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INDIAN AND NORTHERN AFFAIRS CANADA
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INDUSTRIAL MINERALS AND MINOR METALS AND THEIR POTENTIAL FOR DEVELOPMENT IN THE YUKON

Compiled By

D.A. Downing, Resource Engineering
Revised and Updated from Original Study by A. Woodsend (1988)

Canada

Yukon
Government

This report is available from:
Exploration and Geological Services Division,
200 Range Road, Whitehorse, Yukon Y1A 3V1

PREFACE

This open file represents the first major update and revision of A. Woodsend's 1988 study entitled *Industrial Minerals and Minor Metals and Their Potential For Development In The Yukon*. The original study was commissioned by the Klondike Placer Miners Association and was funded by the Industrial Research Assistance Program of the National Research Council of Canada.

This current version is an extensive update of the original report and was prepared using the most recent data available. Location maps displaying each individual Yukon occurrence and its appropriate Yukon Minfile occurrence number have also been added.

The reformatting and compilation of information for this report was performed by David Downing (Resource Engineering). Project advisers were Lori Walton, Mineral Development Agreement (MDA) Coordinator and Steve Morison, Chief Geologist, Exploration and Geological Services Division (EGSD), Northern Affairs Program, Yukon Region. Robert Deklerk, Staff Geologist, EGSD, reviewed and edited the report.

This report was funded under the Canada/Yukon Economic Development Agreement (EDA).

S.R. Morison
Chief Geologist
Exploration and Geological Services Division
Northern Affairs Program
Yukon Region

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(from first edition, December 1988)

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Project advisers were John Maissan, Director, Energy and Mines Branch of the Yukon Territorial Government, and Gordon Gutrath, President and Chief Executive Officer of Queenstake Resources Ltd.

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CONTENTS

SUMMARY

The industrial minerals and minor metals are reviewed alphabetically. Where applicable, information has been included on mineral types, uses, deposit characteristics, mining methods, producers, market specification, prices, Canadian deposits, and Yukon occurrences.

Comments are also made on the likelihood of the discovery of Yukon deposits and the potential for their development.

Industrial minerals and minor metals which have been identified as deserving more attention in the Yukon are grouped as follows:

Group 1: Industrial mineral deposits known to occur in the Yukon which could be developed given a likely change in market conditions.

barite

Group 2: Industrial minerals and minor metals which are presently known to occur in the Yukon in uneconomic amounts, but for which there is a reasonable chance of discovering economically viable deposits.

cassiterite, fluorspar, gypsum, jade, nepheline syenite, olivine, phosphates, rare earths, talc.

Group 3: Industrial minerals which, though presently unknown in the Yukon, could be expected to occur, and which command a high-enough price to encourage exploration.

celestite, china clay (kaolin), cryolite, diamonds, lascas.

Group 4: Industrial minerals and rocks for which baseline studies and inventories are needed to assess the potential for development or improve their present exploitation.

dimension stone, lime, peat, sand and gravel.

INTRODUCTION

SCOPE OF THE STUDY

The primary objective of this study is to evaluate the potential of industrial minerals and minor metals in the Yukon through literature search and communications with industry and government agencies.

On a world-market scale particular attention has been given to those industrial minerals which fell into one or more of the following categories:

a) those of which Canada is a net importer,

b) those of which Western Canada is a net importer,

c) those for which there is an inadequate world market supply, and which therefore command premium prices,

d) those for which there is a growing need due to a decline in existing supplies, and

e) those for which markets are growing due to changing modern technologies.

Narrowing the focus to the Yukon, the intention was to identify:

a) known industrial mineral deposits which could be developed given a likely change in market conditions,

b) industrial minerals and minor metals which are presently known to occur in the Yukon in uneconomic amounts, but for which there is a reasonable chance of discovering economically viable deposits,

c) industrial minerals which, though presently unknown in the Yukon, could be expected to occur, and which command a high-enough price to encourage exploration, and

d) industrial minerals and rocks for which baseline studies and inventories are needed to assess the potential for development or improve their present exploitation.

REPORT FORMAT

The industrial minerals and minor metals are covered under alphabetically arranged headings. Information has been included where applicable, on mineral types, industrial uses, deposit characteristics, mining methods, market specifications, current prices, and Yukon occurrences documented in the Yukon Minfile.

Yukon occurrence listings from the Yukon Minfile are provided for each commodity. The locations for those commodities with multiple occurrences are plotted on Yukon maps.

An index of minerals and rock types has been included.

FACTORS LIMITING INDUSTRIAL MINERAL DEVELOPMENT IN THE YUKON

All the major industrial minerals have been covered in this study, but even a brief glance at the table of contents will show that there are those that are either unlikely to occur in the Yukon, or, if they do occur, are unlikely to be developed successfully.

Some of the factors limiting deposit occurrences are the geological setting, past and present climate, and geomorphological environment. The major factor limiting deposit development is the distance to markets.

Geological Setting

The geological environments which favour the occurrence of commercially viable deposits of many of the industrial minerals are rare or absent in the Yukon.

Sillimanite, for example, occurs in the higher grades of thermally and regionally metamorphosed argillaceous rocks such as sillimanite-cordierite gneisses, biotite-sillimanite hornfels and micaceous sillimanite schists. In the Yukon this grade of metamorphism is rare, being limited to narrow zones on the contacts of the highest temperature intrusives.

Another example is graphite, economic deposits of which are usually confined to shield rocks, a geological environment which does not occur in the Yukon.

Climatological Environment

Climate, past and present, can have a bearing on the formation of mineral deposits. For example diatoms flourish in the warm waters of subtropical inland seas. Though they can, and do, survive in much cooler environments, the ratio of diatom remains to particles of sediment falls so that more northerly diatomite deposits tend to be low grade.

Other minerals that require warmer climates for their development include nitrates, manganese oxides,and borates.

Geomorphological Environment

Some deposits require a particular geomorphological environment, or land form, for their development. For example most of the world's supply of rutile, ilmenite, zircon and monazite is produced from beach sands and it is unlikely that such beaches will be found on the Yukon's Arctic coastline.

Transportation Considerations

Many industrial minerals are characterized by their low unit values and sensitivity to transportation costs. In such cases deposits have to be near their markets. Exceptions exist when deposits are directly on tidewater allowing the use of cheap water transportation.

The Yukon's small population and relative remoteness means that it is unlikely that the lower priced, bulk-usage commodities could be exploited profitably. The emphasis needs to be on quality deposits of those minerals that command a relatively high unit price.

PLACER BY-PRODUCT MINERALS

Minerals that are referenced as placer by-products (or accessories) are anatase, cassiterite, garnet, ilmenite, kyanite, magnetite, monazite, rutile scheelite, staurolite, topaz, and zircon.

COMMODITY PRICES

Where possible product prices have been included, but it must be stressed that price structures for most industrial minerals are not as clear-cut as they are for precious and major metals. Quoted and list prices may bear little relationship to actual prices, which are usually negotiated between buyer and seller, taking into account such factors as transportation distances, product specifications, and local competition. Indeed the prices for some commodities are confidential, either because of intense competition for market shares, or conversely because a single company dominates production.

ABRASIVES:

diamond, corundum, emery, garnet, staurolite

TYPES AND GENERAL DESCRIPTION

Natural abrasives, in order of decreasing hardness, are diamond, corundum, emery and garnet. Some types of sandstones and grits are also used as grindstones, pulpstones, hones and scouring powders, and a variety of materials such as china clay and talc are used as 'soft abrasives' for polishing and buffing.

Synthetic abrasives include carborundum, made by fusing silica, coke and sawdust, and boron carbide (fused borax, coke and tungsten carbide). Corundum can also be produced artificially by fusing bauxite in an electrical furnace, and synthetic diamonds now compete with natural stones in the smaller size ranges.

In general synthetic abrasives are preferred to their natural counterparts because their size, shape and grain can be closely controlled during manufacture.

Among the low-cost abrasives are silica sand, pumice and slag. However, silica sand has been banned in Europe as a sand blasting agent due to the induced health risk of contracting silicosis. Staurolite, slag and garnet are substitutes for silica sand in sand blasting applications. Slag has the best cost advantage but is also under environmental scrutiny due to its high metal content. Slag may not be used for sand blasting bridges in British Columbia due to the sensitivity of fish and the aquatic environment to heavy metals.

A new area of demand for abrasives is in ultra high-pressure water jets for industrial cutting and cleaning. A superior quality supply is required and thus demands a higher price for the product. The expanding application of this technology promises to sustain demand for abrasives, particularly garnet.

DIAMOND

Diamond is both the hardest material known to man and possesses the best abrasion resistance. It's brittle nature, however, results in a tendency to shatter under stress.

More than 80% of all natural diamonds are used industrially as cutting or abrasive agents. Those used as abrasives are the black diamonds (carbonado) and the poorly coloured or flawed diamonds (bort).

Before 1870 all world production was from alluvial (placer) deposits, but in 1870 the diamond bearing kimberlites of the Cape Colony, (now South Africa) were discovered. Subsequently kimberlite pipes were found throughout southern and central Africa, Australia, Russia and in North America. Diamonds have only been found in one other type of rock, laproite. Of more than 3000 kimberlite bodies discovered in the world only about 2% contain economic concentrations of diamonds.

