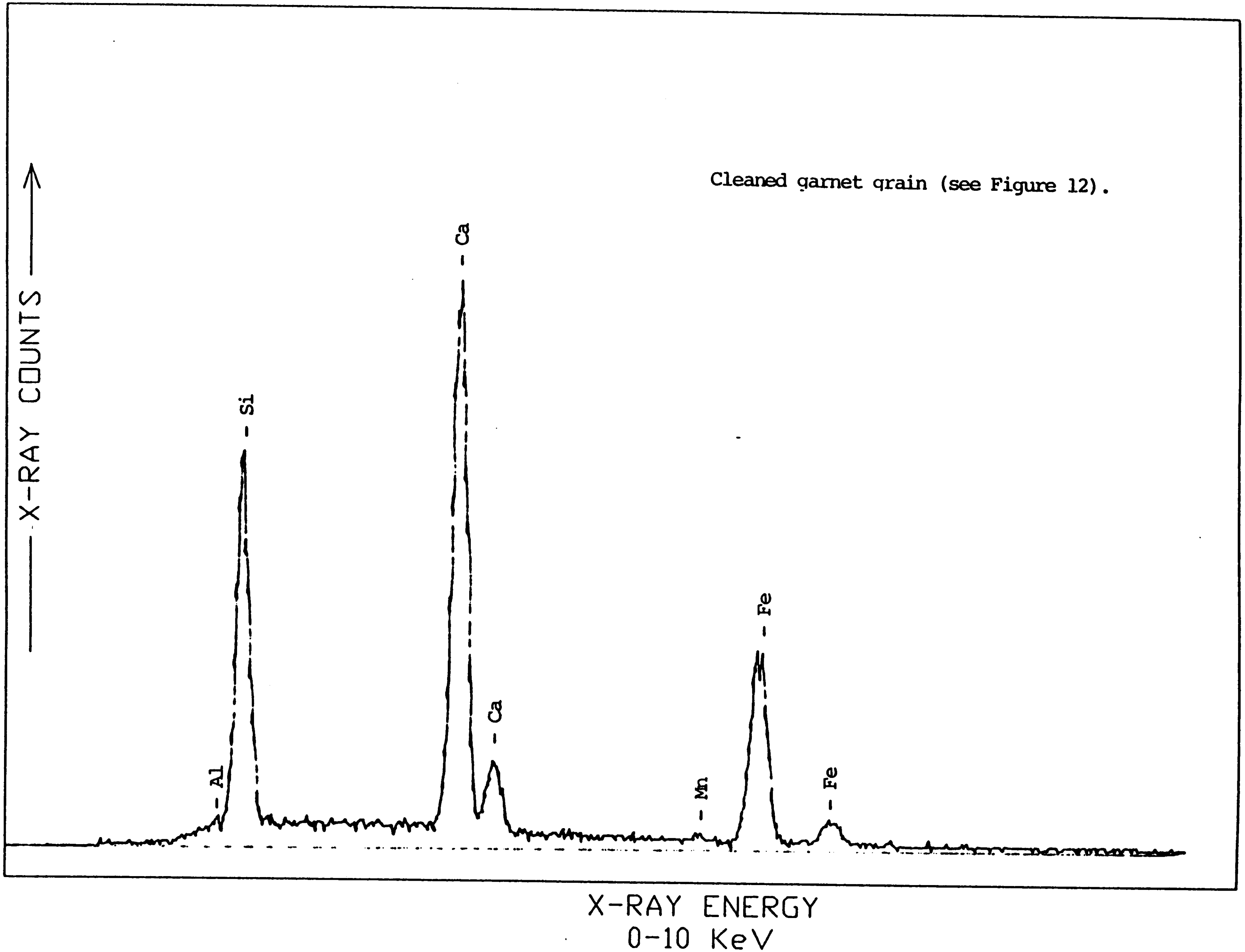
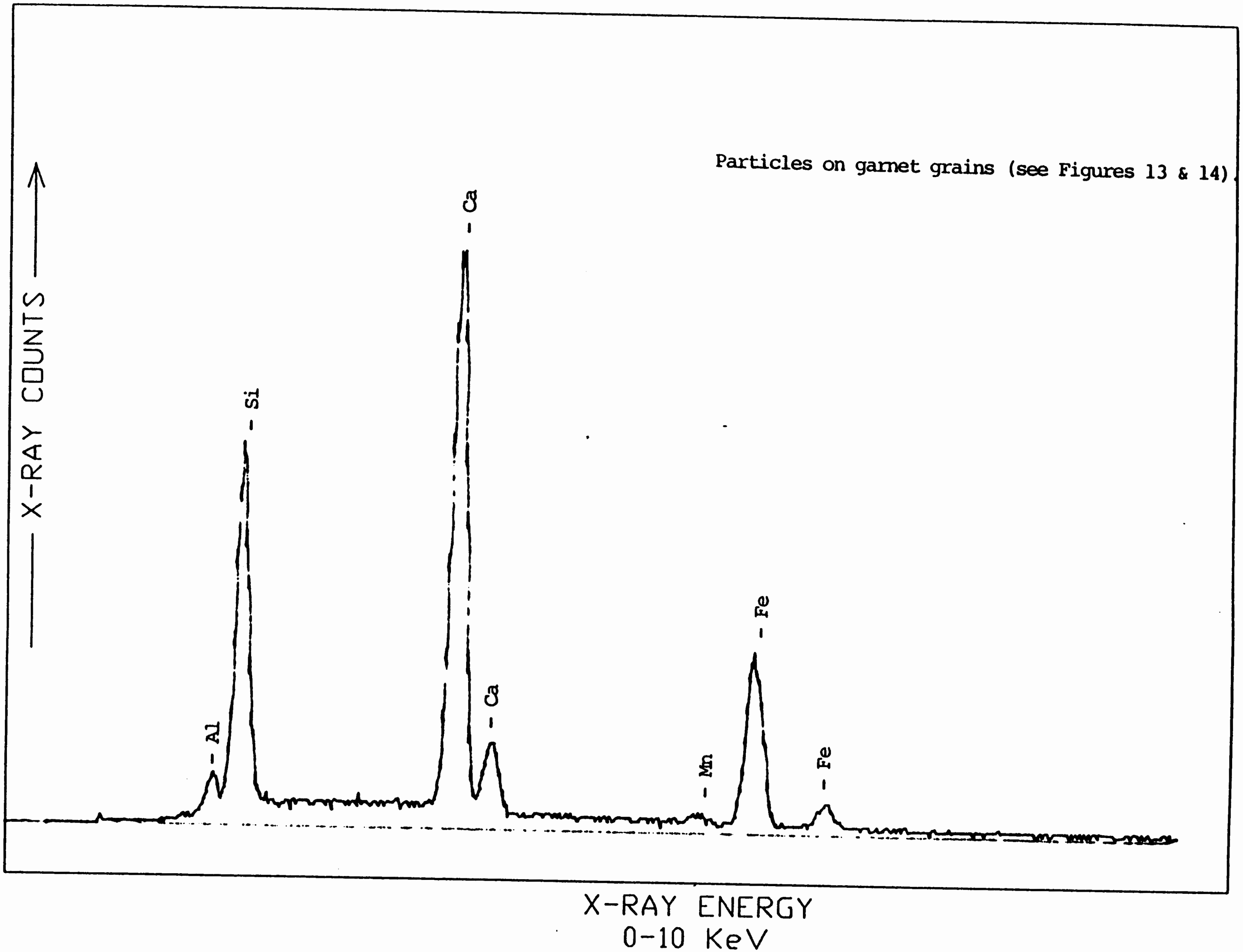


