Industrial Development Subsidiary Agreement

GRINDING MATERIALS MARKET STUDY

NOVEMBER 1981

Research Report

Province of British Columbia
Ministry of Industry and Small Business Development

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Expansion Économique Régionale

GRINDING MATERIALS MARKET STUDY

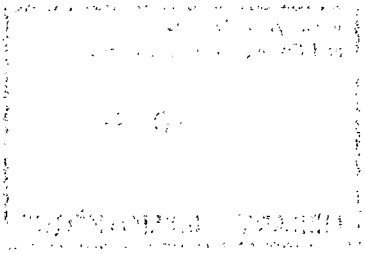
NOVEMBER 1981

Prepared For

B.C. MINISTRY OF INDUSTRY AND SMALL BUSINESS DEVELOPMENT

Prepared By

DON FERENCE & ASSOCIATES LTD.



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The consultants acknowledge with gratitude the assistance and cooperation received from the numerous government and private organizations and individuals during the preparation of this report.

The responsibility for the report, as written, and all conclusions reached herein, are the consultants' alone, and the report does not necessarily reflect the opinions of those who assisted during the course of this investigation or the Federal and Provincial governments, which funded the study.

EXECUTIVE SUMMARY

Purpose of Study

The major purpose of the study is to determine the current and future demand for grinding balls, grinding rods, and mill liners in B.C. and the Yukon. The scope of the study also includes a preliminary analysis of the feasibility of establishing a production facility for grinding materials in British Columbia.

Method of Study

We have conducted approximately 50 interviews with representatives of mining companies, industry associations, and government departments to determine the likely level of activity in the mining industry in B.C. and the Yukon in the next ten years. Due to the difficulty in predicting the start-up date of potential mines, we developed three alternative scenarios to depict a high, medium and low level of mining activity in B.C. and the Yukon.

For each existing and potential mine, we obtained information on the current and projected consumption of grinding balls, grinding rods, and mill liners. We also conducted interviews with mine superintendents and designers of mineral processing equipment to determine the likely technological improvements and trends affecting the demand for grinding materials in the future.

To assess the feasibility of establishing a local production facility for grinding materials, we contacted equipment suppliers and producers of grinding materials in eastern Canada and the United States. From these interviews, we obtained information on the initial capital investment required and the approximate operating costs to produce grinding materials.

Findings and Observations

Our major observations and findings regarding the demand for grinding materials are summarized as follows:

1. The current size of the annual market for grinding media in B.C. and the Yukon is estimated to be approximately 70,200 tons of grinding balls and 28,900 tons of grinding rods.

2. The major users of grinding materials are metal mines in B.C. and the Yukon, while the volume of grinding materials used by other operations, such as limestone quarries and cement plants, is minimal.

3. The demand for grinding balls in B.C. and the Yukon is projected to be as follows (in tons):

	Level of Mining Activity		
Year	Low	Medium	High
1985	76,400	96,900	112,900
1990	107,000	133,000	161,200

4. The demand for grinding rods in 1985 and 1990 is projected to increase slightly as shown below (in tons):

	Level of Mining Activity		
Year	Low	Medium	High
1985	29,100	29,100	30,800
1990	29,100	30,800	32,500

5. The major trend in milling technology is the utilization of

a semi-autogenous grinding circuit rather than the conventional rod mill and ball mill grinding circuit. Because the majority of new mines are likely to use semi-autogenous mills, the major grinding media used will be grinding balls rather than rods.

6. Due to the forecasted increase in mining activity, the total sales revenue for mill liners is projected to be as follows (in millions of 1981 dollars):

	Level of Mining Activity		
Year	Low	Medium	High
1985	$15.4	$18.4	$21.0
1990	$19.0	$24.0	$28.3

Conclusions and Recommendations

Based on the market research undertaken, our conclusions regarding the market potential for a local grinding materials facility are as follows:

1. Due to an increase in demand, there exists considerable market potential to produce grinding balls for the mining community in B.C. and the Yukon. Furthermore, the users of grinding balls appear willing to split their purchases to reduce the current dependency on one major supplier. Based on a likely market share of about 40%, the potential sales volume of a local grinding ball plant is estimated to increase from about 28,000 tons in 1981 to 40,000 tons by 1985.

2. The market potential for grinding rods, however, is limited as the demand appears to have reached a plateau, with little growth foreseen.

3. There exists ample production capacity in B.C. to meet the current and projected demand for mill liners.

Based on a preliminary feasibility analysis, there appears to exist some potential to establish a grinding ball production facility in B.C. The cost and availability of raw materials on a long term basis, however, are the critical factors in determining the viability of the project. Consequently, we recommend that a detailed feasibility analysis be conducted for a grinding ball plant in B.C. Some of the major aspects that should be investigated in the study include the likely sources and costs of raw materials as well as an in-depth financial analysis of the project.

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I. METHOD OF STUDY

As indicated in our proposal, we have conducted a study of the market for grinding balls, rods and mill liners in British Columbia and the Yukon. A description of the scope and method of the study is provided in the following paragraphs.

In order to identify the existing and potential mining developments in B.C. and the Yukon, we have met with representatives of the Mining Association of B.C., the B.C. Ministry of Energy, Mines and Petroleum Resources, and the B.C. Ministry of Industry and Small Business Development. Based on the information provided, we compiled a list of the existing operations that use grinding materials and the potential mines that have been identified and are likely to be developed within the next ten years.

To obtain information on the usage of grinding materials, we have prepared and sent approximately 30 questionnaires to the purchasing agents of the major mining operations in B.C. and the Yukon. A list of the metal mines and cement plants that we contacted is provided in Appendix 1 of the report. For each operation, we obtained information on the annual tonnage of ore milled, the consumption of grinding materials by type and size, the present suppliers of grinding balls, rods and mill liners, and projections of the consumption of grinding materials in 1985 and 1990. To verify the information on the current consumption of grinding materials, we also contacted the major suppliers of grinding rods, balls and mill liners to determine the amount sold to the mining community in B.C. and the Yukon.

To determine the incremental volume of grinding materials resulting from new mining developments in B.C. and the Yukon, we contacted mining company representatives responsible for planning and implementing new projects. A list of the potential mining developments included in this study is provided in Appendix 2 of the report.

For each potential mine, we obtained information on the likely start-up date, production volume, type of grinding circuit, the size and type of grinding materials to be used, and the likely consumption rates for grinding balls, rods and mill liners. The decision to proceed with a new mine and the estimated start-up date, however, depend on a number of factors including the selling price of metals and world economic conditions. Furthermore, the high degree of fluctuation in metal prices makes it difficult to evaluate the viability of a project. Due to the difficulty in predicting the start-up date of potential mines, we developed three alternative scenarios to depict a high, medium and low level of mining activity in B.C. and the Yukon. For each scenario, we determined the specific mines and likely tonnage of ore to be processed over the next 10 years.

To assess the technological improvements likely to occur in mineral processing, we conducted interviews with mill superintendents of five of the larger mines in B.C. In addition, we interviewed the following individuals involved in the research and design of milling equipment:

- Mr. Derek Barrett
  Senior Metallurgical Engineer
  Wright Engineers Limited

- Mr. Bill Thomas
  Mineral Processing Engineer
  H.A. Simons (International) Ltd.

- Dr. Andrew Mular
  Mineral Process Engineering Department
  University of British Columbia

To determine the capital investment required to set up a production facility for grinding materials, we contacted representatives of major furnace and forging equipment suppliers in eastern Canada and the U.S. We also contacted the following manufacturers of grinding balls and rods in other parts of North America to determine their approximate operating costs, labour and power requirements and the type of production process employed:

- A.R.M.C.O
  Kansas City, Missouri

- C. F. & I.
  Pueblo, Colorado

- Manitoba Rolling Mills Ltd.
  Selkirk, Manitoba

- Algoma Steel Corporation Ltd.
  Sault Ste. Marie, Ontario

To determine the viability of a local production facility for grinding materials, we interviewed representatives of Pacific Continuous Steel, Ocean Foundries Ltd., and Western Canada Steel to determine their rationale for discontinuing production of grinding balls and rods. In addition, we contacted representatives of companies currently producing mill liners in B.C., as well as a number of other local manufacturers, in order to determine their reasons for not expanding their production operations to include grinding balls and rods. Some of the companies contacted include the following:

- Esco Ltd., Port Coquitlam
- Mainland Manufacturing, Richmond
- CAE Machinery Ltd., Vancouver
- Kockums Industries Ltd., Surrey
- Reliance Foundry Co. Ltd., Surrey