Kimberlites are mantle derived material that erupt at very high speed followed by collapse back into their own vent. They form volcanic funnel-shaped necks or pipes and are composed of ultra-basic peridotite. Considerable contamination with clasts of country rock occurs as the explosive vent collapses in on itself. Typically, assemblages of alteration products from the source peridotite predominate close to the earth's surface due to the instability of the mantle minerals in the surface environment.

Kimberlite pipes are usually irregular in shape but are contained within a distinctly circular area 100s of meters in diameter and they tend to be found in clusters. The traditional thinking is that diamondiferous kimberlites are only found on ancient cratons. This is increasingly challenged with the number of diamonds being found in the North American Cordillera.

Regional exploration for diamond deposits, both primary and alluvial, begins with the examination of stream sediments and soils for the presence of a specific group of mantle derived, high temperature minerals associated with kimberlite intrusives. Generally these are pyrope, chrome diopside, ilmenite, zircon and perovskite. These minerals may be concentrated using gravity techniques. Diamond has a specific gravity of 3.51. Areas with concentrations of these minerals are then sampled taking very large volumes from which any diamonds are recovered by a portable gravity treatment plant. The high iron content of the mantle derived minerals usually allows the detection and mapping of pipes through the use of geophysics.

While gold sampling may focus on concentrations in the order of one part per million, diamond sampling may depend on sample concentrations of one part per billion.

Today the world's leading producers of natural industrial-grade and gem diamonds are Zaire, Australia, USSR, South Africa, and Ghana. The diamond market is very tightly controlled by the Central Selling Organization of the De Beers group which markets more than 80% of the world's production. Prices range from dollars per carat to thousands of dollars per carat depending upon quality. One carat equals 200mg.

There is no current commercial production in North America, however, exploration continues to locate new kimberlite pipes on an almost annual basis. Increasing exploration success throughout the late 1980's to the present has resulted in a quantum leap in the number of companies exploring for diamonds. The addition of junior exploration companies and major claim staking rushes over the last five years has greatly raised the profile of diamond potential in Canada.

Prior to the turn of the century, hundreds of diamonds were located during placer mining for gold in the northeastern United States. The diamonds were concentrated in the terminal glacial deposits of the multiple continental glaciations that extended to the south of the great lakes. Historically diamonds were also known from several other local sources, the most prolific being what is presently Crater of Diamonds State Park in Arkansas.

Throughout eastern Canada diamonds are erratically found in glacial drift. Exploration over several years has uncovered fields of kimberlitic pipes at several locations. The first promising discoveries were at Isle Bizzard near Montreal, the Kirkland Lake area and on Sommerset Island in the Northwest Territories. At present time none of these pipes have returned economic quantities of diamonds but are currently being reevaluated.

Recent important discoveries include a diamond camp at Fort Collins on the Colorado-Wyoming border where some one hundred pipes have been found, fourteen of them diamond bearing. In Saskatchewan there has been considerable activity east of Prince Albert where Monopros Ltd, an affiliate of De Beers Consolidated Mines, and Uranerz Exploration and Mining discovered kimberlitic material. A major staking rush 300 km northeast of Yellowknife in the Northwest Territories followed the announcement of 81 small diamonds from a 155 meter core sample late in 1991. A subsequent 160 tonne bulk sample of the Pine Lake pipe contained diamonds up to 90 carats. A cluster of micro-diamond bearing pipes on the Michigan-Wisconsin border is at the commercial evaluation stage.

Throughout the North American Cordilleran an increasing number of diamonds and diamond targets are being located. In British Columbia the Cordilleran alkaline belt occupies a broad zone parallel to and encompassing the Rocky Mountain Trench. In the Yukon this trend continues into the Tintina Trench. The alkaline rocks in this belt range in age from Devonian to Sub-recent, and include carbonatites, nepheline syenites and ultramafic lamprophyres. Though only one kimberlite, the Cross Diatreme, has been found in this belt, there are several diatreme pipes, one of which contained two microdiamonds. Several diamonds have recently been discovered in Alaska by placer miners along the northwestern extension of this belt.

Synthetic diamonds can compete with natural stones in size ranges up to 16 mesh, and this has resulted in price decreases for the smaller stones. End uses for synthetic diamonds are machinery 27%, mineral services 18%, stone and ceramic products 17%, and abrasives 16%.

Possible diamond substitutes for abrasive uses are cubic boron nitride, fused aluminum oxide, silicon carbide, garnet, emery and corundum.

CORUNDUM

Corundum has a composition of Al_2O_3, and occurs as non-transparent grey to brown six-sided prisms which often taper at both ends to a barrel-shaped form. The gem varieties of corundum are ruby (red), sapphire (blue), Oriental Amethyst (purple), Oriental Emerald (green), and Oriental Topaz (yellow).

Corundum crystallizes from a magma rich in alumina and poor in silica, and is also found in pegmatites that intrude basic igneous rocks. Prior to 1921 the world's primary production was from Ontario's nepheline syenites. Current production is from Zimbabwe, South Africa, India, Russia, Turkey, and Greece.

The North American market consumes 400 tonnes of corundum per year, but it is predicted that future use will see a steady decline due to the substitution of plastics for glass in many optical components, especially eyeglasses.

Corundum abrasive grain is priced at $1 - $3/kg

EMERY

Emery is a natural mixture of granular corundum and magnetite with some hematite and spinel, and is so named from Cape Emeri on the island of Naxos, Greece. Deposits are usually formed by contact metasomatism of crystalline limestone, basic igneous rocks, and chlorite and hornblende schists. Producers are Zimbabwe, South Africa, India, Greece, Turkey and the United States.

Emery demands a price of $2 - $3/kg.

GARNET

There are many different types of garnet but the most useful as abrasives are the iron-bearing almandine garnets with a composition $3FeOAl_2O_3(SiO_2)_3$. Though these are common in many metamorphic rocks, the traditional commercial in situ deposits in North America were all in the Adirondack Mountains of New York State and Maine where up to 80% of the rock may be formed of garnet. Until recently there was only limited production from western North America that came from placers in Idaho. North American reserves have remained relatively constant at a 10-15 year supply. Due to this fact new deposits must be of very high grade and exceptional quality to break into the market.

New deposits have recently been developed both in Idaho and British Columbia. At Hedley, British Columbia, the Crystal Peak Garnet deposit is scheduled for production in late 1992. Many other small deposits of garnet are known in Canada and there was production in the past from Lennox and Addington Counties, Ontario, where almandine garnets occur in gneisses.

Two potential sources of garnet exist within Yukon. Garnet as a byproduct of placer mining has long been considered. Although not worthwhile at the present time an increasing demand for higher quality abrasive products could conceivably reverse this situation. Yukon also has extensive skarn deposits associated with Cretaceous intrusives. Typically the garnet content is too low to be considered for commercial production, however, they have never been systematically evaluated in terms of abrasives.

US production, 85% of which is consumed domestically, is some 32 000 tonnes/annum valued at more than US$7.2 million. End uses are abrasives 60%, water filtration 30%, electronic components 7%, ceramics and glass 3%. The use of garnet in ultra high-pressure water jets for industrial cutting and cleaning is increasing demand and value for the product. Demand is also benefiting from health concerns over alternate abrasives.

Current prices for garnet range from $100/tonne for sand blasting product to $200/tonne for higher quality filtration and water jet cutting material to a high of >$300/tonne for heat-treated and coated abrasive.

STAUROLITE

With a composition $FeAl_4Si_2O_{10}(OH)_2$, staurolite is a resistant heavy mineral recovered as a byproduct from Du Pont's heavy mineral mines in Florida. It is marketed under the brandname 'Starblast'. The supply is closely related to the demand for titanium dioxide, and at present there are large stocks of staurolite available. Continuing pressure from health agencies to limit the use of silica sand in sandblasting may result in increased demand. The market for staurolite is small and local. Price for bagged product is $0.25 - $0.50/kg.

YUKON OCCURRENCES

To date in Yukon there are no commercially viable abrasive deposits. Though most placer heavy mineral concentrates contain garnet, the quantities are too small to warrant upgrading and marketing. Garnet bearing skarn deposits associated with Cretaceous intrusives are widespread in Yukon. No documented evaluation of the potential for commercial grade deposits has been carried out. Staurolite has been identified, usually with kyanite, in heavy mineral concentrates in the Klondike.

ASBESTOS

With past asbestos producers in the Yukon at Clinton Creek and in northern British Columbia at Cassiar, there has been intense exploration for asbestos in the Territory. The following section is intended only as a general summary.

Asbestos is a term applied to a group of minerals that can be separated easily into fibers that are resistant to heat. The properties that make asbestos valuable are incombustibility, infusibility, fibrous structure, strength and flexibility of fibers, low heat conductivity, high electrical resistance, chemical inertness, and resistance to decay.

The six varieties of asbestos fall into two mineral groups: 1) chrysotile, or serpentine asbestos, and 2) amphibole asbestos, including anthophyllite, amosite, crocidolite, tremolite, and actinolite.

Canadian chrysotile deposits in Quebec are the world's leading producers.