FIGURE 14. SEM photo of separate dirty area at a magnification of 1700X. Energy dispersive analysis of submicron-sized grains (Appendix I) identifies them as garnet.



Cleaned garnet grain (see Figure 12).
X-RAY COUNTS
Al
Si
Ca
Ca
Mn
Fe
Fe
X-RAY ENERGY
0-10 KeV



Particles on garnet grains (see Figures 13 & 14)
X-RAY COUNTS
Al
Si
Ca
Ca
Mn
Fe
Fe
X-RAY ENERGY
0-10 KeV

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April 17, 1989

Mr. Robert Wolfe, P.Eng. Fax: (604) 684 - 6270
Vice President
Polestar Exploration Inc.
701 - 675 West Hastings St.
Vancouver, B.C.
V6B 1N2

Dear Mr. Wolfe:

Attached is an outline of our preliminary research proposal for the Oro-Denoro orebody. The approximate cost of this work, including the University's 65% overhead charge, is $58,000.

We are currently submitting a detailed budget plan to UBC's Office of Research and Technology. Until the budget and work plan are approved by ORT, they must be considered preliminary. We will send you the detailed budget information as soon as possible and we apologize for the delay in getting this information to you. If you have any questions or comments regarding the attached work plan, please feel free to call either Andy Mular or myself.

I am forwarding a second copy of this proposal by courier this afternoon.

Yours truly,

B.L. Street
Research Engineer

/ml

Enclosure

ws2:bls.004

PRELIMINARY RESEARCH PROPOSAL FOR POLESTAR EXPLORATIONS' ORO-DENORO GARNET DEPOSIT
APRIL, 1989

PURPOSE

This work will aid in designing a processing flowsheet for the Oro-Denoro garnet orebody. Emphasis is on maximizing the tonnage of coarse (16M X 50M) garnet concentrate produced, while ensuring maximum recovery of sulfides in a separate concentrate. The work is divided into the following parts:

A. Liberation studies to determine the effect of crushing procedure on free garnet recovery

B. Coarse (+50M) Ore Treatment:
   - Gravity separation to remove non-sulfide gangue
   - Magnetite removal
   - Production of sulfide concentrates

C. Fine (-50M) Ore Treatment:
   - Magnetite removal
   - Physical treatment methods to produce a sulfide concentrate
   - Froth flotation to produce a sulfide concentrate

Flowsheet design has not been included in this proposal. If Polestar Explorations elects to have UBC design the process flowsheet, design costs will be estimated at that time.