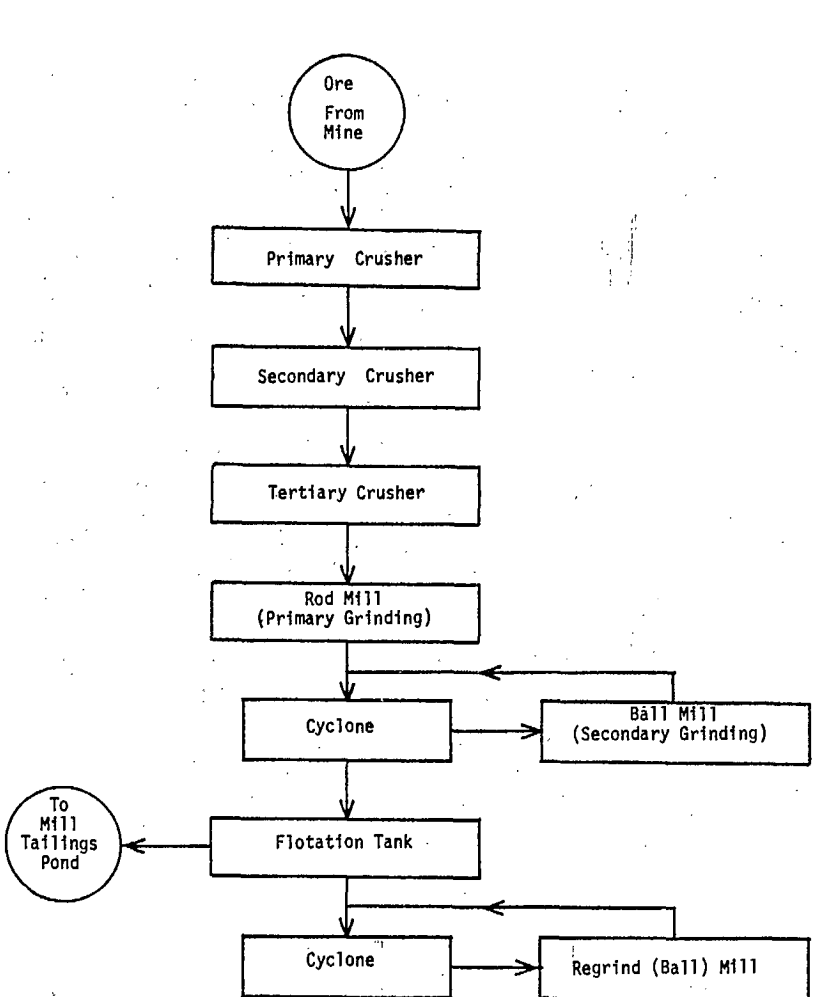

Figure 1. Conventional Rod and Ball Mill Circuit

II. DESCRIPTION OF GRINDING PROCESS

Grinding materials are used primarily in the mining industry to reduce metallic ores for concentrating or further processing. One of the most common types of grinding operations used in B.C. is the conventional rod and ball mill grinding circuit illustrated in Figure 1 on the opposite page. As shown in Figure 1, the ore is first fed through an extensive three-stage crushing process to reduce the size of the ore sufficiently to pass through a 3/4 inch screen.

The crushed ore is then fed into a rod mill for the initial or primary grinding stage. An illustration of a typical rod mill is provided in Figure 2 on the following page. The rod mill is loaded with an initial charge of grinding rods of 35% to 40% of the total mill volume. As the mill rotates around its horizontal axis, the rods are carried up the side of the mill and fall on the ore below. This action causes the ore particles to break into smaller pieces.

The ore from the rod mill is then fed into a ball mill for secondary grinding. A ball mill, which is illustrated in Figure 3 on the following page, resembles a rod mill in both appearance and operation except that balls, instead of rods, are used as the "grinding medium". A charge of up to 40% of grinding balls is loaded into the mill, and, as the mill rotates, the balls fall on the ore reducing the material to the size desired. Because the diameters of the balls are smaller than the rods used for primary grinding, the ball mill is capable of producing a finer grind than the rod mill.

The grinding media, itself, is gradually reduced in size through prolonged impact and abrasion in the mill. The worn particles are screened out of the mill and regularly replaced with additional grinding material.

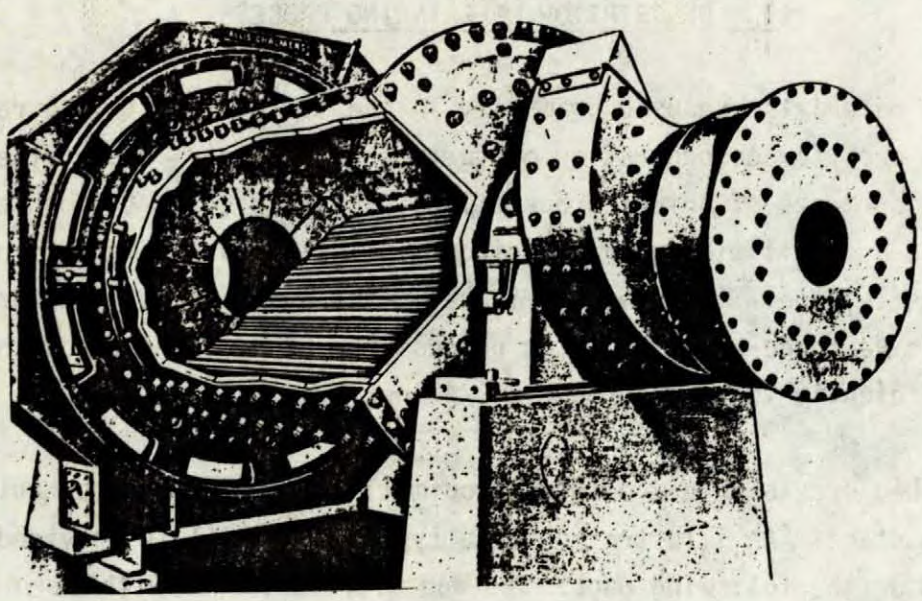

Figure 2. Rod Mill

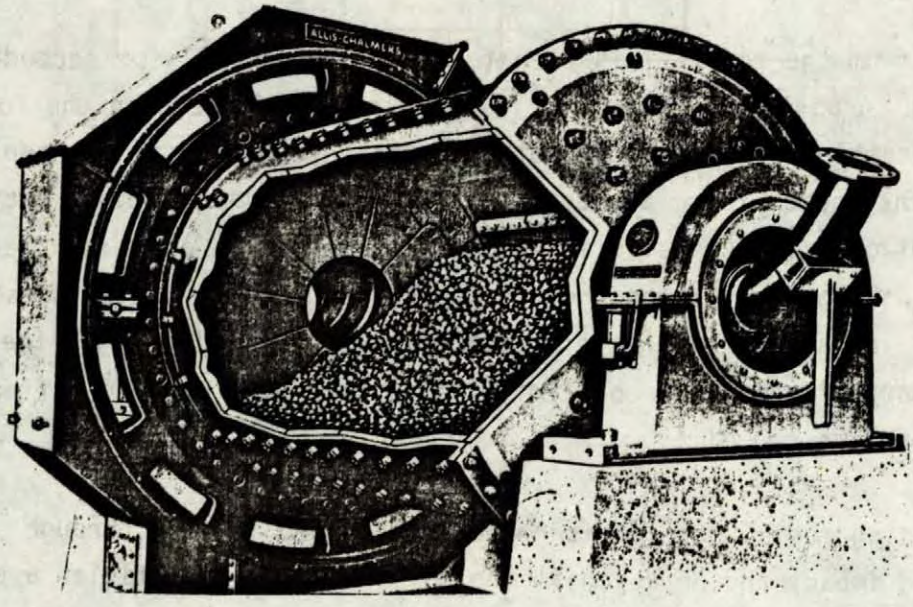

Figure 3. Ball Mill

From the secondary ball mill, the fine ore is conveyed into a floatation tank for separation of the metal concentrate. Any oversize particles of concentrate are passed through a small ball mill to regrind the material before it is processed further.

The size of rod and ball mills used in a conventional grinding circuit varies considerably depending on the production throughput, ore characteristics, and the particle size desired. Generally speaking, the size of rod mills found in B.C. range from 10 feet to 14 feet in diameter. The ball mills, however, vary from 2 feet in diameter for regrind mills to 17 feet in diameter for secondary mills.

Within the last fifteen years, semi-autogenous grinding circuits have been used increasingly by the B.C. mining industry. A typical grinding circuit utilizing a semi-autogenous mill is illustrated in Figure 4 on the following page. As shown, only a single-stage crushing operation is employed and the ore is crushed to a size of approximately 10 inches in diameter.

The crushed ore is then fed to a semi-autogenous mill for primary grinding. The concept of a semi-autogenous mill is similar to a ball mill, except that a smaller ball charge of 6% to 10% of the mill volume is used. In addition, the semi-autogenous mills are much larger than ball mills and range from 24 feet to 34 feet in diameter. By increasing the height of the mill, the falling ore particles also act as a "grinding medium" thereby reducing the amount of steel grinding media required.

The ore from the semi-autogenous mill is then fed to a secondary ball mill similar to that used in a conventional rod and ball mill circuit. As shown in Figure 4, a small regrind mill is also employed in the semi-autogenous grinding circuit to reduce any oversize particles of metal concentrate.