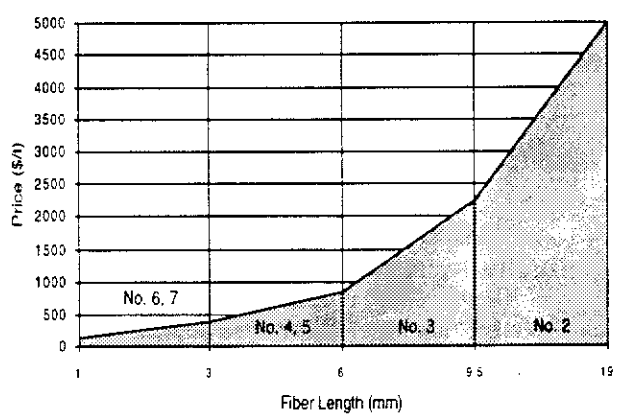
Cassiar Asbestos Corporation Limited produced mostly high quality fiber from a small ultramafic body located on Porcupine Hill on the south side of Clinton Creek near Fortymile, 80 km northwest of Dawson City.

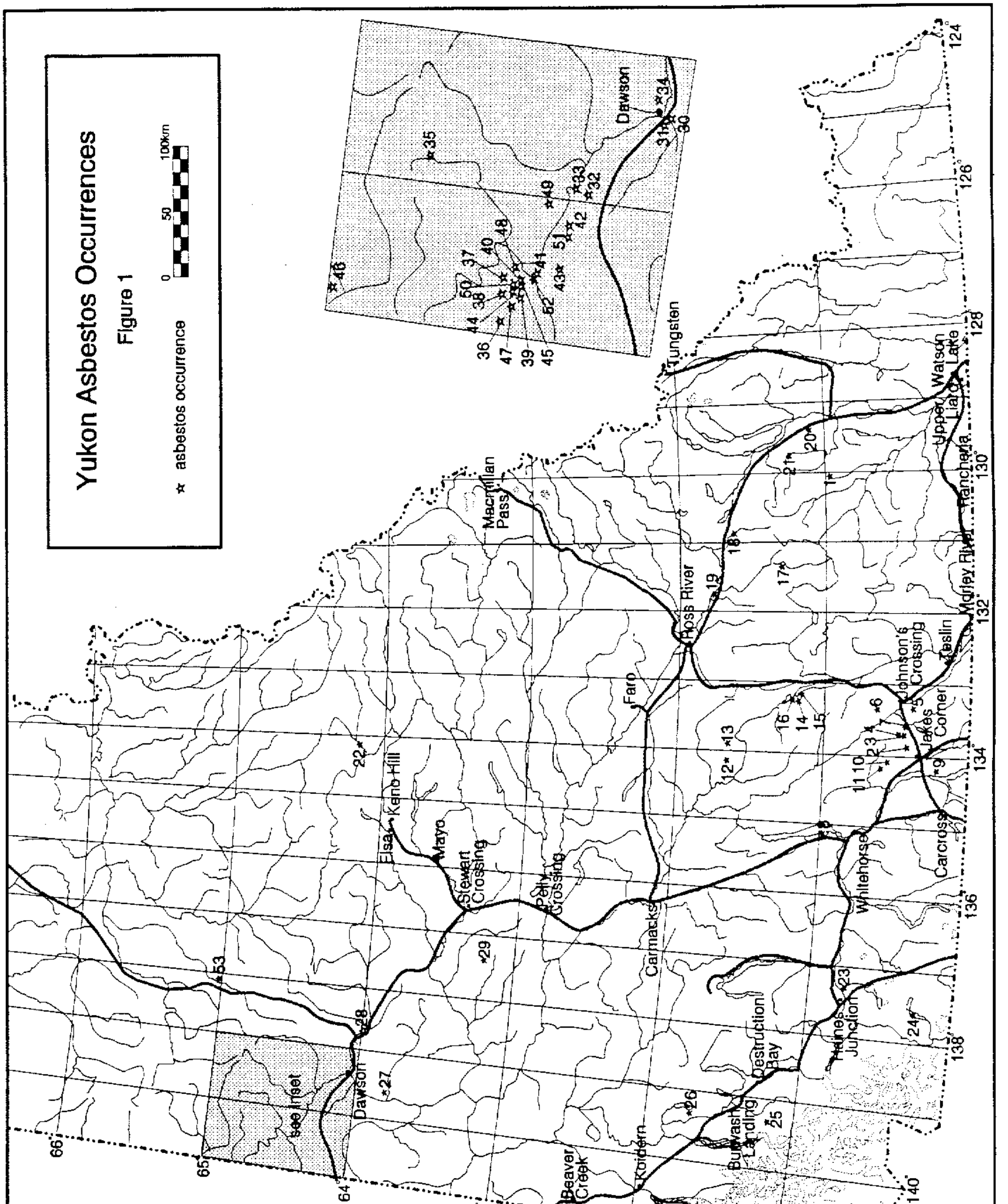
Several other asbestos-bearing ultramafics in the Clinton Creek - Woodchopper Creek - Cassiar creek areas have been explored, and asbestos occurrences are reported in the Yukon's other main ultramafic areas in the Kluane and Campbell Ranges and near Teslin.

The market for asbestos products has been depressed for several years now due to increasing concerns over the health problems associated with asbestos fibers. A 1989 ban of asbestos products in the United States was lifted late in 1991. The controlled use of asbestos rather than a ban is expected to have positive effects on the market throughout the world.

Substitution for asbestos by other natural and synthetic fibres is increasing. Competition comes from glass, carbon, aramid fiber, glass & rock wool; wollastonite and other fibrous silicate minerals; cermets; SiN; PVC(pipes).

Asbestos Price vs Fiber Length




Yukon Asbestos Occurrences
Figure 1
asbestos occurrence
0
50
100km
see inset
Dawson
Tungsten
Macmillan Pass
Ross River
Faro
Keno Hill
Elsa
Mayo
Stewart Crossing
Pelly Crossing
Carmacks
Whitehorse
Carcross
Jakes Corner
Johnson's Crossing
Teslin
Morley River
Rancheria
Upper Liard
Watson Lake
Haines Junction
Destruction Bay
Burwash Landing
Koidern
Beaver Creek
60
61
62
63
64
65
66
124
126
128
130
132
134
136
138
140

YUKON ASBESTOS OCCURRENCES

No.	NTS	Minfile No.	Name
1	105B16	52	PORCUPINE
2	105C05	10	RIBA
3	105C05	11	SEAFORTH
4	105C05	12	SQUANGA
5	105C06	13	HAYES PEAK
6	105C11	15	GUNSIGHT
7	105C05	28	DALAYEE
8	105D14	48	EFFIE
9	105D08	69	MARSH
10	105D09	70	LAVALEE
11	105D09	71	MICHIE
12	105E09	15	ILLUSION
13	105F12	5	DUNITE MOUNTAIN
14	105F06	8	TOWER PEAK
15	105F06	9	DODY
16	105F06	63	RYHORCHUK
17	105G06	16	EL
18	105G10	43	BOT
19	105G12	48	PUP
20	105H03	14	LIND
21	105H05	16	TUCHITUA
22	106D01	4	WHITING
23	115A11	32	REX
24	115A05	44	ISLAND
25	115G06	10	DUKE
26	115G11	65	TINCUP
27	115O13	47	INDIAN
28	115O15	121	ASBESTOS BLUFF
29	115P03	19	ROSEBUD
30	116B03	11	FIBRE
31	116B03	12	MIDNIGHT DOME
32	116B05	43	ASS
33	116B05	44	WOODCHOPPER
34	116B03	117	SHAROL
35	116B13	154	DEM
36	116C07	22	SPHERE
37	116C07	23	BUDINSKI
38	116C07	24	FOXY
39	116C07	25	CLINTON CREEK
40	116C07	26	ACHERON
41	116C07	28	CONSTANTINE
42	116C08	33	CALEY
43	116C08	116	MICKEY
44	116C07	119	SMITHERINGALE
45	116C07	120	JUDY
46	116C07	121	KAVANAUGH
47	116C07	122	JOHNNY
48	116C08	123	CHUDY
49	116C08	129	TJOP
50	116C07	141	CRIPPLE
51	116C08	144	TIZA
52	116C07	145	SIKANNI
53	116G01	NW34	DYKE

BARITE

witherite

GENERAL DESCRIPTION

The two chief barium minerals are barite ($BaS0_4$) and witherite ($BaC0_3$), the former being by far the most commercially important.

Barite is found frequently as a gangue mineral in lead-zinc veins, and as veins and bedded replacement deposits, usually within limestones and dolomites. Yukon deposits are mostly sedimentary exhalative deposits. Bedded and nodular barite are found as stratiform horizons within the black shales of the Selwyn Basin. It can also form residual deposits from the weathering of barite-bearing rocks.

Witherite is a comparitively rare mineral found in association with barite or in narrow veins with galena and sphalerite.

USES and SPECIFICATIONS

More than 65% of North American barite production is used as a weighting agent in oil and gas well-drilling fluids, for which there is no effective substitute. Other less important uses are as a white paint pigment, filler in rubber, whitener and filler in paper, and a component of glass and barium chemicals. The uses of barium have been increasing and include secondary barite products of barium sulphide, barium carbonate, barium oxide, barium nitrate, barium metal, barium precipitate, lithopone ($BaSO_4ZnS$), barium hydroxide.