SAMPLE SELECTION

The Oro-Denoro orebody is a skarn deposit into which hydrothermal fluids have deposited calcite and sulfides. Feasibility studies show that the cut-off between mineralized (ie sulfide containing) and barren skarn (ie containing garnet but no sulfides) is sharp. Feasibility studies indicate the following tonnages:

Ore (diluted) - 0.95% Cu, 0.02 oz/ton Au, 0.3 Oz/ton Ag	1.49 Million tons
Low Grade - 0.33% Cu	0.25 Million tons
Barren Skarn	3.45 Million tons
TOTAL	5.19 Million tons

For this testwork, a composite feed sample will be required, using ore from several different locations within the deposit. The objective in selecting subsample locations is to represent the three types of rock listed above - ore, low grade, and barren skarn - in the same proportions as they occur in the orebody. Accordingly, the following subsamples will be requested:

	Location	Weight of Sample	Nearest Vertical Drill Hole (Ref. Only)
ORE			
1.	5700W, 4300S, 3500 Elev.	20 kg.	WC - 26A
2.	5650W, 4300S, 3500 Elev.	20 kg.	WC - 26A
3.	5600W, 4250S, 3500 Elev.	20 kg.	F - 34
4	5500W, 4500S, 3600 Elev.	20 kg.	T - 6
5.	5500W, 4400S, 3500 Elev.	20 kg.	F - 8
6.	5400W, 4500S, 3400 Elev.	20 kg.	F - 2
LOW GRADE			
1.	5700W, 4400S, 3550 Elev.	20 kg.	F - 17
BARREN SKARN			
1.	5700W, 4500S, 3500 Elev.	20 kg.	F - 16
2.	5700W, 4200S, 3600 Elev.	20 kg.	F - 18
3.	5650W, 4500S, 3500 Elev.	20 kg.	F - 16
4.	5650W, 4300S, 3450 Elev.	20 kg.	F - 33
5.	5600W, 4400S, 3500 Elev.	20 kg.	F - 12
6.	5550W, 4500S, 3600 Elev.	20 kg.	F - 27
7.	5550W, 4300S, 3400 Elev.	20 kg.	F - 13
8.	5550W, 4400S, 3650 Elev.	20 kg.	F - 12
9.	5500W, 4300S, 3400 Elev.	20 kg.	F - 9
10.	5450W, 4500S, 3500 Elev.	20 kg.	F - 7
11.	5400W, 4400S, 3500 Elev.	20 kg.	F - 3
12.	5400W, 4250S, 3400 Elev.	20 kg.	F - 4
13.	5350W, 4250S, 3500 Elev.	20 kg.	-
14.	5300W, 4300S, 3500 Elev.	20 kg.	-
	TOTAL WEIGHT	420 KG.	

These subsamples will be jaw crushed and blended together to form the feedstock for the testing program.

PLAN OF WORK

PRELIMINARY WORK

Feed Preparation - crush all feed by jaw crusher to -1/2 inch.
- blend crushed product and divide into sublots of approximately 40 - 50 kg each. Assay for Cu, S, Fe, Mg, Ca, Si, Au and Ag to establish uniformity of sublots.

A. LIBERATION STUDIES

Roll Crushing - Crush two 40 kg. lots of feed in a roll crusher, one to a top size of 12M, the other to a top size of 16M.

For each lot:

- Wet screen product at 50M. Retain -50M for Part C. (Fine Ore Treatment)
- Screen the +50M material into the following size fractions:

  12M X 16M (coarser sample only)
  16M X 20
  20M X 30M
  30M X 40M
  40M X 50M

- assay each size fraction for Cu and S.
- split out 4000 gm of each size fraction and clean as follows:
  a) sink-float separation at S.G. 3.0 to remove non-sulfide gangue
  b) magnetic separation to remove magnetite
  c) electrostatic OR whims separation to remove sulfides
- record product assays and weights at each step. Check final concentrate microscopically to be sure it is mostly garnet/epidote/diopside. Calculate garnet and sulfide distributions.
- re-crush rejects of each size fraction as shown below. Repeat above tests on re-crushed material. Repeat cycle until all material is -40M

Top size of fraction	Top size after re-crushing
12M	20M
16M	30M
20M	40M
30M	40M
40M	not re-crushed (discarded to tails)

- Perform metallurgical balance on data. Calculate overall free garnet recovery and recovery vs. size. Assess the effects of crushing procedure on garnet recovery and sulfide distribution, and choose the crusher top size (12M or 16M) for use in all remaining tests.

B. COARSE (+50M) ORE TREATMENT

Objectives are:

- to find the best method of recovering garnet while rejecting non-sulfide gangue.
- to separate contained sulfides from the garnet concentrate. Because previous testwork by other firms has indicated that gravity separation will not remove sulfides from the garnet, investigation will focus on other methods of sulfide removal.
- to remove any contained sulfides from the light mineral tailings.

Issues to be investigated are:

- jigging vs tabling for the coarsest size ranges
- effect of processing closely sized vs unsized feed.
- possible use of spirals (on sized and unsized feed).
- use of electrostatic and wet high intensity magnetic (WHIMS) separation for sulfide recovery

Jigging/Tabling

- Roll crush 100 kg of ore to the top size determined in Part A.
- Wet screen at 50M (Keep -50M material for Part C)
- Take a subsample of +50M and table it. Assay for Cu and S. Estimate garnet content.
- Screen the remaining +50M feed into the size fractions used in Part A.
- Jig/Table the size fractions. Assay products and estimate garnet content.
- Compare the results of jigging vs tabling, sized vs unsized material.