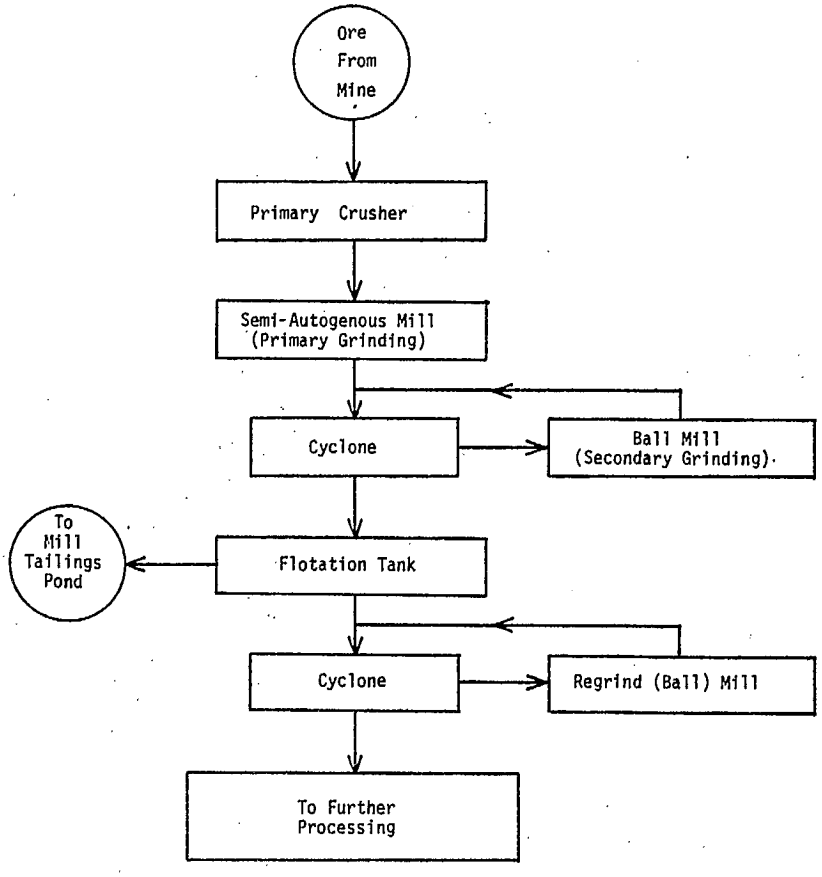

Figure 4. Semi-Autogenous Mill Circuit

The major differences of a semi-autogenous grinding circuit, therefore, are a less extensive crushing circuit and the replacement of the rod mill with a semi-autogenous mill for primary grinding. The decision to use a specific type of grinding circuit depends on a number of factors including the hardness and breakage characteristics of the ore, the particle sizes desired, and the volume of ore to be processed.

Based on interviews with mill superintendents, some of the advantages of a semi-autogenous grinding circuit include a lower consumption of grinding media and mill liners. For large volume operations, the capital costs of the semi-autogenous grinding circuit are also likely to be lower than the conventional rod and ball circuit due to a less extensive crushing stage.

Another method of processing ore is to use a fully autogenous mill for primary grinding. Autogenous mills use the ore, itself, as the grinding medium and grinding balls are not required. The use of this type of mill is limited; the Highmont mine in the Highland Valley employs the only fully autogenous mill in B.C.

Mill liners are used to line and protect the interior of all grinding mills. Their wear necessitates continual replacement while the "shell" of the mill remains intact. As illustrated in Figures 5 and 6 on the following page, the two major types of mill liners used are the wave liner and the wedge-type liner. The purpose of the ribbed design of the wave liner is to carry the ore and grinding materials to the top of the grinding mill. For wedge-type mill liners, a separate "lifter bar" is used for this purpose. The wedge-type liners are most often used in primary grinding mills, while the wave liners are found in secondary ball mills.

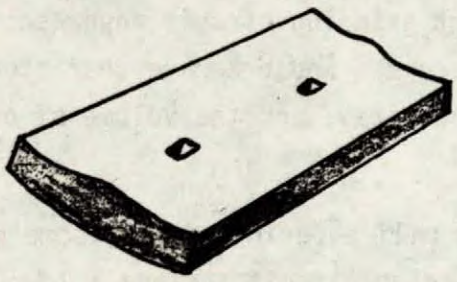

Figure 5. Wave Liner

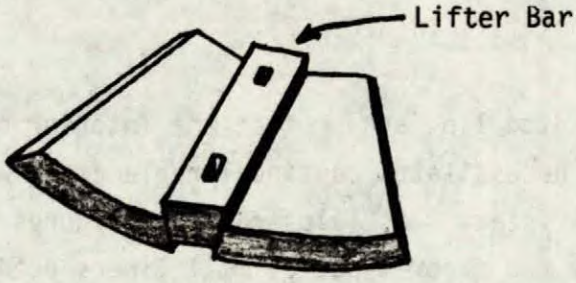

Figure 6. Wedge-Type Liner

III. CURRENT MARKET FOR GRINDING BALLS AND RODS

Our observations and findings regarding the present demand for grinding balls and rods in B.C. and the Yukon are provided in the following paragraphs.

A. SIZE OF THE MARKET

The size of the market for grinding balls and rods in 1981 for B.C. and the Yukon is estimated to be a total of 99,100 tons. Grinding balls are the predominant type of grinding media used and are estimated to account for 70,200 tons or 71% of the total usage. The other type of grinding media used are grinding rods, which account for 28,900 tons or the balance of current consumption.

The usage of grinding media is estimated to have increased by approximately 9,900 tons in 1981 from a level of 89,200 tons in 1980. The major increase in consumption is due to a number of new mine developments such as the Highmont and Kitsault mines, as well as the reactivation of the Granduc mine. The majority of the increase in consumption consists of grinding balls. As shown below, the use of grinding balls in B.C. and the Yukon is estimated to have increased by approximately 7,400 tons from a level of 62,800 tons in 1980 to 70,200 tons in 1981:

CONSUMPTION OF GRINDING MEDIA

IN B.C. AND THE YUKON

Year	Balls (tons)	Rods (tons)	Total (tons)
1981	70,200	28,900	99,100
1980	62,800	26,400	89,200
Change	+7,400	+2,500	+9,900

TABLE 1

MAJOR USERS OF GRINDING MATERIALS

IN B.C. AND THE YUKON IN 1981

Major Mineral Processed	Consumption of Grinding Media		
	Balls (tons)	Rods (tons)	Total (tons)
Copper	57,300	17,900	75,200
Molybdenum	6,300	7,500	13,800
Lead and Zinc	5,400	2,200	7,600
Gold and Silver	1,100	900	2,000
Other	100	400	500
Total	70,200	28,900	99,100

B. MAJOR USERS

A breakdown of the total consumption of grinding media by type of mine is provided in Table 1 on the opposite page. As indicated, the copper mines in B.C. and the Yukon are estimated to account for 76% of the total consumption of grinding balls and rods in 1981. Due to the predominance of semi-autogenous grinding circuits in copper mines, the majority of grinding media consumed consists of grinding balls.

Grinding materials are also used in molybdenum, gold, silver, lead and zinc mining operations. The proportion of grinding rods used for these mines is greater than for copper mines, due to the more frequent use of conventional rod and ball mill grinding circuits.

The volume of grinding media used by other types of operations, such as cement plants and limestone quarries, is minimal, amounting to less than 500 tons of grinding balls per year.

C. LOCATION OF USERS

There are approximately 25 major metal mines currently operating in B.C. and the Yukon which account for the majority of the grinding materials consumed. A map showing the location of these mines is provided in Figure 7 on the following page. As indicated in Figure 7, the total market has been divided into four major areas by utilizing the boundaries of the regional economic districts. The specific regional districts included in each market area are listed in Appendix 3 of the report. An analysis of the consumption of grinding balls and rods in each area is provided in Table 2 on the following page.

The major users of grinding balls and rods are located in the south central area of B.C. and the area comprising northern B.C. and the Yukon.