Ore deposits of barite are generally massive and of high purity (better than 90% barite), and are selectively mined to minimize contamination with wall rock. It is generally uneconomic to produce a barite concentrate from gangue material in barite-base metal deposits.

Processing normally includes crushing followed by metallurgical upgrading which may involve heavy media separation and tabling, then washing, drying, dry milling and air classification.

Specifications for drilling-grade barite are a specific gravity of 4.2, a minimum of 92% $BaSO_4$, a particle size of 90%-95% minus 325 mesh, and a maximum 250 ppm of soluble alkaline earths such as calcium or witherite. This last specification is important because calcium and witherite dissolve in the drilling fluid and adversely effect the fluid's density. Calcium can be easily floated off a barite gravity concentrate, but witherite is a more serious problem because it is toxic and has a density similar to that of barite.

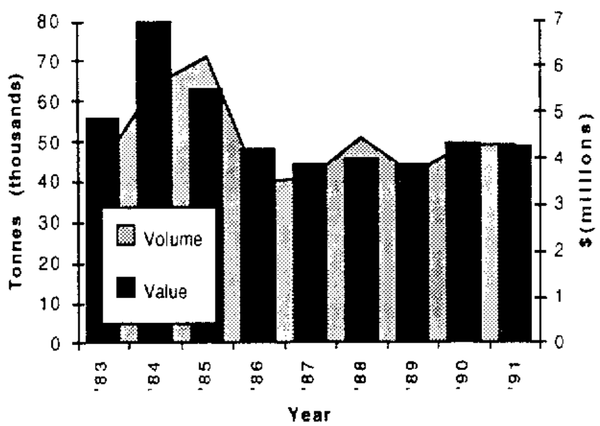
Specifications for barite to be used in paint (chemical grade) are 94% $BaSO_4$, a particle size of 200 mesh or smaller, and a high degree of whiteness and light reflectance.

WORLD PRODUCTION

In the late 1980's North American consumption was at an all time low due to a stagnant oil and gas well-drilling industry caused by low world oil prices. Imports of Chinese and Moroccan drilling grade barite into the gulf coast exceeded domestic production.

Canadian production is from operations in British Columbia, Ontario and Nova Scotia, with intermittent production from Newfoundland. In British Columbia, Mountain Minerals Co Ltd operates the Parson Mine which ships crude barite to be milled at Lethbridge, Alberta, and Baroid of Canada processes small quantities from tailings near Spillimacheen.

Canadian Barite Production



In northern British Columbia, Magcobar Minerals Division of Dresser Canada Inc started production from the Fireside deposit near km 588 of the Alaska Highway in 1984. Production continued the following year, but since 1986 the mine has seen only sporadic production.

YUKON DEPOSITS

In 1983 Yukon Barite Company Ltd signed agreements to supply Gulf Canada and Esso with drilling barite from the TEA deposit for use in the Beaufort Sea. Approximately 8000 tonnes was mined and stockpiled near Ross River. Though a mill was built 5 km south of Ross River, management and legal problems forced the closure of the operation before any of the feed was milled. Further reserve drilling took place in 1986. The claims were transferred to H. Coyne and Sons Ltd. in Oct. 1989. The pit was rehabilitated in 1990 and 1991, a mill was set up in Ross River and a test run was completed. The enterprise is continuing to identify markets and will be evaluating other occurrences in 1992 for production potential.

The TEA (SAMOVAR, Minfile #105O 020) deposit is in the northwestern Selwyn Mountains. It consists of a 100 m thick bedded barite section with accessory interbeds of baritic limestone, limestone, chert and shale at the base of the shale member of the Devonian - Mississippian Earn Group. The barite is high quality and requires only screening and grinding to produce a drilling grade mud. Reserves are at least 68 000 tonnes.

Several other deposits in the Selwyn Mountains carry barite as an accessory to lead-zinc-silver mineralization. Examples are the TOM-JASON (Minfile #115O 07, 019) and the MEL-JEAN (Minfile #95D 05, 08) properties. The latter has a reported average grade of 51.6% barite with lead and zinc sulphides and could potentially produce three concentrates assaying 95% barite, 79% Pb and 64.7% Zn respectively.

The OMEGA (Minfile #115P 045) property on the east side of the Syenite Range 110 km east of Dawson City is held by Noranda Exploration Company Ltd. It has a reported potential for 2 million tonnes of drilling grade barite. The property is close enough to the Klondike Highway to be considered as a source of direct-shipping ore for the Beaufort oil drilling program.

FUTURE POTENTIAL

A substantial rise in the price of oil would stimulate oil and gas well drilling, which in turn would improve the presently depressed barite market. A limiting factor is China which has enormous barite deposits with which it could flood the world market. However since it has entered production it has not taken such action and the market outlook appears very stable.

Prices at the moment range from $45/tonne for drilling grade barite up to $750/tonne for barium nitrate.

The Yukon has an impressive number of barite occurrences. A detailed inventory of these occurrences would target those deposits that merit additional work. Areas previously explored for stratabound lead-zinc deposits, particularly in the vicinity of roads, should be re-examined for their barite potential.

A number of smaller high grade barite vein occurrences are located in the metamorphic halos of Cretaceous intrusives in barite rich shales. These veins could conceivably be mined to provide material for upgrading slightly sub-grade barite from the larger barite deposits.

The effectiveness of stream sediment and soil sampling combined with gravity surveys as an exploration method has been demonstrated in the discovery and development of the OMEGA property.

Yukon deposits are obviously competitive in supplying North Slope and Beaufort drilling projects.

They can also compete effectively on a world wide basis where located close to highway infrastructure.

YUKON BARITE OCCURRENCES

Formational

No.	NTS	Minfile No.	Name
3	95D06	5	MEL
4	95D15	9	LAST
5	95D15	15	DAVE
7	95E01	46	STAMMERS
11	105B01	105	STOLLERY
12	105C09	3	BAR
15	105F06	64	ASKIN
16	105F15	65	DIRK
18	105F15	88	GROWTH
19	105F14	89	WOODSIDE
20	105F15	115	MT. ROSS
21	105G14	94	DWONK
23	105I06	30	NOR
24	105I12	36	ORO
25	105I06	46	COMINCO
26	105I07	56	BOROVIC
27	105J16	23	PETE
28	105J16	24	COCO
29	105J13	25	ST. GODARD
30	105K05	106	URN
31	105K12	110	MT. MENZIE
32	105L14	32	HORSFALL
33	105L14	50	HANK
34	105L15	51	DROMEDARY
35	105L09	52	ANACONDA
36	105L14	54	KAL
37	105M16	79	TINY ISLAND
38	105M16	80	GORDEY
39	105N15	16	ANDREA
41	105O01	1	TOM
42	105O06	6	SCOT
43	105O01	13	RACICOT
44	105O01	19	JASON
45	105O02	20	SAMOVAR
46	105O07	21	WALT
47	105O07	22	TRYALA
48	105O03	23	DRIZZLE
49	105O01	24	NIDD
50	105O01	27	GARY
51	105O01	28	FETCH
52	105O06	29	GOW
53	105O08	36	FAN
54	105O07	45	STROSHEIN
55	105O07	46	MINORCO
56	105O01	52	BAILES
57	105P10	31	GRAVITY
58	105P12	32	BAROID
61	106B05	30	MARTHA
62	106B07	31	EMBAYMENT
64	115P14	45	OMEGA
65	116A12	24	SANGUINETTI
66	116A12	29	ST. BRIDGET
67	116A12	30	LOMOND
68	116B09	128	REIN
69	116B09	142	GRAPS

Formational (MV*)

No.	NTS	Minfile No.	Name
2	95C04	SE24	TROPICAL
60	106B14	23	KEN
70	116G07	NW48	BILBO

*Mississippi Valley

Skarn

No.	NTS	Minfile No.	Name
12	105C09	3	BAR

Vein

No.	NTS	Minfile No.	Name
1	95C05	SE23	POOL
14	105F14	38	BARITE MOUNTAIN
22	105H12	48	TED
40	105N10	20	JAGOWERITE
71	116G01	NW58	HIP
73	116H08	NW65	HEIDI
74	116G08	NW66	BANGON

Volcanogenic

No.	NTS	Minfile No.	Name
13	105F07	12	MM
17	105F10	73	BNOB

Uncertain

No.	NTS	Minfile No.	Name
6	95D07	21	KRONIG
10	105B03	34	PLATE
63	106B07	33	FLYBYE
72	116G01	NW62	JADE