Spiral Treatment - Repeat procedures for Jigging/tabling test, using a spiral separator. Assess the relative efficiency of spirals vs jigs/tables, and the effect of sized vs unsized feed.

Sulfide Recovery from Tailings - Assay the tailings streams from spiral treatment and Jigging/tabling. Determine whether or not sulfide losses warrant retreatment of the tails. If treatment is indicated, consider electrostatic (dry) and WHIMS (wet) tests as required.

Sulfide Recovery from Garnet Concentrate - combine garnet concentrates obtained in the above tests and split into 5 lots. Test the following methods of sulfide recovery:

Electrostatic:

- treat one lot (unsized) in the Carpco electrostatic separator. Make rougher and scavenger passes, then combine the products and make one cleaner pass. Assay and calculate recoveries.
- size the second lot as per Part A. Subject the sized samples to electrostatic separation as above.
- treat the third and fourth lots as per lots one and two above, only in a free-fall type electrostatic separator.
- compare the results of electrostatic tests.
- decide whether sulfide losses to electrostatic separator tails are sufficient to merit further treatment of the tails. (For details, see item C)

Wet High Intensity Magnetic Separation (WHIMS)

- Treat one lot of the garnet concentrate in a wet high intensity magnetic separator and assess sulfide recovery.

Retain all sulfide concentrates for use in Part C.

C. FINE (-50) ORE TREATMENT

The object is to recover a sulfide concentrate from the -50M fines, using a dry separation method if possible. Feed will be the -50M material collected in Parts A and B, blended together and divided into 4000gm sublots.

Electrostatic Separation

- screen one sublot of feed into 50 X 100M, 100 X 150M, and -150M fractions.
- assay -150M fraction to determine sulfide losses.
- perform electrostatic separation on 50 X 100M and 100 X 150M fractions, using rougher, scavenger, and cleaner passes.
- assay products and evaluate.

- perform electrostatic separation as above on one sublot of 50 X 150M sample and one sublot of 50 X 0M sample. Evaluate and compare results.

Wet High Intensity Magnetic Separation (WHIMS)

- Treat one sublot of feed in the wet high intensity magnetic separator and evaluate results.

Flotation

- Using 2000 gm sublots of unsized -50M feed, perform 5 flotation tests under a variety of conditions (Feed % solids, reagent dosage, condition time). Assay and calculate recoveries.

Grinding and Retreatment of Coarse Tails to Recover Sulfides

- if the coarse tailings (calcite/quartz) show significant sulfide content, wet gring the tailings to -100M.
- Test one lot of ground tailings via froth flotation and one lot via WHIMS, and assess sulfide recoveries.

Mineralogical Characterization of Sulfide Concentrates

- select several sulfide concentrates from the preceding tests and characterize via scanning electron microprobe. Analyse distribution of gold and silver throughout the sulfides.

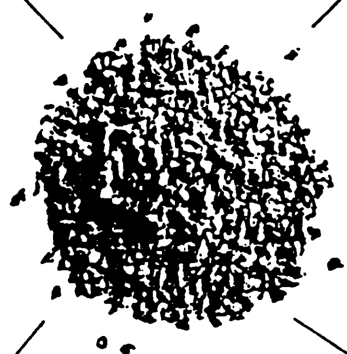
TAKE A CLOSER LOOK AT IGE GARNET

NON TOXIC

You might be using boiler or mineral slag now but health, environmental and disposal problems make **IGE GARNET** abrasive the medium of choice. Plus **IGE GARNET** cuts up to 3 times faster than slag.

SAVES MONEY

IGE GARNET cutting and blasting crystals will not round over like aluminum oxide or steel grit. This dramatically increases productivity and recyclability.



NO FREE SILICA

When it comes to silicas there simply is no longer a choice. You know the health risks, what you may not know, is that **IGE GARNET** blasting mediums out perform silica sands in all categories.

REDUCES LABOR

Get silicon carbide performance without the exorbitant cost. **IGE GARNET saves contractors up to 75%.**

UNIVERSAL APPLICATION

IGE GARNET is available in grits fine enough to polish titanium parts and coarse enough to blast off heavy epoxy effortlessly. **Shown here is 16 grit actual size.**

DOESN'T PEEN

Steel shot is fine for peening but **IGE GARNET** gives you the cutting edge.

CUTS FASTER AND RECYCLES

Unlike glass beads or staurolite **IGE GARNET** is specially processed to yield a constantly sharp angular grain. **IGE GARNET** provides optimum cutting the first time and every time.

Your business is blasting and finishing — our business is to help you do it quicker, safer and more economically.

IGE GARNET

INDUSTRIAL GARNET EXTRACTIVES INC. · WORLD · IGE

Miners and Manufacturers of Natural Garnet for Industry

Call Toll Free: **1-800-443-6463**

In Maine Call **(207) 674-2989**

Industrial Garnet Extractives Inc. P.O. Box 56 West Paris, Maine 04289

Some Points To Consider

Versatility In Abrasive Cleaning/Finishing...

- Coarse grains provide deep cutting action.
- Medium grains facilitate removal of burrs, flash and scale.
- Fine grains permit polishing with very little stock removal.
- For surface treatment of steel, non-ferrous metals and alloys, wood, plastic, silicon wafers and chips, even leather.
- Allows a full range of profile depths and anchor patterns.

Environmental Factors...