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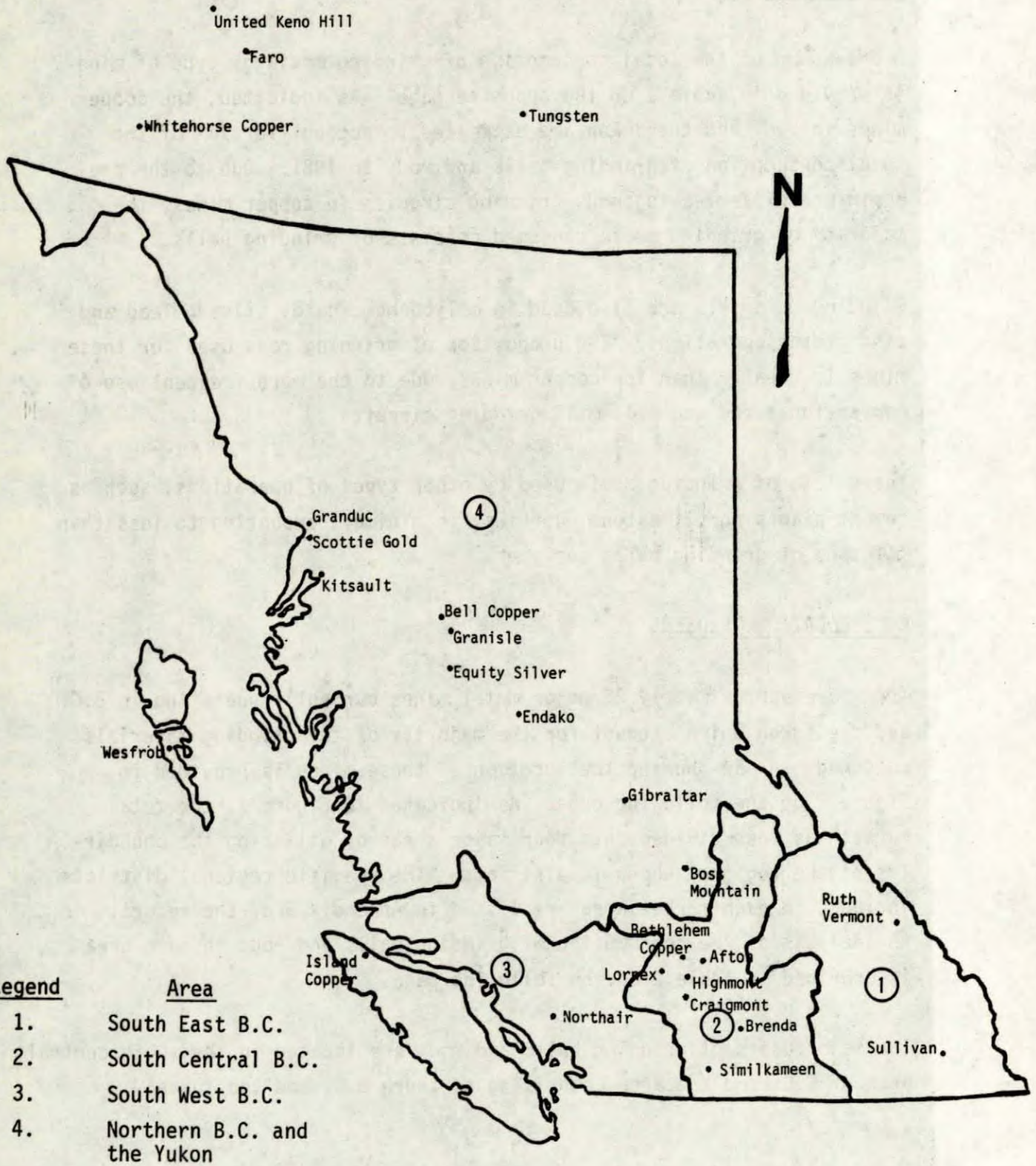
Figure 7. Major Metal Mines in B.C. and the Yukon



Legend	Area
1.	South East B.C.
2.	South Central B.C.
3.	South West B.C.
4.	Northern B.C. and the Yukon

TABLE 2

MARKET FOR GRINDING BALLS AND RODS

IN B.C. AND THE YUKON BY REGION, 1981

Area	Consumption of Grinding Media		
	Balls (tons)	Rods (tons)	Total (tons)
South East B.C.	1,000	400	1,400
South Central B.C.	33,900	9,600	43,500
South West B.C.	15,400	-	15,400
Northern B.C. and the Yukon	19,900	18,900	38,800
Total	70,200	28,900	99,100

TABLE 3

SIZES OF GRINDING MEDIA USED

IN B.C. AND THE YUKON IN 1981

Diameter (inches)	Grinding Balls (tons)	Grinding Rods (tons)	Total (tons)
1 - 1½	7,000	-	7,000
2	10,300	-	10,300
2½	21,900	-	21,900
3	18,200	3,400	21,600
4	6,200	25,500	31,700
5	6,600	-	6,600
Total	70,200	28,900	99,100

These two regions account for approximately 83% of the total estimated consumption of grinding media in 1981.

Due to the predominant use of large semi-autogenous mills in the south central and south west areas of B.C., the consumption of grinding balls is considerably greater than grinding rods. The highest usage of grinding rods occurs in the area comprising northern B.C. and the Yukon where conventional grinding circuits are more often employed.

D. SIZES OF GRINDING MEDIA

Grinding balls are produced in standard sizes ranging from one inch to five inches in diameter. The size of ball used depends on a number of factors including the particle size of ore desired and the dimensions of the grinding mill. Generally speaking, as the size of the ball is reduced, a finer grind and smaller particle size is produced.

Large grinding balls, which consist of balls four inches and five inches in diameter, are used in semi-autogenous mills. The medium size balls, which range from two inches to three inches in diameter, are used mostly in secondary ball mills. Some medium size balls are also mixed with larger balls in semi-autogenous mills to obtain the desired grind. The small grinding balls, ranging from one inch to one and a half inches in diameter, are used primarily in small regrind ball mills.

A breakdown of the consumption of grinding balls and rods in 1981 by size is provided in Table 3 on the opposite page. As indicated, the medium size balls account for 50,400 tons or about 72% of the total

consumption of grinding balls. The high proportion of medium size balls is due to their use in both semi-autogenous and conventional grinding circuits.

The volume of large grinding balls consumed in 1981 is estimated to be a total of 12,800 tons. The balance of the current consumption of grinding balls consists of smaller balls ranging from one inch to one and a half inches in diameter.

Two sizes of grinding rods, three inches and four inches in diameter, are currently used in B.C. and the Yukon. The length of the grinding rods vary considerably and are specifically made to fit the dimensions of each rod mill. The major size of grinding rod used is the four inch rod which accounted for about 88% of the total rod consumption in 1981.

E. TYPES OF GRINDING MEDIA

Almost all of the grinding balls used locally are forged from high carbon steel in the AISI C1075 to C1090 range. The steel is modified with chromium and/or silicon to increase hardness and wearability.

While cast iron and steel balls have been used in the past in B.C., they are reported to have fallen out of favor with the local mill operators due to poor grinding performance. Some of the problems experienced with cast grinding balls include hollow centres and ball breakage in the mill.

A conical shaped cast slug is also currently offered in B.C. as an alternative grinding medium. While sales of grinding slugs have been considerable in eastern Canada, the volume of slugs sold in B.C. and the Yukon has been minimal.

The grinding rods used by the local mining community are made from a hot-rolled high carbon steel similar to that used to make forged grinding balls. Alloys of chromium and/or silicon are also added to increase the durability and performance of the rods.

F. SOURCES OF SUPPLY

Approximately 85% of the grinding balls used in B.C. and the Yukon are currently supplied by Stelco Inc. from their production facilities in Edmonton, Alberta. An additional 8% of the grinding ball market is supplied by the Algoma Steel Corporation Ltd. in Sault Ste. Marie, Ontario while the other 7% of grinding balls used are imported from the United States.

At one time, grinding balls were imported from Japan, South Korea and the United Kingdom but these sources contribute an insignificant amount today. In the early 1970's, grinding balls were also produced in B.C. by Pacific Continuous Steel who produced a forged steel ball, and Ocean Foundries who made cast iron balls and slugs. Both of these operations ceased production in 1976 for a number of reasons including raw material shortages and quality control problems.

Stelco also supplies approximately 85% of the grinding rods used in B.C. and the Yukon from their Edmonton plant. The other major supplier of grinding rods is Manitoba Rolling Mills in Selkirk, Manitoba. Grinding rods were formerly imported into B.C. from Japan. According to information supplied by Statistics Canada, approximately 2,500 tons of grinding rods were imported from Japan in 1978, but this volume fell off to only 34 tons in 1980.

Grinding rods were also manufactured for a limited period by Western Canada Steel in Richmond, B.C. The maximum diameter of rods produced by Western Canada Steel was only three and a half inches. Due to the limited demand for the smaller size rods, the company ceased production of grinding rods about five years ago.

TABLE 4

GRINDING MEDIA CONSUMPTION BY SIZE OF MINE

IN B.C. AND THE YUKON IN 1981

Annual Tons Milled (000,000's tons)	Number of Mines	Consumption of Grinding Media		
		Balls (tons)	Rods (tons)	Total (tons)
0 - 1	9	800	900	1,700
1 - 5	6	11,400	5,200	16,600
5 - 10	4	13,600	6,600	20,200
10 - 15	3	13,000	12,000	25,000
15 +	3	31,400	4,200	35,600
Total	25	70,200	28,900	99,100

G. GRINDING MEDIA PRICES

The current prices charged for forged steel grinding balls, F.O.B. supplier, ranges from $520 per net ton to $590 per net ton depending on the diameter of the balls. The smaller and larger balls command a premium price while the two inch and the two and a half inch balls are the lowest in price.

Due to the lack of significant sales of cast balls or slugs in B.C., representative selling prices for these products are not available.

The current price charged for grinding rods, F.O.B. supplier, ranges between $420 per net ton and $440 per net ton depending on the diameter and the length of the rod.

Freight costs are additional and vary substantially for the various suppliers of grinding media. As an illustration, the rail rates to ship grinding balls from Edmonton, Alberta to Ashcroft, B.C. are approximately $14 per net ton, as compared to a charge of $78 per net ton to ship balls from Sault Ste. Marie, Ontario to Ashcroft, B.C.