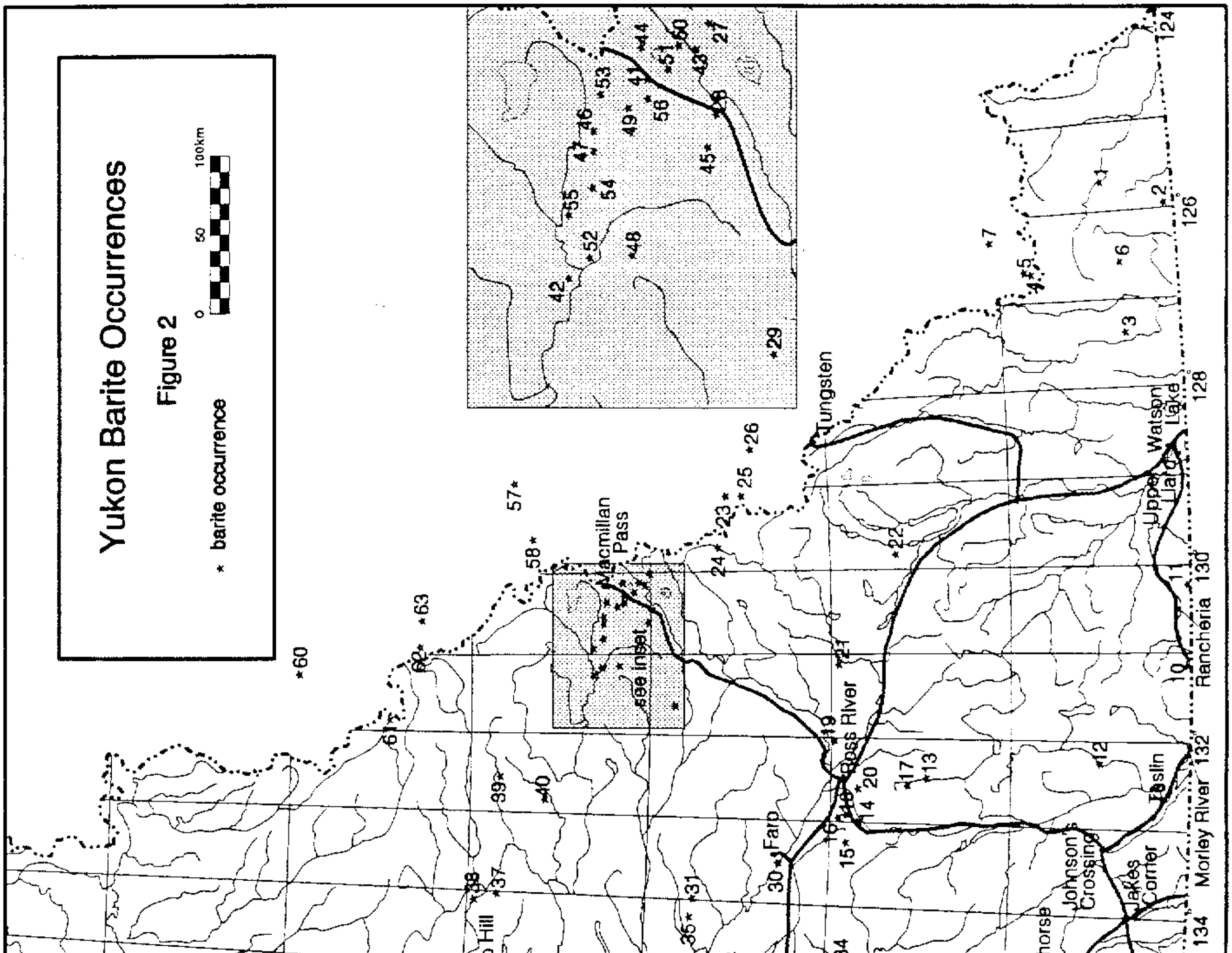
BORATES

GENERAL DESCRIPTION

Of the many minerals which contain boron, only a few are commercially important. These are:

borax	$Na_2B_4O_7.10H_2O$
kernite	$Na_2B_4O_7.4H_2O$
colemanite	$Ca_2B_6O_{11}.5H_2O$
ulexite	$NaCaB_5O_9 \cdot 8H_2O$
boracite	$Mg_6C_{12}B_{14}O_{26}$

Typically these minerals are found near hot springs and in lakes in volcanic regions. The boron is emitted in vapours and exhalations escaping from fumaroles


Yukon Barite Occurrences
Figure 2
* barite occurrence
0 50 100km
see inset
Macmillan Pass
Tungsten
Watson Lake
Upper Liard
Rancheria
Teslin
Morley River
Johnson's Crossing
Jakes Corner
Whitehorse
Carcross
Ross River
Faro
Carmacks
Keno Hill
Elsa
Stewart Crossing
Pelly Crossing
Dawson
Haines Junction
Destruction Bay
Burwash Landing
Kolderm
Beaver Creek

and solfataras. These vapours are dissolved in water and the boron compounds deposited by natural evaporation as surface efflorescences, lake deposits or evaporates.

Borax buried under later sediments is transformed to kernite by partial dehydration. Kernite may be hydrated to tincalconite with $5H_2O$, and back again to borax. Kernite exposed during mining also hydrates to borax.

USES

Borax is used chiefly in the manufacture of porcelain enamels, earthenware and china glazes, and glassware. 'Pyrex' is a borosilicate glass. Borax is also used in detergents, solvents, fireproofing solutions, fluxes and welding rod coatings, and taxidermy. In addition it is a food preservative, soil additive, antiseptic and deodorant. Boron and boron carbide are used as abrasives.

PRODUCERS

Turkey and California produce most of the world's borax. California production is from a Tertiary kernite deposit near Kramer in the Mojave desert. This deposit is 1.6 km wide, 30 m thick, and lies at a depth of 120 m. (The mineral kernite derives its name from Kern County, California.) Production involves dissolving the kernite followed by evaporation and redeposition of borax from the super-saturated solution.

Additional US production is from Searles Lake brines and from an underground deposit of colemanite and ulexite in Death Valley, (marketed as 'Twenty Mule Team Borax').

Annual US production is consistently in the 1 250 000 tonne range. Turkey produces about 1 5000 000 tonnes annually.

The US imports colemanite and ulexite from Turkey, and a small amount of boric acid from Turkey, Italy and Argentina.

Other world producers are Russia, Argentina, Chile, China and Peru.

Sales are on a bulk tonnage basis with a minimum 99.5% boron chemical content. The market is slowly increasing with prices very stable. Borax pentahydrate demands a price of $285/tonne.

CANADIAN DEPOSITS

Given Canada's geological environment and climactic conditions it is unlikely that commercial borate deposits will be found.

CALCITE CRYSTALS

Iceland spar

Calcite($CaCO_3$), is one of the most common minerals, being the principal constituent of limestone. Calcite crystals have a strong double refraction, and when flawless, are used for polarizing light in optical instruments.

The most noteworthy deposits of calcite crystals are in Iceland (hence the name Iceland spar) where the calcite is embedded in clays within pockets and cavities in basaltic lavas. Other deposits are in South Africa, Spain and New Mexico.

In recent years 'polaroid' has substituted for calcite for some purposes.

CASSITERITE

Cassiterite, SnO_2, is the ore mineral of tin. It is a resistant heavy mineral which will, under the right conditions, accumulate to form placer deposits. In the late 1980s, Brazil emerged as the world's leading tin producer doubling its market share in 5 years. The remaining bulk of the world's tin production is from placers in Malaysia and Indonesia, with additional hardrock production primarily from Australia and Bolivia.

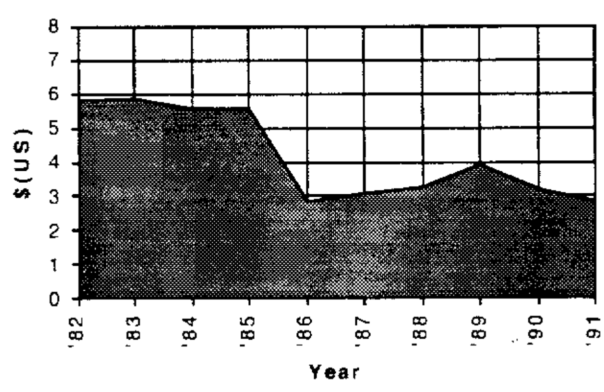
In situ deposits are generally in or near a specific kind of granite, generally referred to as a 'tin granite', which is usually enriched in such elements as fluorine, boron, and silica.