- No free silica—chemically inert.
- Minimal dusting and residue—superior to mineral slags and silica sands; costly cleanup after blast finishing often eliminated.

Cost Benefits...

- Low breakdown rate: extreme hardness and structural tenacity permit multiple blast cycles.
- High specific gravity (4.0): greater impact force with 15-20% less air pressure for energy savings. Try 80-90 PSI.
- Low initial cost: compared with expensive energy-intensive manufactured abrasives.
- Excellent cleaning rates: savings in labor, overhead and other process-based costs.

EMERALD CREEK garnet is the most environmentally-safe, cost-effective natural abrasive available for pressure blasting. And the right choice for your application.

Technical Data and Chemical Composition

Emerald Creek Garnet

- Type Almandite
- Chemical Composition $Fe_3Al_2(SiO_4)_3$ with Mg and Mn in partial substitution for Fe
- Description Almandite garnet is the iron-rich endmember of the garnet solid solution series As garnet is a homogeneous mineral, there are no free chemicals
- Approximate Chemical Analysis

		Average Oxide
Silicon Dioxide	SiO_2	21 83%
Ferric Oxide	Fe_2O_3	43 83%
Aluminum Oxide	Al_2O_3	25 20%
Manganese Dioxide	MnO_2	3 0 %
Magnesium Oxide	M,O	4 27%
Calcium Oxide	CaO	69%

- Crystal System Cubic
- Habit Dodecahedrons with occasional trapezohedrons
- Hardness 7 5 on Mohs Scale
- Specific Gravity 4 0
- Durability Very Good
- Fracture Sub-conchoidal
- Susceptibility to Acid None
- Moisture Absorption Inert (none)
- Magnetism Very slightly magnetic
- Pathological Effects None
- Free Silica Content None

DISTRIBUTED BY:

MYERS

Myers Metals & Minerals, Inc.
459 Colman Building, Seattle, WA 98104
206/622-2278, TELEX: 75-9030
FAX 206/682-8829

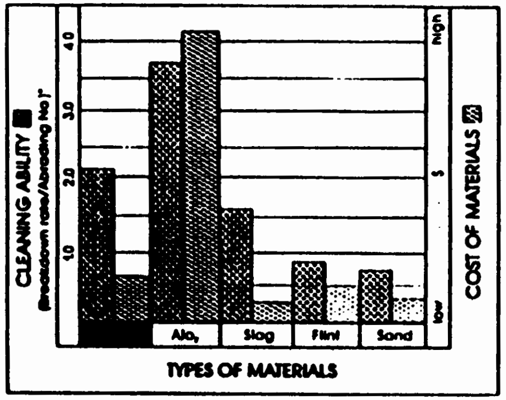
GARNET

The abrasive with GRIT

The Cost-Effective, Environmentally-Safe Blast Abrasive... Almandite Garnet for Highest Productivity.

MYERS

Myers Metals & Minerals, Inc.



*National Association of Corrosion Engineers

Garnet used in blast cabinets can be recycled 8 to 9 times.

Using Almandite Garnet In Pressure Blasting And In Jet Cutting

Garnet sand is an ideal medium for blast room operations with a recovery system. Why?

Cost effectiveness, for one good reason. Garnet's low breakdown rate encourages use in multiple blast cycles—over and over again—after a low initial cost. Sharp-edged angular shape and high specific gravity add up to faster cutting, for reduced operational expense. That's *real* cost effectiveness, compared with other natural abrasives.

Garnet's environmentally safe, too. There's less dust, meaning minimal surface residue. And this is one abrasive which *contains no free silica*. In fact, garnet (a homogenous mineral) contains no free chemicals. That's safety, when and where it counts.

Almandite garnet is *the* fastest cutting, hardest garnet on the market. Time is money when using sophisticated, high cost high pressure jet cutting systems. Our JET CUT brand is the answer. Expect high productivity with almandite garnet.

The Choice Is Yours

Product Grade	U.S. Standard Screen	Metric Equivalent	Size Distribution % Retained
8	6	3.35mm	6.9
	8	2.36mm	75.5
	10	2.00mm	15.8
	12	1.70mm	1.8
8/12	8	2.36mm	3.0
	10	2.00mm	25.4
	12	1.70mm	45.5
	14	1.40mm	22.2
	16	1.18mm	3.8
12	6	3.35mm	.8
	8	2.36mm	17.2
	10	2.00mm	20.3
	12	1.70mm	37.6
	14	1.40mm	22.3
	18	1.00mm	1.7
	(Pan)		
16	12	1.70mm	1.9
	14	1.40mm	26.5
	16	1.18mm	52.7
	18	1.00mm	17.1
	20	850µm	1.9
	30	600µm	.2
25	12	1.70mm	2.4
	14	1.40mm	14.1
	16	1.18mm	26.9
	18	1.00mm	20.2
	20	850µm	17.0
	30	600µm	17.3
	40	425µm	2.0
36	16	1.18mm	0.0
	18	1.00mm	8.9
	20	850µm	26.2
	30	600µm	58.5
	40	425µm	5.8
	(Pan)		.6
30/40	20	850µm	.1
	25	710µm	.2
	30	600µm	8.6
	35	500µm	25.4
	40	425µm	36.5
	45	355µm	22.5
	50	300µm	5.5
	60	250µm	1.1
	(Pan)		.1
50+	30	600µm	2.0
	35	500µm	13.9
	40	425µm	29.8
	45	355µm	23.0
	50	300µm	14.0
	60	250µm	12.3
	70	212µm	3.5
	80	180µm	.2
60	40	425µm	0
	50	300µm	54.1
	60	250µm	38.0
	80	180µm	7.8
	100	150µm	.1
60/80	40	425µm	0
	50	300µm	31.0
	60	250µm	37.1
	80	180µm	28.2
	100	150µm	2.9
80	50	300µm	1.2
	60	250µm	25.2
	80	180µm	64.4
	100	150µm	7.8
	(Pan)		1.8
100	80	180µm	19.1
	100	150µm	41.8
	120	125µm	23.3
	140	106µm	13.2
	200	75µm	2.2
	(Pan)		.4
150	100	150µm	.4
	140	106µm	20.3
	200	75µm	53.9
	230	63µm	7.7
	(Pan)		17.7
250	200	75µm	0
	230	63µm	.1
	325	45µm	76.4
	(Pan)		23.5