H. CONCENTRATION OF PURCHASING

An analysis of the consumption of grinding media by size of mine is provided in Table 4 on the opposite page. As indicated, the purchasing of grinding media is very concentrated. The six largest mines, which include mines processing in excess of 10 million tons of ore per year, are estimated to account for over 60% of the total volume of grinding balls and rods consumed in 1981.

I. PURCHASING CRITERIA

To select grinding media, the mill operators constantly evaluate new sizes and types of materials in order to obtain a more cost effective method and better quality of grind. Small quantities of grinding media are purchased, on a test basis, and the rate of wear is monitored closely. The major factors used in comparing products include initial cost, media consumption rate, the type of grind produced and the mill throughput capable with the grinding material.

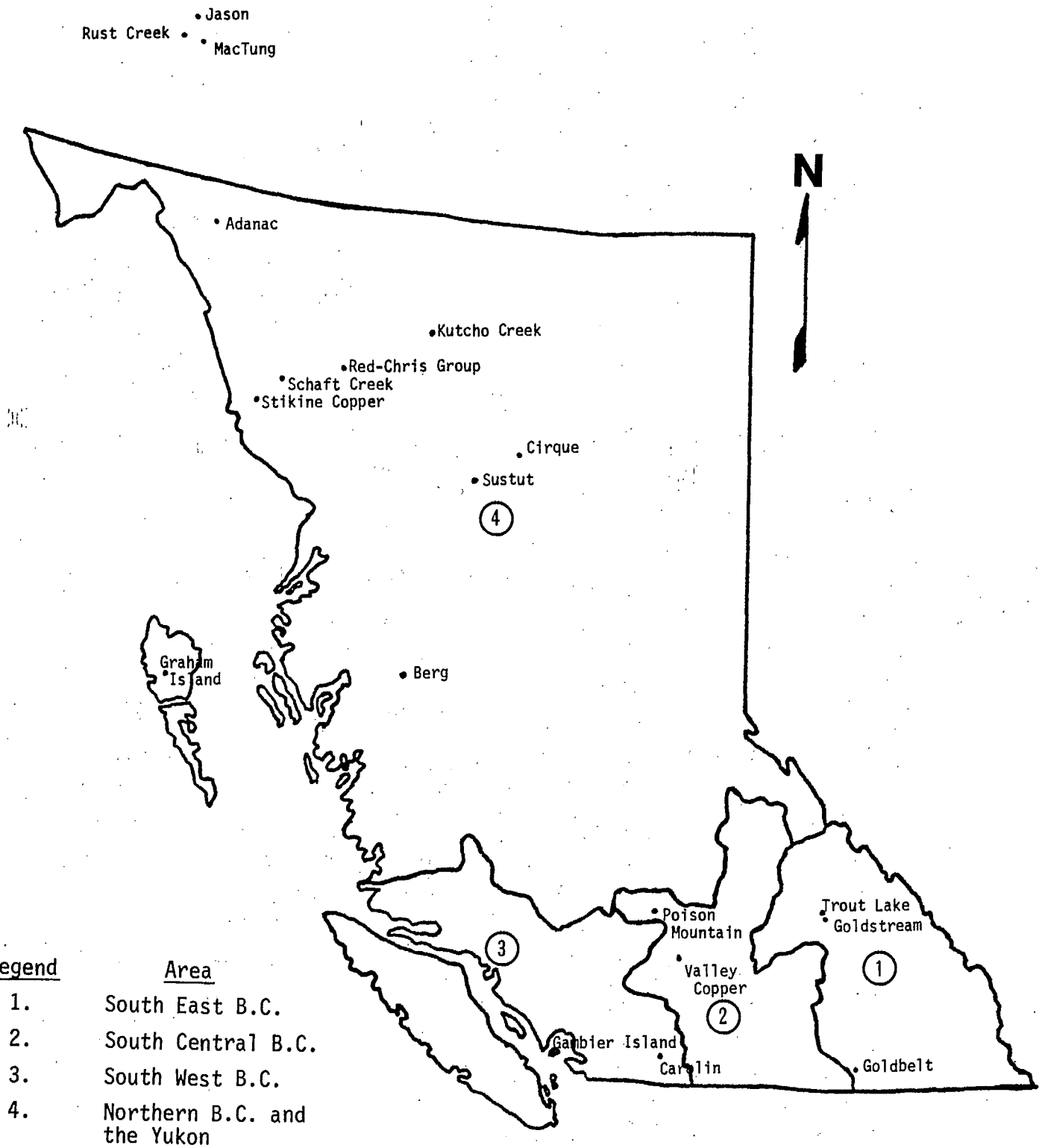
Based on our interviews with the major users of grinding media in B.C. and the Yukon, our observations and findings regarding the degree of satisfaction with the current supply and types of grinding media available are as follows:

1. The majority of users appear satisfied with the product quality and level of service provided by the current suppliers of grinding balls and rods.

2. The major problem experienced, however, is the dominance of the market by one supplier which is detrimental in cases of strikes and company shutdowns. For instance, the employees of the Stelco plant in Edmonton have been on strike for the last three months and the mining community has had to pay a premium to obtain their requirements from other suppliers.

3. In order to alleviate the high dependency on one major supplier, the majority of users appear willing to split their purchases with another producer, given that price and product quality are competitive.

Figure 8. Potential Metal Mines in B.C. and the Yukon *



Legend	Area
1.	South East B.C.
2.	South Central B.C.
3.	South West B.C.
4.	Northern B.C. and the Yukon

* Including mines under development in 1981.

IV. FUTURE DEMAND FOR GRINDING BALLS AND RODS

Our observations and findings regarding the level of mining activity and projected demand for grinding balls and rods in B.C. and the Yukon are provided in the following paragraphs.

A. LEVEL OF MINING ACTIVITY

Due to difficulty in accurately predicting the level of mining activity, we have developed three scenarios to depict a high, medium and low level of mining development in B.C. and the Yukon in the next ten years. A map showing the potential metal mines identified in B.C. and the Yukon is provided in Figure 8 on the opposite page. For each scenario of mining activity, we have identified which of the potential mines are likely to be operating and the total volume of ore to be processed from existing and potential mines. The ore tonnages estimated to be processed in 1985 and 1990, for a high, medium and low level of mining activity, are summarized below:

PROJECTED TONNAGE OF ORE PROCESSED
IN B.C. AND THE YUKON
(000'000'S TONS)

	Level of Mining Activity		
Year	Low	Medium	High
1980	107.6	107.6	107.6
1981	120.9	120.9	120.9
1985	129.5	157.2	178.1
1990	170.5	205.1	243.3

As indicated, the level of mining activity is forecast to increase substantially in B.C. and the Yukon in the period to 1990. Based on a "medium" level of mining activity, the amount of ore processed is projected to increase from 120.9 million tons in 1981 to 157.2 million tons and 205.1 million tons in 1985 and 1990, respectively.

TABLE 5

PROJECTED DEMAND FOR GRINDING BALLS AND RODS

IN B.C. AND THE YUKON

Year	Level of Mining Activity	Consumption of Grinding Media		
		Balls (tons)	Rods (tons)	Total (tons)
1980	-	62,800	26,400	89,200
1981	-	70,200	28,900	99,100
1985	Low	76,400	29,100	105,500
	Medium	96,900	29,100	126,000
	High	112,900	30,800	143,700
1990	Low	107,000	29,100	136,100
	Medium	133,000	30,800	163,800
	High	161,200	32,500	193,700

The major mining developments forecast to occur by 1985, based on a medium level of mining activity, include the expansion of the existing Lornex mine at Logan Lake and the start-up of Valley Copper's mine in the Highland Valley. The major developments foreseen from 1985 to 1990 include the start-up of the Adanac, Schaft Creek and Poison Mountain mines.

Approximately 85% of the incremental tonnage to be processed to 1990 is projected to result from new copper developments. The other types of mines likely to be developed include gold, molybdenum, lead, and zinc mines.

Based on our interviews with mining company representatives, almost all of the new copper mines planned are likely to use a semi-autogenous, rather than a conventional rod and ball mill, grinding circuit. The grinding processes envisaged for the other potential mines include both semi-autogenous and conventional grinding circuits.

B. GRINDING MEDIA REQUIREMENTS

For each alternative level of mining activity, we have developed projections of the grinding balls and rods estimated to be required. A summary of our findings is provided in Table 5 on the opposite page, while a more detailed breakdown is provided in Appendix 4 of the report.

As indicated in Table 5, the total consumption of grinding media in B.C. and the Yukon is projected to increase substantially over the next 10 years. Based on a "medium" level of mining activity, the market for grinding balls and rods is projected to increase from a total of 99,100 tons in 1981 to 126,000 tons and 163,800 tons in 1985 and 1990, respectively.

The major increase in demand is for grinding balls as the total usage of balls is projected to increase from 70,200 tons in 1981 to 96,900 tons and 133,000 tons in 1985 and 1990, respectively. The market for grinding rods, however, is not estimated to change substantially. The annual usage of rods is projected to increase gradually from 28,900 tons in 1981 to 30,800 tons in 1990.