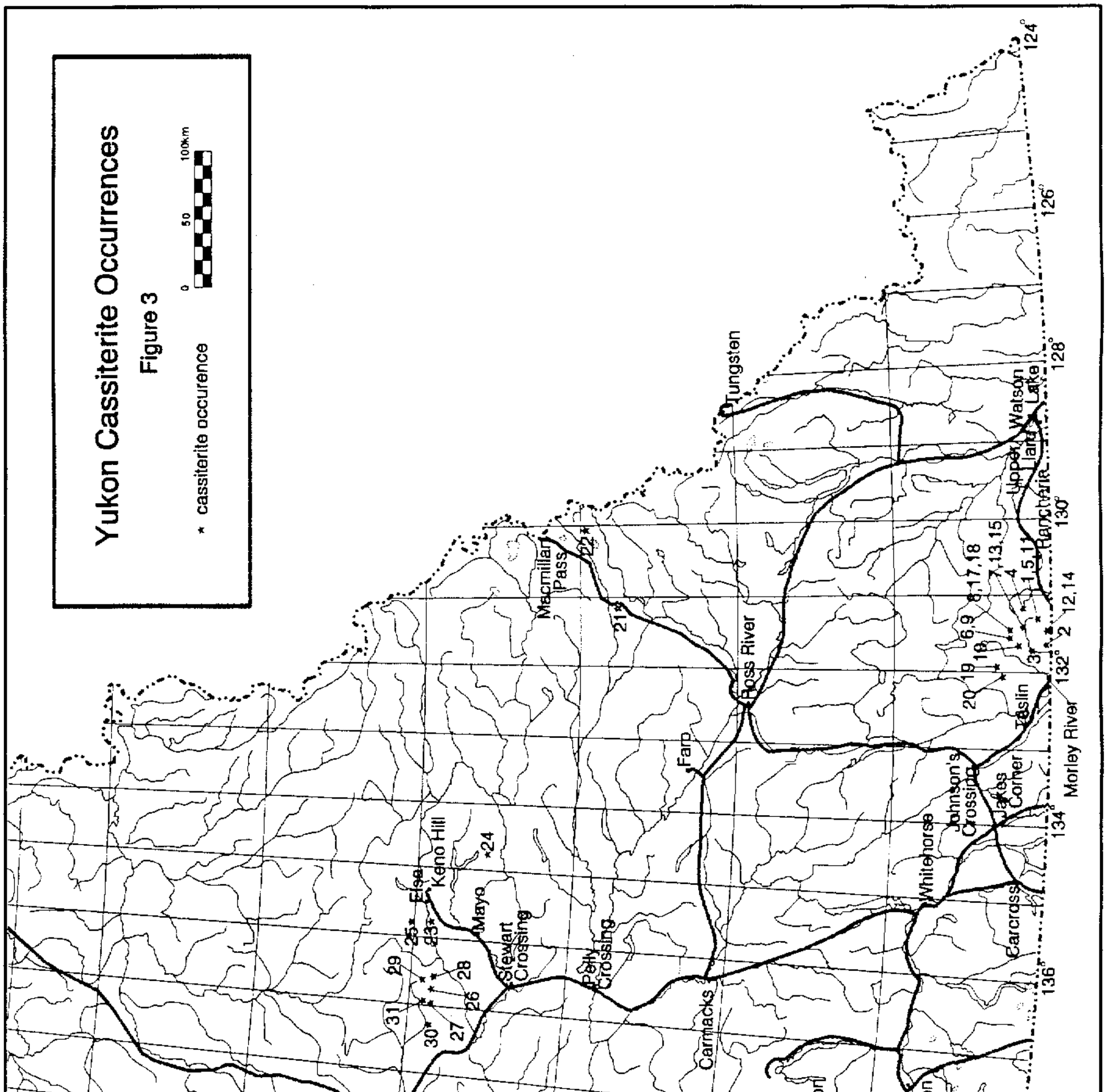
In 1985 tin prices crashed when a cartel of the world tin producers, the International Tin Council, failed. The price fell to almost half of its former value dropping to less than US$3/lb.

Canada's only hardrock tin mine closed in the fall of 1991. Rio Algom's East Kemptville deposit near Yarmouth, Nova Scotia opened two weeks before the collapse of the tin cartel. The mine had 3-4 years reserves remaining but had been unprofitable since opening.

Intense exploration for tin in the Yukon in the late 1970s resulted in the discovery of numerous occurrences grouped primarily in two areas, the Swift River -

Tin Price




Yukon Cassiterite Occurrences
Figure 3
* cassiterite occurence
0 50 100km
Dawson
Mayo
Keno Hill
Elsa
Stewart Crossing
Pelly Crossing
Carmacks
Faro
Ross River
Macmillan Pass
Tungsten
Watson Lake
Upper Liard
Rancheria
Teslin
Morley River
Johnson's Crossing
Jakes Corner
Whitehorse
Carcross
Haines Junction
Destruction Bay
Burwash Landing
Koidern
Beaver Creek
66°
65°
64°
63°
62°
61°
140°
138°
136°
134°
132°
130°
128°
126°
124°

Seagull Creek area in south central Yukon, and the McQuesten River area in central Yukon. None of the discoveries proved economic at the time.

Cassiterite found in placer concentrates is of two kinds: colloidal cassiterite or 'wood tin', and normal cassiterite.

Colloidal cassiterite is a minor component of heavy mineral concentrates from several creeks in the Klondike and the source is thought to be the porphyritic rhyolite between Hunker Creek and the Klondike River. There is an in situ tin occurrence with associated topaz and fluorite near the mouth of Germaine Creek, (Minfile #116B 06).

Normal (non-colloidal) cassiterite is found in placer concentrates from several creeks east of the Tintina Trench. Examples are Clear Creek, Barney Pup, Johnson Creek, Highet Creek and Dublin Gulch. The quantities recovered have not justified their cleaning and shipping.

YUKON CASSITERITE OCCURRENCES

Skarn

No.	NTS	Minfile No.	Name
11	105B03	30	PARTRIDGE
12	105B03	36	SCREW
13	105B03	73	CURRENT
14	105B03	80	SLOUCE
15	105B03	82	PONT
2	105B04	38	LOGJAM
3	105B04	40	JC
17	105B04	70	CAN
18	105B04	85	TIN
19	105B05	120	KARTUHINI
20	105C08	36	MULLIGAN

Vein

No.	NTS	Minfile No.	Name
1	105B03	35	GODDART
8	105B04	84	DU
9	105B04	86	CUSP
21	105J11	8	MT. SHELDON
22	105J16	16	ITSI
24	105M07	66	KALZAS
23	105M13	31	STREBCHUK
25	106D04	24	SHEPPARD
30	115P14	34	BARNEY
26	115P15	8	EAST RIDGE
28	115P15	30	OLIVER
31	115P15	51	JABBERWOCK

Uncertain

No.	NTS	Minfile No.	Name
4	105B03	78	VERLEY
5	105B03	79	SKIN
7	105B03	83	SIN
6	105B04	81	DUVAL
10	105B04	88	SMITH
27	115P15	10	RIDGE
29	115P15	31	BIX
32	116B02	4	GERMAINE

CELESTITE

With a composition $SrSO_4$, celestite is the main commercial source of strontium. It is frequently associated with barite in vein deposits (together with calcite and galena), with gypsum in sedimentary beds, as disseminations in limestones, and in solution cavities in limestones. Type deposits are the celestite beds in Cyprus, and those discovered in Qatar in the late 1980's which contains 63 000 tonnes containing 75%-85% strontium sulphate.

Strontium compounds are used mainly for purifying electrolytic zinc and in the manufacture of colour television picture tubes. It's use in ceramic magnets is a growing field. It is also widely used in pyrotechnic and other applications for its brilliant and unique red flame wavelength. Strontium adds desirable properties to a variety of metallic alloys.

All North American strontium is imported, largely from Mexico. Turkey and Spain are the only other two major exporters of twelve producing countries. World production capacity of 250 000 tonnes is 95% utilized.

A past Canadian celestite producer was Kaiser Aluminum's mine at Loch Lomond, Nova Scotia. Celestite also occurs in vein deposits in Ontario.

The Yukon's potential as a celestite producer is not known. There do not appear to be any published references to occurrences in the Territory, even though celestite has a close association with barite. Any investigation into the Yukon's barite (or gypsum) deposits should not overlook the possibility of a celestite component.

CHROMITE

Chromite is briefly described in this report due to its use as a refractory sand.

Chromite is the only commercial source of chromium for steel alloys. It is also used for its refractory properties in bricks and foundry sand. It is employed for a wide variety of other uses including ceramic colourant, wood preservative, photographic chemicals and fireworks.

Chromite has a formula of $FeCr_2O_4$ with substitution of Mg and Al common. Refractory grade chromite typically contains 35% Cr_2O_3 and up to 30% Al_2O_3 with less than 15% Fe.

Most of the worlds chromite comes from stratiform deposits such as the layered intrusions of the Bushveld Complex in South Africa. Nodular and podiform deposits are more numerous in the western cordillera and are usually hosted in Alpine-type and Alaskan-type intrusions.

The major world producers are South Africa, Russia, Albania, India, Finland and Turkey. The two largest importers are Japan and the United States.

South African refractory grade sand (46% Cr_2O_3) averaged US$90/tonne fob Transvaal in1991.

There is some concern over the occupational health risks of working with chrome which could lead to substitution in the future.

(also see Chromium, listed with minor metals p.29)

YUKON CHROMITE OCCURRENCES

No.	NTS	Minfile No.	Name
1	105C05	12	SQUANGA
2	105D09	71	MICHIE
3	105F12	5	DUNITE MOUNTAIN
4	115A12	37	STRIDE

CLAY MINERALS:

ball clay, stoneware clay, china clay, kaolin, fire clay, bentonite, fullers earth, attapulgite, common clays

TYPES AND GENERAL DESCRIPTIONS

Clay deposits are bodies of loose, earthy, very fine grained natural sediment or soft rock, composed largely of clay size (less than 4 microns diameter) or colloidal particles of hydrous aluminum silicates.

The clay minerals themselves are largely formed by the decomposition of feldspathic rocks, and hence clay deposits also contain fine grains of quartz, decomposed feldspar, carbonates, ferruginous matter and other impurities. The physical and chemical characteristics of each clay deposit are governed by the composition of the parent material and the manner and environment of deposition.

The most important commercial characteristics are plasticity, degree of swelling when wet, retention of shape after drying, shrinkage after drying, hardening by firing, and shrinkage after firing.