Other sizes available upon request.

NOTE: These specifications are approximate and subject to change and variation due to the changing nature of the natural garnet deposits and due to processing procedures. For critical applications, please consult with us for current specifications or for special requirements.

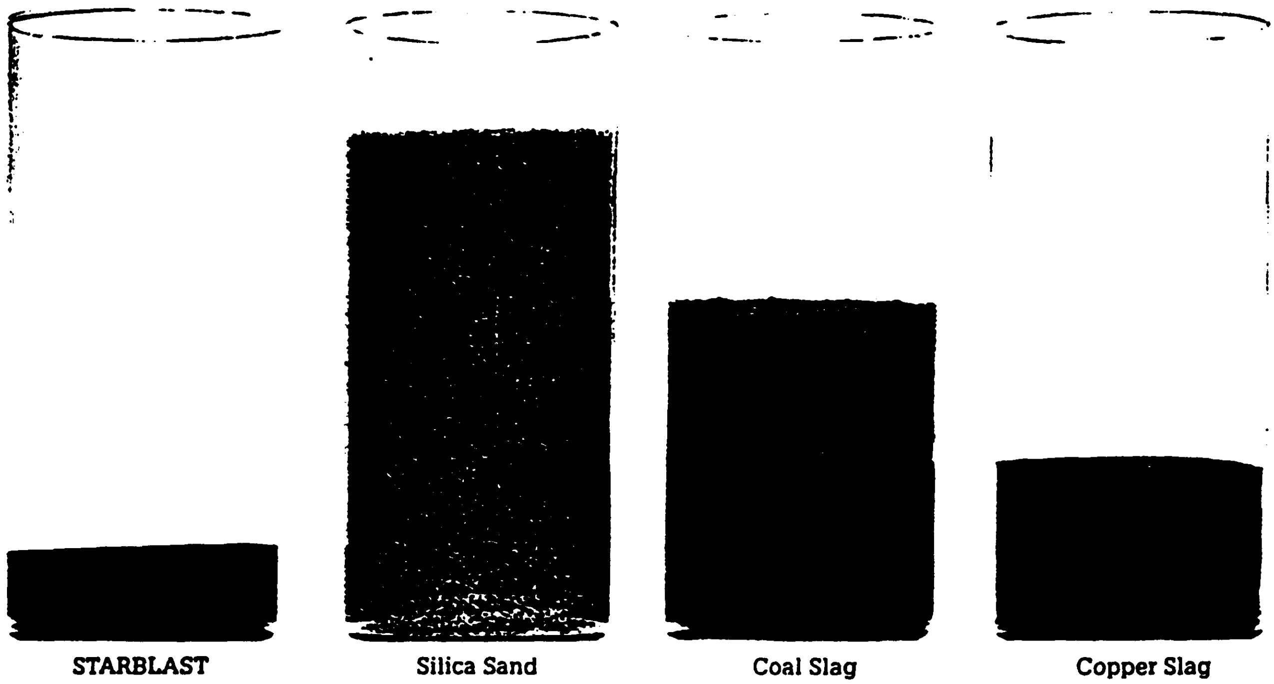
MYERS Is Your Source For Almandite Garnet

MYERS is the sales representative for EMERALD CREEK GARNET, serving domestic and international users. We have stocking distributors in various locations, maintaining inventories to provide year-round deliveries.

Standard packaging is in 100-pound, multi-wall sacks with 40 sacks (4,000 pounds) per pallet. Bulk packaging is also available in Super Sacks, steel drums and pallet boxes.

Most sizes are available from inventory stock, for shipment by truck or rail, from the mine/mill facility. We take pride, however, in producing special grades in all ranges—especially the coarser sizes, for high-profile requirements—to meet your most demanding specifications.

It takes less STARBLAST* to get the job done.



Compared to STARBLAST, more than 6 times as much silica sand, almost 4 times as much coal slag, and more than 2 times as much copper slag are needed to clean the same area of metal to a near-white finish

STARBLAST* will save you money while outperforming other abrasives

Cleans faster
STARBLAST is hard, fine, clean and dense, so it can greatly reduce blasting time when cleaning mill scale, rusted surfaces or brittle paints.