The major trends affecting the future demand for grinding media are outlined below:

1. By using the ore itself as an additional grinding medium, the requirements for steel grinding media in a semi-autogenous grinding circuit are reduced by approximately 10% as compared to a conventional rod and ball mill circuit. With increasing use of semi-autogenous mills, therefore, the average consumption rate of grinding media per ton of ore processed in B.C. and the Yukon is projected to decrease slightly in the next ten years as shown below:

AVERAGE CONSUMPTION RATE OF GRINDING MEDIA

IN B.C. AND YUKON

(BASED ON MEDIUM LEVEL OF MINING ACTIVITY)

Year	Media Consumption Rate (pounds per ton of ore)
1980	1.66
1981	1.64
1985	1.61
1990	1.60

2. Due to predominance of semi-autogenous mills in new mine developments, usage of grinding rods is not forcast to increase significantly.

TABLE 6

PROJECTED DEMAND FOR GRINDING MEDIA BY SIZE

IN B.C. AND THE YUKON

(Based on a medium level of mining activity)

Diameter (inches)	1981 (tons)	1985 (tons)	1990 (tons)
Grinding Balls			
1 - 1½	7,000	7,600	9,700
2	10,300	10,500	12,700
2½	21,900	28,900	39,800
3	18,200	29,700	42,000
4	6,200	9,200	13,300
5	6,600	11,000	15,500
Total	70,200	96,900	133,000
Grinding Rods			
3	3,400	3,100	3,300
4	25,500	26,000	27,500
Total	28,900	29,100	30,800
Total Grinding Media	99,100	126,000	163,800

3. The market for large grinding balls, which are used in semi-autogenous mills, is projected to increase considerably in the next 10 years as shown in Table 6 on the opposite page. Based on a medium level of mining activity, the demand for 4-inch and 5-inch grinding balls is estimated to increase from a total of 12,800 tons in 1981 to 20,200 tons and 28,800 tons in 1985 and 1990, respectively.

4. The demand for medium size balls is also projected to increase substantially from 50,400 tons in 1981 to 69,100 tons and 94,500 tons in 1985 and 1990, respectively. Due to their use in both semi-autogenous and conventional rod and ball grinding circuits, the medium size balls ranging from 2 inches to 3 inches in diameter are likely to continue to be the major size of grinding ball used by the mining industry in B.C. and the Yukon.

5. The two most rapidly expanding markets for grinding media are the south central B.C. region and the region comprising northern B.C. and the Yukon. An analysis of the demand for grinding balls and rods is provided in Table 7 on the following page. As indicated, the major increase in demand to 1985 is projected to originate from the south central area of B.C. due to developments such as Valley Copper in the Highland Valley. After 1985, the major increase in demand is projected to occur in the northern B.C. and Yukon region, due to developments such as the Adanac, Schaft Creek and Berg mines.

TABLE 7

PROJECTED DEMAND FOR GRINDING BALLS AND RODS

IN B.C. AND THE YUKON BY REGION

(Based on a medium level of mining activity)

Area	Consumption of Grinding Media		
	1981 (tons)	1985 (tons)	1990 (tons)
South East B.C.	1,400	1,700	4,400
South Central B.C.	43,500	64,800	77,600
South West B.C.	15,400	15,700	15,800
Northern B.C. and the Yukon	38,800	43,800	66,000
Total	99,100	126,000	163,800

V. MARKET FOR MILL LINERS

The mill liners in a grinding mill usually last between one and two years. Because they are replaced infrequently, accurate data on the regular consumption of mill liners was not readily available from a number of the mining companies contacted. Our observations and findings, based on the information obtained, are provided in the following paragraphs.

A. SIZE OF THE MARKET

The total market for mill liners in 1981 in B.C. and the Yukon is estimated to be approximately $14.5 million. Because lifter bars are used in conjunction with mill liners, we have included the consumption of lifter bars in our market estimates. Mill liners are made of the following materials:

- Cast steel, containing alloys of either chromium and molybdenum or manganese
- Ni-Hard iron
- Rubber

A breakdown of the total market by type of mill liner is provided in Table 8 on the following page. As indicated, steel liners are estimated to account for approximately 66% of the total liner sales volume. The remainder of liners used are iron and rubber liners which account for 19% and 15% of sales, respectively. Steel liners are used in primary and secondary mills while the use of iron and rubber liners is limited to smaller ball mills and regrind mills.

B. SOURCES OF SUPPLY

Unlike grinding balls and rods, a significant production of mill liners exists today in B.C. A list of the major manufacturers is provided on the following page:

TABLE 8

DEMAND FOR MILL LINERS

IN B.C. AND THE YUKON IN 1981

Type of Material	Estimated Sales Volume	% of Total
Steel	$ 9,600,000	66%
Iron	2,700,000	19
Rubber	2,200,000	15
Total	$14,500,000	100%

MANUFACTURER	LOCATION	TYPE OF LINER PRODUCED
Esco Ltd.	Port Coquitlam, B.C.	Steel
CAE Machinery	Vancouver, B.C.	Steel
Mainland Manufacturing	Richmond, B.C.	Steel, Iron
Kockums Industries	Surrey, B.C.	Steel, Iron
Reliance Foundry	Surrey, B.C.	Steel

In addition, Skega is currently setting up a manufacturing facility to produce rubber liners in Kamloops, B.C., which should be operational in 1982.

The other suppliers of mill liners to the local mining community include the following producers located in eastern Canada and the U.S.:

MANUFACTURER	LOCATION	TYPE OF LINER
Abex Industries	Selkirk, Manitoba	Steel
Foothills Steel Foundry	Calgary, Alberta	Steel
Sorel Steel	Sorel, Quebec	Steel
Norcast	Mont Joli, Quebec	Iron
Wabi Iron Works	New Liskeard, Ontario	Iron
Skega	North Bay, Ontario	Rubber
B. F. Goodrich	Kitchener, Ontario	Rubber
Minneapolis Electric	Duluth, Minnesota	Steel
Magotteaux	Nashville, Tennessee	Steel
Trelleborg	Solon, Ohio	Rubber

An analysis of the market share held by B.C. producers of metal liners is provided in Table 9 on the following page. As indicated, the local producers of mill liners currently account for 42% of the total sales of metal liners. The majority of B.C. production consists of steel mill liners as very few iron liners are made locally.

TABLE 9

MARKET SHARE ANALYSIS OF METAL LINERS USED

IN B.C. AND THE YUKON IN 1981

Source of Supply	Steel Liners (tons)	%	Iron Liners (tons)	%	Total (tons)	%
B.C.	3,500	56%	20	1%	3,520	42%
Other provinces	930	15	2,200	99	3,130	37
U.S.	1,800	29	-	-	1,800	21
Total	6,230	100%	2,220	100%	8,450	100%

In the last few years, the market share of B.C. producers has been eroded by aggressive pricing policies and lower wage costs of the U.S. and eastern Canadian mill liner manufacturers. As a result, there presently exists considerable excess production capacity in B.C. foundries.

The plant being set up by Skega in Kamloops will be the only producer of rubber mill liners in B.C. as the rubber liners used locally are currently supplied from eastern Canada and the U.S.

C. PRICE OF MILL LINERS

The price of mill liners depends on a number of factors including the volume purchased, complexity of design, and the source of supply. The current price charged by B.C. producers of steel liners averages approximately $.87 per pound while the average price of iron liners produced in B.C. is approximately $.85 per pound.

As mentioned previously, the competition is intense from eastern Canada and U.S. suppliers who are delivering iron and steel mill liners into B.C. at discounts of 30% to 35% less than that charged by local producers.

D. PURCHASING METHODS

Mill liners are not produced in standard sizes and must be custom made for each grinding mill. The procedures employed to purchase mill liners are to produce a detailed set of drawings and specifications for the liners required. This information is then submitted for bid to prospective manufacturers.

To test alternative products, a sample mill is converted with a complete set of new mill liners. Extensive tests are then conducted to monitor the degree of liner wear, mill operating expenses, and effect on the ore grind in order to compare the cost of the new mill liner with competitive products available.

E. FUTURE DEMAND FOR MILL LINERS

The major trends affecting the future demand for mill liners are as follows:

1. Based on interviews with industry representatives, mill liner wear is reduced by about 10% in semi-autogenous circuits, as compared to the conventional rod and ball mill circuit. Due to increased use of semi-autogenous mills, the consumption of mill liners is projected to grow at a slower rate than the total volume of ore processed in B.C. and the Yukon.

2. The most rapid growth in the mill liner market is projected to occur in steel liners due to the preference for semi-autogenous mills in new mines. Steel liners are used in semi-autogenous mills because they are capable of withstanding the impact of the large grinding balls as they fall from the top of the mill.

We have developed market projections for mill liners based on the alternative levels of mining activity in B.C. and the Yukon. The total sales revenue of mill liners, based in 1981 dollars, is estimated to be as follows for each scenario:

MARKET FOR MILL LINERS
IN B.C. AND THE YUKON
($ millions)

	Level of Mining Activity		
Year	Low	Medium	High
1981	$14.5	$14.5	$14.5
1985	15.4	18.4	21.0
1990	19.0	24.0	28.3

As indicated, the total sales of mill liners in B.C. and the Yukon, based on a medium level of mining activity, are projected to increase from $14.5 million in 1981 to $18.4 million and $24.0 million in 1985 and 1990, respectively.