BALL CLAYS

Ball clays (pipe clays) are essential in the manufacture of pottery. They are highly plastic and therefore easily moulded before firing, and after firing they are white or cream coloured. They are widely used in general earthenware, electrical and other porcelain, wall tiles and sanitary ware.

STONEWARE CLAYS

Stoneware clays or brick clays generally contain less than 20% Al_2O_3 and up to 50% silica, and are intermediate between low-grade common clays and purer kaolinitic clays. They are used in the manufacture of salt-glazed and other types of stoneware, sewer pipes, flue liners and facing brick. Deeply weathered shales may also be used as stoneware clays.

CHINA CLAY

China clay (kaolin, ceramic clay) is so called because it was originally obtained from China's Kiangsi Province in the eighteenth century. The term kaolin is a corruption of the chinese word 'Kauling', the 'high ridge' or Kuling range to the east of King-te-chen, the town which for centuries has been the focus of Chinese pottery manufacture.

China clay is used in paper and ceramics production, as a filler in rubber, wall plaster and paints, a stiffener in textiles, and a component of some types of cement.

China clay deposits are of two general types; in situ, and residual. They are formed as a result of the decomposition of feldspars in granite or granitic rocks. Decomposition leaches out the potash and leaves a residue of kaolin, quartz and mica. Residual deposits are from the transportation and redeposition of the kaolin.

Paper grade china clay commands a premium. Suitable deposits contain a minimum of 38% Al_2O_3, LOI (loss on ignition) of about 14%, a maximum of 0.5% Fe_2O_3 , a maximum of 0.2% TiO_2, and a combined maximum of 0.2% Na_2O and K_2O. The end product should be white with a brightness between 80 and 90, be free from grit, and fire white.

FIRE CLAY

Fire clay or refractory clay is a detrital clay composed mainly of kaolinite with a high alumina and silica content. It is used in the manufacture of firebricks and crucibles and as a component of foundry sand.

BENTONITE

Bentonite is the commercial name for material containing not less than 85% of the clay mineral montmorillonite, a hydrated silicate of aluminum with calcium and magnesium. Montmorillonite is a soft mineral with a white, grey-white or rose-red colour and a characteristic ability to absorb water.

There are two general types of bentonite deposits: sodium bentonite (or western bentonite) which absorbs a large percentage of water, swells considerably, and contains sodium as its predominant exchangeable ion, and calcium bentonite (or southern bentonite) which does not swell appreciably, and has calcium as its chief exchangeable ion. There are numerous intermediary types between these two. Most bentonite deposits are formed from the alteration of beds of volcanic ash, or by direct precipitation of montmorillonite in shallow marine basins.

In its natural form bentonite is used as a binder in stock feeds, iron ore pellets, and foundry sand, as a carrier for pesticides, a cleanser for animal fur, and as kitty-litter.

When treated with sulphuric acid bentonite becomes 'activated', and is used for purifying and decolouring petroleum and vegetable oils, animal fats, waxes, beverages and syrups. It is also used as a catalyst in the cracking of crude oil.

FULLER'S EARTH

Fuller's Earth (bleaching clay), very similar to calcium bentonite, is a fine-grained greenish brown or yellowish clay-like substance which differs from ordinary clay in its unusually low degree of plasticity. Its name is derived from its earliest use for 'fulling' or cleansing woolen fabrics and cloth by its ability to absorb grease and oily matter. It is still used to remove greasy matter from woolen goods, and to decolour oils, and as a filler in cosmetics.

ATTAPULGITE (& SEOPIOLITE)

Attapulgite is a lath-shaped clay mineral with a chain-type structure which forms a specific type of fuller's earth. North American production is primarily from Florida and Georgia.

COMMON CLAYS

Common clays and shales are used almost entirely for the manufacture of structural clay products, cement in particular.

CANADIAN CLAY DEPOSITS

Most Canadian deposits are the result of Pleistocene continental glaciation and subsequent stream transport. Deposits include marine and lake sediments, reworked glacial tills, interglacial clays and floodplain clays.

Clays and clay products are materials mainly characterized by high bulk, low unit value, and sensitivity to transportation costs.

Ball clay occurs as deposits of kaolinite, quartz and mica in the Whitemud and Ravenscrag Formations of southern Saskatchewan and southeastern Alberta.

Stoneware clay is also produced principally from the Whitemud Formation, with less important sources near Abbotsford, Quesnel and Williams Lake in British Columbia.

No Canadian China clay deposits have yet been developed because of their small size and attendant benefication problems. As a result almost all Canada's requirements are imported, 56% into Ontario, 35% into Quebec, 4% into Manitoba and 3% into British Columbia. Demand for China clay relies heavily on the paper industry which now accounts for 75% of its use.

Recently however, Fargo Resource Limited has begun to evaluate its Lang Bay property in British Columbia. Fargo reports a primary kaolin deposit and a related secondary deposit in the Brown Bed formation. Benefication tests have been successful in producing a good filler-grade product from the primary deposit for use in the paper industry. The secondary deposit is of a grade suitable for ceramic and cement uses. A feasibility study showed it to be economically viable. A 1500 tonne bulk sample was collected in 1991. The kaolin produces a 60 brightness product with an abrasion of under 20 mg. This product would be suitable for paper making. A second stage test, in which the kaolin is actually used in processing will be completed in 1992.

Kaolin prices vary greatly depending on the product grade, but recent quotes per tonne range from $150 to $240 for coating clays, $80 to $120 for filler clays, and $50 to $65 for pottery clays.

Fire clay deposits are found in the Whitemud Formation, and on Sumas Mountain in British Coulmbia, but nonetheless considerable amounts are imported from the US into Ontario and Quebec because of the cost of transportation from western Canada.

Canadian bentonite occurrences are confined to the Cretaceous and Tertiary formations in Manitoba, Saskatchewan, Alberta and British Columbia.

Pembina Mountain Clays Inc produces non-swelling bentonite from the Upper Cretaceous Vermillion River Formation near Morden, Manitoba. Most of the production is processed at the company's Winnipeg plant where it is leached, washed, filtered, dried, pulverized and bagged It's main uses are as a decolourizer and purifier of mineral and vegetable oils .

Avonlea Mineral Industries Ltd mines and processes bentonite near Wilcox, Saskatchewan, and supplies well-drilling muds, foundry sand binders, and animal feed binders from its plant which has a 60 000 tonne/year capacity.

Dresser Industries Inc mines swelling bentonite from the Upper Cretaceous Edmonton Formation near Rosalind, Alberta. The mined material is dried, pulverized and bagged for use as foundry clay, a farm reservoir sealant, feed pelletizer, and drilling mud additive.

About 54% of Canada's bentonite is used as a binder in the pelletizing of iron ore concentrates, but with the recent decline in the iron ore industry this use is diminishing.

Drilling muds contain about 10% swelling bentonite which is used to prevent the loss of drilling fluid in permeable formations, and as a suspension agent to carry drill cuttings to the surface. Currently drilling muds consume 22% of Canada's bentonite.

Drilling muds are expected to account for most of the future increase in demand for Canadian bentonite, while demand related to the iron ore industry is expected to remain flat.

YUKON OCCURRENCES

Of all the clays, China clay commands the highest unit price, and a Yukon deposit could be well placed to serve the Pacific Rim markets. Unfortunately there are no known deposits in the Territory, either because conditions were never right for their formation, or because deposits that did form were subsequently removed by glaciation. There is still the potential for a discovery in the Bonnet Plume Basin and in the Dawson coal basin.

Bentonite has been reported in the Tertiary coal-basins near Watson Lake, and lower grade common clays are widespread.

With the exception of China clay it is unlikely that a clay deposit in the Yukon could be developed for external markets due to shipping costs. With regards to internal markets, although bricks were made in Dawson City in the days of the Klondike gold rush, no present-day demand of sufficient size has been identified.

CONSTRUCTION MATERIALS

cement, sand and gravel, common clays and shale, perlite, pumice, vermiculite, dimension stone

CEMENT

The Romans discovered that quicklime added to the volcanic ash of Puzzuoli gave a cement that set under water, and Puzzuolan cement is still produced today. In 1756 John Smeaton in England made a cement that set under water by burning an argillaceous limestone. That led to a search for similar limestones and the production of 'natural' cements. However the composition of the limestones used was extremely variable, and the dependability of the product unpredictable. In 1824 Aspdin made the first Portland Cement, so named because it resembled the famous Portland stone of England.

Portland Cement is produced by burning in a kiln a finely ground mixture containing about 75% CaO_3, and clayey minerals consisting of 20% SiO_2, Al_2O_3 , and Fe_2O_3, and 5% magnesia, alkalies etc. The kiln product is a fused complex of calcium silicates and aluminates in the form of rough spheres termed clinker. The clinker is ground to a fine powder and mixed with gypsum to prevent too rapid setting. When combined with water, sand, gravel, crushed stone or other aggregates, the cement binds the materials together to form concrete.

Limestone is the chief rock used to supply the calcium oxide, and the nearer it approaches the composition of the cement mixture the better. MgO should not exceed 10%, and pyrite and free silica should be absent. Calcium can also be supplied by marl, furnace slag and oyster shells. SiO_2 and Al_2O_3 are supplied by clay or shale. The combination of raw materials used are (1) limestone with clay or shale, (2) cement rock, alone or with high calcium limestone, (3) blast furnace slag and limestone, (4) marl and clay, (5) oyster shells and clay.