Less material needed
STARBLAST requires a much leaner abrasive/air mixture to clean the same size area as other abrasives. Pound for pound, you use less STARBLAST per square foot on most surfaces.

Low dust generation means increased productivity
Increase continuous blasting time by reducing the need to clear the air of excessive dust. Improved visibility also means fewer interruptions and less rework.

Reduces cleanup & disposal costs
You use less STARBLAST to get the job done, greatly reducing abrasive cleanup time.

Improves margin of safety
STARBLAST'S low dusting and low free silica content result in airborne respirable dust and respirable free silica levels that are up to 25 to 30 times below applicable OSHA standards.

Reduces handling costs
Thanks to its high bulk density, more STARBLAST can be loaded into your hoppers and blasting pots.

Reduces equipment replacement costs
STARBLAST granules are rounded and uniformly sized, unlike sharp-edged abrasives which cause excessive wear on nozzles, hoses and whips. With STARBLAST, you can reduce equipment repair and replacement costs.

Cleans better
STARBLAST produces a superior white metal finish, free from dust, oily residue and free iron. With STARBLAST there is minimum abrasive imbedment.

Stores conveniently
You can store STARBLAST close to the job site; there's no need for heated storage because STARBLAST is not hygroscopic.

Recycles better
STARBLAST is very economical on a single-use basis. To further reduce costs, it can be recycled as many as 4 to 6 times–making it even cheaper to use than less expensive single-use abrasives.

**STARBLAST is made only by Du Pont*

What is STARBLAST ?

STARBLAST abrasive is a premium loose abrasive made from a blend of course and fine staurolite mineral grains mined from Du Pont's Starke, Florida, heavy mineral deposits. The material is scrubbed and chemically washed to ensure freedom from dirt, dust and ultrafines. Staurolite grains are uniformly sized and have clean rounded surfaces.

How to use STARBLAST

STARBLAST will work in all air-blast equipment designed for loose abrasives, generally at a much leaner abrasive/air mixture. In general, it's better to feed too little STARBLAST than too much. To adjust, start blasting with abrasive feed closed. Open abrasive valve until the stream is just visible, then back off slightly so the stream is no longer visable.

With any abrasive, good blasting practice is essential if maximum value in use is to be achieved.

STARBLAST cannot be expected to compensate for deficiencies in air supply, hoses, nozzles, etc. But STARBLAST can make a good blast operation even better.

Where to use STARBLAST

STARBLAST has been found especially valuable in the steel fabricating industry for removing mill scale and rust from steel. Also, paints of all types have been removed effectively by STARBLAST, but performance decreases on more resilient paint films. STARBLAST provides excellent feather-edging, precisely controlled cutting and confined spot preparation.

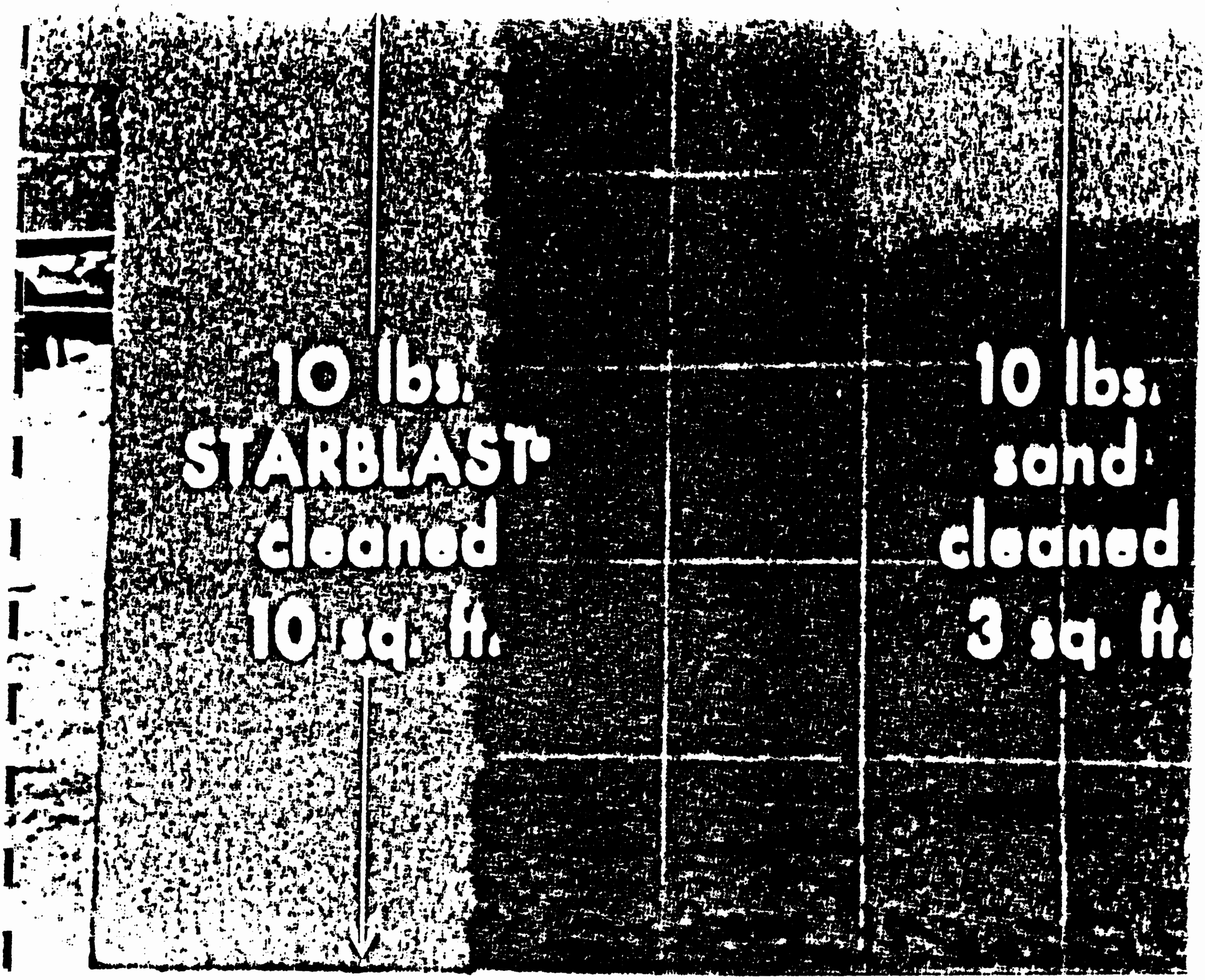
When blasting metal, STARBLAST shows superior advantage for producing the white metal finish (free of residue or embedding) so difficult to get with other abrasives. You can also achieve near white, commercial, or brush off finishes by working faster or using a greater nozzle-to-work distance.