VI. PRODUCTION OF GRINDING MATERIALS

The following section of the report provides a preliminary analysis of the need for and viability of establishing production facilities for grinding materials in British Columbia.

A. NEED FOR A PRODUCTION FACILITY

Based on the market research undertaken, our findings and conclusions regarding the market potential for a B.C. grinding materials plant are as follows:

1. Due to an increase in demand, there exists considerable market potential for the production of grinding balls for the mining community in B.C. and the Yukon. Furthermore, the users of grinding balls appear willing to split their purchases in order to reduce the current dependency on one major supplier.

2. The market potential for grinding rods, however, is limited as the demand appears to have reached a plateau with little growth foreseen.

3. There presently exists ample production capacity in B.C. to meet the current and projected demand for mill liners. The establishment of additional facilities to produce mill liners would be to the detriment of existing B.C. manufacturers.

Based on the above analysis, we have limited our feasibility study to include the production of grinding balls only. Utilizing a likely market share of 40%, the potential sales volume of the grinding ball plant is currently estimated to be about 28,000 tons per year. If the projected increase in mining activity occurs, the potential sales volume of the plant is estimated to increase to about 40,000 tons per year by 1985.

B. ALTERNATIVE PRODUCTION METHODS

Grinding balls can be made from either a forging or a casting production process. Due to the buyer preference for a forged ball versus a cast ball in B.C., we have limited our analysis to the production of forged grinding balls only. Cast balls, however, are used in other markets in North America and found to be price competitive. Therefore, we feel that the production of cast balls should be an alternative method to be examined in further investigations of the feasibility of a local grinding ball plant.

Depending on the form of raw material used, there are three methods of producing forged grinding balls which are as follows:

1. Ball Forging Plant.

   To produce grinding balls, the major raw material required is high-carbon round steel bars modified with chromium and/or silicon. The diameter of the bar should be approximately 75% of the size of the ball to be produced. The basic steps to produce forged grinding balls are as follows:

   a. The steel bars are placed in an electric induction furnace, or similar type of furnace, and heated to a temperature of 2300 degrees Fahrenheit.

   b. The heated bars are conveyed from the furnace into a ball forge machine which shears off a short length of steel and compresses the material between two semi-spherical dies to make a round ball.

   c. The steel balls are fed through a ball-rounding machine

to remove the rough edges and ensure that the shape of the ball is indeed round.

d. The balls are then conveyed through a water quenching system and tempering furnace to increase the hardness and durability of the product.

The major advantage of this method of producing grinding balls is the relatively low initial capital investment. The problem foreseen, however, is the availability of a guaranteed long term source of raw material.

At the present time, the only manufacturer in B.C. capable of producing the round steel bars required to make grinding balls is Western Canada Steel located in Richmond, B.C. Other likely sources of steel bars include eastern Canadian producers or manufacturers in Japan or the United States.

Based on our interviews with steel distributors, the market for round bar stock fluctuates considerably and steel mills are unwilling to commit themselves to a contract price for a long period. In order to obtain an accurate estimate of the availability and likely cost of steel bars on a long term basis, more detailed negotiations with potential suppliers would first have to be undertaken.

2. Steel Rolling Mill and Ball Forging Plant.

For this alternative, the source of raw material is cast steel billets instead of round steel bars. A steel rolling mill, however, would have to be purchased for the grinding ball production facility. To produce grinding balls, the steel

billets are heated and fed through the rolling mill which forms and rolls the material into round steel bars. The plant set up in B.C. by Pacific Continuous Steel utilized a rolling mill to produce grinding balls from steel billets. While the initial capital investment of this alternative is higher than a ball forging plant, the major advantages are that steel billets are likely to be more readily available and less expensive than round bar stock.

However, even though steel billets are a less specialized product, it is difficult to be assured of a regular source of supply. One of the major reasons that Pacific Continuous Steel ceased production was the lack of a regular supply of steel billets of suitable quality to make grinding balls.

3. Integrated Steel Mill.

A third method of producing grinding balls is to construct a fully integrated steel mill capable of producing balls from scrap steel. As a result, a local source of raw material for the plant could be obtained. At the present time, there appears to be an excess of scrap steel in B.C., as considerable quantities are shipped to mills in Washington. According to Statistics Canada, approximately 121,742 tons of scrap steel were exported to the U.S. through B.C. ports in 1980.

The capital costs for an integrated steel mill, however, are substantial, as steel making furnaces and continuous casting equipment are required in addition to a steel rolling mill and ball forging equipment. Furthermore, to obtain sufficient sales to justify a steel mill, it is likely that other steel

TABLE 10

GRINDING BALL PLANT

ESTIMATED CAPITAL COSTS

Land	$ 600,000
Building	400,000
Equipment	
Induction Furnace	1,000,000
Ball Forge Machine	1,800,000
Quenching and Tempering System	800,000
Other Equipment	400,000
	5,000,000
Contingency Allowance @30%	1,500,000
Estimated Capital Costs	$6,500,000

products would also have to be produced. An evaluation of the potential markets for other steel products, as well as an assessment of the long term availability of scrap metal in B.C., would have to be undertaken to determine the feasibility of this alternative.

Due to the limited scope of the study, we have concentrated our analysis on the feasibility of a ball forging plant using round steel bars, as this alternative requires the least capital investment. Further analysis would have to be undertaken to determine if the lower cost and greater availability of raw material provided by the other production alternatives are sufficient to justify the additional capital investment required.

C. CAPITAL INVESTMENT

Based on interviews with equipment suppliers and producers of grinding balls in the U.S. and eastern Canada, we have obtained estimates of the minimum capital investment required to establish a grinding ball plant using round steel bars as a source of raw material.

For an annual production volume of approximately 28,000 tons, on a three shift per day basis, the capital costs to set up a grinding ball plant in the Lower Mainland are estimated to be approximately $6.5 million. A breakdown of the major costs of the production facility are provided in Table 10 on the opposite page.

D. PRELIMINARY FEASIBILITY ANALYSIS

The major expense in producing forged grinding balls is the cost of the raw material. Based on discussions with local steel distributors, we obtained the current price of round steel bars of a suitable quality to make grinding balls. Total raw material cost, including provision for waste material, is estimated to be in the range of $390 to $410 per ton of grinding balls produced.

Based on interviews with grinding ball producers supplying other markets in North America, the conversion costs, including labour, power, repairs, overhead and depreciation expenses, to make forged steel balls are estimated to range from $100 to $125 per ton, depending on the size of ball produced. As a result, the total costs to produce grinding balls are estimated to be between $490 and $535 per ton.

If the facility was located in the Lower Mainland, for example, the freight rate by rail to the Highland Valley would be approximately $14 per ton, which is about the same as shipping balls from Edmonton, Alberta to the Highland Valley. Consequently, the price charged for grinding balls, F.O.B. Vancouver, could be at least equivalent to that of the current suppliers.

Based on an average revenue of $550 per ton, the income, before interest charges, of the grinding ball plant is estimated to range from $15 per ton to $60 per ton of grinding balls produced. If the project is financed at current interest rates of about 18%, the interest cost would be about $40 per ton of grinding balls produced. As a result, there appears to exist some potential to establish a viable grinding ball plant in B.C. using purchased steel bars.

To determine the actual viability of the grinding ball plant, however, more detailed financial analyses would first have to be undertaken. Based on our initial review, some methods of enhancing the feasibility of the project are as follows:

1. Utilizing used production equipment, thereby reducing the initial capital investment required.

2. Arranging long term financing through debentures or other methods, in order to reduce interest costs.

3. Reducing raw material costs through a long term contract guaranteeing a minimum purchase quantity.

4. Increasing the initial production volume to more than 28,000 tons per year.

As mentioned previously, the direct raw material costs could also be reduced by using steel billets or scrap steel as the source of raw material, instead of round steel bars. A more detailed analysis, however, would have to be undertaken to determine the minimum production volumes to justify the capital investment required for these two alternatives.

Further analysis would also have to be undertaken to determine the competitiveness of a local grinding ball plant as compared to the plants currently supplying the market. The degree of competition from the Stelco plant in Edmonton would likely be very stiff since this plant utilizes scrap metal as its source of raw material. Furthermore, the capital investment required by Stelco to add capacity to their existing plant would likely be lower than the cost of constructing a new grinding ball plant.

E. CONCLUSIONS AND RECOMMENDATIONS

Based on our preliminary analysis, there appears to be some potential for the establishment of a viable grinding ball production facility in B.C. The cost and availability of raw material on a long term basis, however, are the critical factors in determining the viability of the project. Consequently, we recommend that a more detailed feasibility analysis be undertaken for a local grinding ball plant. Some aspects which should be included in the study are as follows:

1. The most economic form of raw material to use, including alternatives such as round steel bars, steel billets, or scrap steel.