STARBLAST vs. sand

Dense, rounded and uniformly sized granules of STARBLAST (left) actually "knock off" mill scale unlike angular sand which cuts it off. The result is a smoother, cleaner surface which increases paint adherence and requires less paint to get the job done within specifications. Smoother granules also mean reduced blasting equipment wear and replacement cost.

STARBLAST

Silica Sand



STARBLAST® gives you superior value-in-use to increase your profitability

In tests against silica sand, STARBLAST reduces costs by more than 30%!
In documented test results, STARBLAST abrasive cleaned more than 3 times as much mill scale-bearing steel to a near white finish as the same amount of silica sand. The cost comparison table below shows that although the initial cost of STARBLAST is equal to sand, the total cost savings on equipment and labor make STARBLAST a real money saver. These data are based on cleaning to a near white metal versus the data in the "Controlled Comparison Tests Booklet" blasting to a white metal finish

Costs/SQ. FT.

	Material	Equipment	Labor	TOTAL
STARBLAST	5.0¢	4.1¢	2.5¢	11.6¢
Silica sand	5.0¢	7.8¢	4.7¢	17.5¢

Basis: Bagged STARBLAST $100/ton delivered
Bagged sand $[illegible] ton delivered

Du Pont will give you the name of your nearest STARBLAST distribu who will show you firsthand how you can really BLAST OFF to increased savings with STARBLA

For fast STARBLAST action
1-800-527-2601

UMPTIONS FOR FINANCIAL PROJECTIONS - YEAR 1

		1	2	3	4	5	6	7	8	9	10	11		
		---	---	---	---	---	---	---	---	---	---	---		
	ORE MINED(000's)	0	0	0	0	0	0	0	0	0	0	0		
LDS (NET RECOVERABLE)	GARNET	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%	80.00%		
	WASTE	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%	17.50%		
	COPPER	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%	0.72%		
		------	------	------	------	------	------	------	------	------	------	------		
		98.22%	98.22%	98.22%	98.22%	98.22%	98.22%	98.22%	98.22%	98.22%	98.22%	98.22%		
		------	------	------	------	------	------	------	------	------	------	------		
	GOLD (OUNCES/TON)	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010		
	SILVER(OUNCES/TON)	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100		
st Year of Operation														
oduction volume	GARNET	0	0	0	0	0	0	0	0	0	0	0		
00'S)	GOLD	0	0	0	0	0	0	0	0	0	0	0		
	SILVER	0	0	0	0	0	0	0	0	0	0	0		
	COPPER	0	0	0	0	0	0	0	0	0	0	0		
		------	------	------	------	------	------	------	------	------	------	------		
		0	0	0	0	0	0	0	0	0	0	0		
		------	------	------	------	------	------	------	------	------	------	------	------	------
les volume	GARNET	0	0	0	0	0	0	0	0	0	0	0	0	0
00'S)	GOLD	0	0	0	0	0	0	0	0	0	0	0	0	0
	SILVER	0	0	0	0	0	0	0	0	0	0	0	0	0
	COPPER	0	0	0	0	0	0	0	0	0	0	0	0	0
		------	------	------	------	------	------	------	------	------	------	------	------	------
		0	0	0	0	0	0	0	0	0	0	0	0	0
		------	------	------	------	------	------	------	------	------	------	------	------	------
olesale price ($Cdn)	GARNET(PER TON)	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	$40.0	
------------------------	GOLD(PER OUNCE)	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	$459.5	
B GREENWOOD	SILVER(PER OUNCE)	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	$6.00	
-----------	COPPER (PER TON)	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	$2,700	
riable Costs														

	MINING	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	
	MILLING/BAGGING	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	$12.00	
	SMELTER/TRANSPORT	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	

← are the yields realistic ?. Considering the need to free the copper & magneti[illegible] Will the product be coarse enough for sandblasting