2. The specific sources and likely costs, on a long term basis, of raw material to make grinding balls.

3. The specific production process to be employed.

4. A detailed financial analysis of the estimated capital costs, net income and return on investment for the project.

APPENDIX 1

LIST OF EXISTING MINES

AND CEMENT PLANTS CONTACTED

DON FERENCE
& ASSOCIATES LTD.

LIST OF EXISTING MINES AND CEMENT PLANTS CONTACTED

A) METAL MINES

MINE	OPERATOR	LOCATION OF MINE
Afton	Afton Mines Ltd.	Kamloops, B.C.
Beaverdell	Teck Corporation	Beaverdell, B.C.
Bell Copper	Noranda Mines Ltd.	Babine Lake, B.C.
Bethlehem Copper	Bethlehem Copper Corporation	Ashcroft, B.C.
Boss Mountain	Noranda Mines Ltd.	Hendrix Lake, B.C.
Brenda	Brenda Mines Ltd.	Peachland, B.C.
Brinco	Brinco Mining Ltd.	Cassiar, B.C.
Craigmont	Craigmont Mines Ltd.	Merrit, B.C.
Delkalb	Delkalb Mining Corp.	Ashcroft, B.C.
Endako	Placer Development Ltd.	Endako, B.C.
Equity Silver	Equity Silver Mines Ltd.	Houston, B.C.
Faro	Cyprus Anvil Mining Corp.	Faro, YT.
Gibralter	Gibralter Mines Ltd.	Williams Lake, B.C.
Granduc	Canada Wide Mines Ltd.	Stewart, B.C.
Granisle	Noranda Mines Ltd.	Babine Lake, B.C.
Highmont	Teck Corporation	Highland Valley, B.C.
Island Copper	Utah Mines Ltd.	Port Hardy, B.C.
Kitsault	Amax of Canada Ltd.	Alice Arm, B.C.
Lornex	Lornex Mining Corporation Ltd.	Logan Lake, B.C.
Northair	Northair Mines Ltd.	Brandywine Falls, B.C.

MINE	OPERATOR	LOCATION OF MINE
Ruth Vermont	Ruth Vermont Mines Ltd.	Golden, B.C.
Scottie Gold	Scottie Gold Mines Ltd.	Stewart, B.C.
Silvana	Dickenson Mines Ltd.	New Denver, B.C.
Similkameen	Newmont Mines Ltd.	Princeton, B.C.
Sullivan	Cominco Ltd.	Kimberly, B.C.
Tungsten	Canada Tungsten Mining Corp. Ltd.	Tungsten, NT.
United Keno Hill	United Keno Hill Mines Ltd.	Elsa, YT.
Whitehorse Copper	Whitehorse Copper Mines Ltd.	Whitehorse, YT.
Wesfrob	Falconbridge Nickel Mines Ltd.	Tasu, Q.C.I, B.C.
Western	Westmin Resources Ltd.	Buttle Lake, B.C.

B) CEMENT PLANTS

COMPANY	LOCATION
Genstar Cement	Delta, B.C.
Canada Cement Lafarge	Kamloops, B.C.
Canada Cement Lafarge	Richmond, B.C.

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APPENDIX 2

LIST OF POTENTIAL MINING DEVELOPMENTS

DON FERENCE
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LIST OF POTENTIAL MINING DEVELOPMENTS

MINE	COMPANY	LOCATION OF MINE
Adanac	Placer Development Ltd.	Atlin, B.C.
Berg	Kennco Exploration Ltd.	Houston, B.C.
Carolin *	Carolin Mines Ltd.	Hope, B.C.
Cirque	Cyprus Anvil Mining Corp.	Williston Lake, B.C.
Gambier Island	20th Century Energy	Gambier Island, B.C.
Graham Island	Consolidated Cinola Mines	Q.C.I., B.C.
Goldbelt	Goldbelt Mines Inc.	Salmo, B.C.
Goldstream *	Noranda Mines Ltd.	Revelstoke, B.C.
Jason	Pan Ocean Oil Ltd.	MacMillan Pass, Y.T.
Kutcho Creek	Esso Resources Canada	Dease Lake, B.C.
MacTung	Amax Northwest Mining Ltd.	MacMillan Pass, Y.T.
Poison Mountain	Long Lac Minerals Exploration Ltd.	Lillooet, B.C.
Red-Chris Group	Texagulf Canada Ltd.	Dease Lake, B.C.
Rust Creek	Hudson Bay Mining & Smelting	MacMillan Pass, Y.T.
Schaft Creek	Teck Corporation	Telegraph Creek, B.C.
Stikine Copper	Kennco (Stikine) Mining Ltd.	Telegraph Creek, B.C.
Sustat	Falconbridge Nickel Mines Ltd.	Williston Lake, B.C.
Trout Lake	Esso Resources Canada	Revelstoke, B.C.
Valley Copper	Cominco Ltd.	Highland Valley, B.C.

* Under construction in 1981.

APPENDIX 3

REGIONAL DISTRICTS INCLUDED IN FOUR MARKET AREAS WITHIN B.C.

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REGIONAL DISTRICTS INCLUDED IN FOUR MARKET AREAS WITHIN B.C.

Area	Regional Districts Included
South East B.C.	Columbia - Shuswap Central Kootenay East Kootenay
South Central B.C.	Thompson - Nicola Central Okanagan North Okanagan Kootenay Boundary Okanagan - Similkameen
South West B.C.	Greater Váncouver Central Fraser Valley Dewdney - Alouette Sunshine Coast Powell River Capital Cowichan Valley Nanaimo Fraser - Cheam Squamish - Lillooet Alberni - Clayoquot Comox - Strathcona Mount Washington
Northern B.C.	Stikine Peace River - Liard Kitimat - Stikine Skeena - Queen Charlotte Central Coast Bulkley - Nechako Fraser - Fort George Cariboo

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APPENDIX 4

MARKET PROJECTIONS FOR GRINDING BALLS AND RODS IN B.C. AND THE YUKON IN 1985 AND 1990

DON FERENCE
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PROJECTED DEMAND FOR GRINDING BALLS AND RODS IN B.C. AND YUKON BY REGION IN 1985

Region	LEVEL OF MINING ACTIVITY Low (tons)	Medium (tons)	High (tons)
Grinding Balls			
South East B.C.	1,300	1,300	4,000
South Central B.C.	37,900	55,800	61,700
South West B.C.	15,600	15,500	15,600
Northern B.C. and Yukon	21,600	24,300	31,600
	76,400	96,900	112,900
Grinding Rods			
South East B.C.	400	400	400
South Central B.C.	9,000	9,000	9,000
South West B.C.	200	200	200
Northern B.C. and Yukon	19,500	19,500	21,000
	29,100	29,100	30,800
TOTAL:	105,500	126,000	143,700

DON FERENCE
& ASSOCIATES LTD.

PROJECTED DEMAND FOR GRINDING BALLS AND RODS IN B.C. AND YUKON BY SIZE IN 1985

Diameter	LEVEL OF MINING ACTIVITY		
	Low (tons)	Medium (tons)	High (tons)
Grinding Balls			
1" - 1½"	7,000	7,600	8,900
2"	9,900	10,500	11,800
2½"	25,400	28,900	32,900
3"	19,700	29,700	35,700
4"	6,800	9,200	10,900
5"	7,600	11,000	12,700
	76,400	96,900	112,900
Grinding Rods			
3"	3,100	3,100	3,300
4"	26,000	26,000	27,500
	29,100	29,100	30,800
TOTAL:	105,500	126,000	143,700

DON FERENCE
& ASSOCIATES LTD.

PROJECTED DEMAND FOR GRINDING BALLS AND RODS IN B.C. AND YUKON BY REGION IN 1990

Region	LEVEL OF MINING ACTIVITY		
	Low (tons)	Medium (tons)	High (tons)
Grinding Balls			
South East B.C.	1,300	4,000	4,000
South Central B.C.	62,000	68,600	68,600
South West B.C.	15,600	15,600	27,500
Northern B.C. and Yukon	28,100	44,800	61,100
	107,000	133,000	161,200
Grinding Rods			
South East B.C.	400	400	400
South Central B.C.	9,000	9,000	9,000
South West B.C.	200	200	200
Northern B.C. and Yukon	19,500	21,200	22,900
	29,100	30,800	32,500
TOTAL:	136,100	163,800	193,700

DON FERENCE
& ASSOCIATES LTD.

PROJECTED DEMAND FOR GRINDING BALLS AND RODS IN B.C AND YUKON BY SIZE IN 1990

Diameter Grinding Balls	LEVEL OF MINING ACTIVITY Low (tons)	Medium (tons)	High (tons)
1" - 1½"	8,700	9,700	11,200
2"	10,300	12,700	14,100
2½"	33,000	39,800	45,900
3"	32,400	42,000	54,400
4"	10,600	13,300	16,700
5"	12,000	15,500	18,900
	107,000	133,000	161,200
Grinding Rods			
3"	3,100	3,300	3,300
4"	26,000	27,500	29,200
	29,100	30,800	32,500
TOTAL:	136,100	163,800	193,700