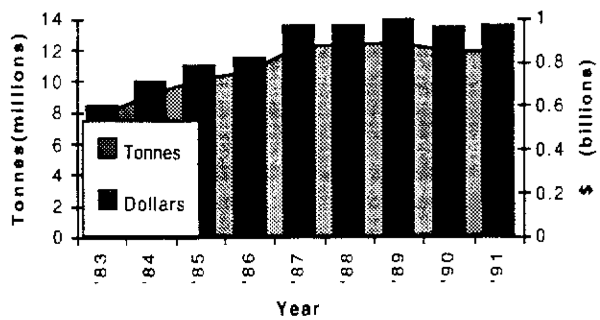
Shales are used in Newfoundland and New Brunswick to manufacture cement, while Ontario and Alberta use common clay from glacial drift. In British Columbia altered volcanic ash and shale is used.

Cement production is energy intensive, using an average 4896 mega joules per tonne produced.

Cement consumption is directly related to the construction industry which has seen no appreciable growth in recent years.

Canada's total production capacity is 16.54 million tonnes/year. Cement plants are concentrated near growth areas and available markets and are typically diversified and vertically integrated as suppliers of ready-mix, stone, aggregates, and concrete products.

Canadian Cement Production

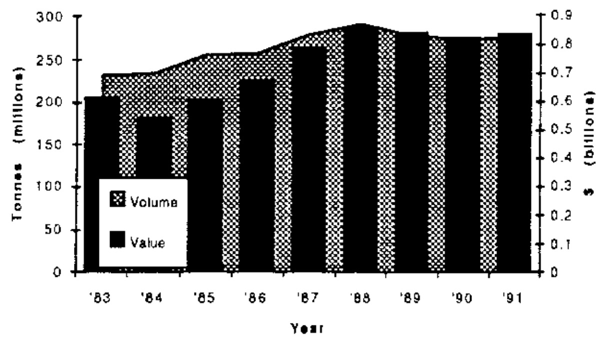


Western Canadian plant locations and capacities follow. Canada Cement Lafarge Ltd's Edmonton plant has a grinding capacity of 220 thousand tonnes/year. Genstar Cement Limited's Edmonton plant has a grinding capacity of 2040 thousand tonnes/year and a clinker capacity of 1186 thousand tonnes/year. Canada Cement Lafarge Ltd's Kamloops plant has a grinding capacity of 190 thousand tonnes/year and a clinker capacity of 180 thousand tonnes/year. CCL's Richmond plant has a grinding capacity of 555 thousand tonnes/year and a clinker capacity of 522 thousand tonnes/year. Genstar's Tilbury Island plant has a grinding capacity of 1000 thousand tonnes/year and a clinker capacity of 855 thousand tonnes/year.

SAND AND GRAVEL

Sand and gravel are essential to modern construction, but because of their low unit cost they are gener-

Canadian Sand & Gravel Production



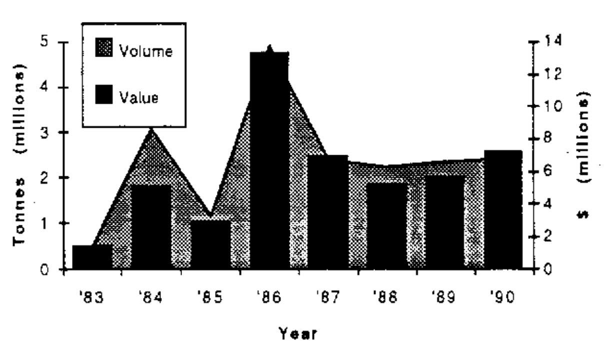
ally only used locally. Sand is a broad term used to cover almost any comminuted rock or mineral, but technically it is restricted to quartz sand with minor impurities of feldspar, mica, and iron oxides.

Size classifications vary but it is generally considered that fine sand has grains between 0.06 and 0.2 mm in diameter, medium sand between 0.2 and 0.5 mm, coarse sand between 0.5 and 2 mm, and gravel between 2 and 8 mm.

Sand deposit types include fluvioglacial, stream channel, flood plain, beach, elevated beach, wind blown, desert dune and marine and fresh water beds.

Most sand and gravel is used for building and paving. Some more specialized uses include mouldings in foundries, abrasives, filters, and a component of glass and refractory products. The purer sands are discussed under the heading 'Silica'.

Yukon Sand & Gravel Production



COMMON CLAYS and SHALES

Common clays and shales are used throughout Canada in the manufacture of lightweight aggregates and cement. Plants are usually adjacent to the deposits of raw material. Clays are dried and kilned, shales are crushed and screened before kilning.

PERLITE

Perlite is a variety of obsidian or glassy volcanic rock that contains 2%-6% of chemically combined water. When crushed and heated rapidly to 760–980^{o}C it expands between 4 and 20 times its original volume. It is used mainly by gypsum product manufacturers as an ingredient in wallboard and in roof insulation board. It is also used as a filter aid. Perlite is open to substitution from vermiculite, pumice, slag, diatomite, and expanded clay and shale.

Canada imports crude perlite from New Mexico and Colorado. In British Columbia, Aurun Mines developed a perlite property in the Empire Valley and in 1984 processed approximately 1000 tonnes for market trials. Other perlite deposits have been found near Francois Lake and Uncha Lake.

PUMICE

Pumice is a highly vesicular lava, the vesicles being formed by escaping gases and vapours during its consolidation It is used in lightweight concretes and as an abrasive. Pumicite is finer grained than pumice, usually less than 100 mesh, and is used in concretes for its pozzolanic qualities. (A pozzolan is a siliceous material with no cementing qualities until finely ground, in which form it will react with calcium hydroxide in the presence of water to form insoluble calcium silicates).

Most North American production is from California, Idaho, New Mexico and Oregon. Canada imports pumice from Greece and Oregon, but there are extensive pumicite beds in British Columbia and Saskatchewan. One example of a British Columbian deposit is in the Lillooet Valley where a coarse pumice agglomerate forms a large talus slope at the base of Plinth Mountain.

Production is dependent on transportation costs. Alternative substitution is by clay, shale, diatomite and crushed aggregate.

VERMICULITE

Vermiculite is used by the construction industry as an insulator. It is discussed under the heading 'Mica'.

DIMENSION STONE

Types include granite, limestone, travertine, marble, serpentine, sandstone, dolerite and soapstone. The term granite in this context can include syenite, monzonite, diorite, and granitic gneisses.

The important characteristics of a deposit are the ease of quarrying, the stone's strength, colour, hardness, workability, texture, porosity, and durability. Some lines of weakness, such as well spaced bedding or jointing planes, are necessary to assist in quarrying, but deep and irregular weathering is undesirable.

Some rocks that combine several of the required attributes have gained world-wide reputations. Examples are Carrara marble, Mexican onyx marble, Italian travertine, Scottish granite, Virginia soapstone, Bedford limestone, Ohio sandstone and Vermont marble.

Although dimension stone is under increasing pressure from other products such as steel, concrete, glass and ceramics, demand for marble, limestone, sandstone and slate has grown in recent years. The greatest growth markets are in residential and interior decorative uses. In the US the end uses of dimension stone are building stone 42%, monuments 27%, rubble 13%, flagging 4% and curbing 4%. The US imports US$302 million annually, largely from Italy.

Western Canadian stones that have been quarried for building materials include Manitoba's Tyndall Stone which is a mottled dolomitic limestone mined at Garson; a red granite from Lac du Bonnet northeast of Winnipeg; a grey granodiorite from Nelson Island, British Columbia; an andesite from Haddington Island, British Columbia; a pink quartzite from Babette Lake, British Columbia; and a sandstone known as Rundal Stone from near Banff, Alberta.

A more complete description of British Columbia's dimension stone types can be found in 'British Columbia Dimension Stone' by G.V.White and Z.D.Hora, British Columbia Ministry of Energy, Mines and Petroleum Resources, Minerals Resource Division, Information Circular 1988-6.

YUKON POSSIBILITIES

Cement consumption in the Yukon is probably of too low a volume to support a local plant, even though the required raw materials are to hand. In addition to a limited market, the Territory may not have the required inexpensive surplus power.

Though sand and gravel deposits are widespread in the Yukon, there is no inventory of their locations and characteristics. If such an inventory were made, particularly of those deposits nearer to roads, highway construction and maintenance could be planned more effectively. (If such a study were commissioned, the fine gold content of the gravels in known placer areas shoul be considered.)

Common clays and shales are also widespread in the Yukon, but it would appear that the local market for products made from them is limited, and transportation to external markets would be too costly.

There are no recorded perlite, pumice or vermiculite deposits in the Yukon.

There are numerous intrusives in the Yukon that could be used for dimension stone. An inventory of those that occur near roads in the south-western part of the Territory and the collection of a suite of samples for cutting and polishing would be the first steps necessary to identify Yukon dimension stone resources.

SidRock, a local stone operation opened in 1991. It produces several rock products including dimension stone and various crushed and paving stone products. The company has recently opened the Red Chief quarry at Jackson Lakes just north of Whitehorse.

CRYOLITE

The name cryolite is derived from two Greek words meaning 'frost' and 'stone', in reference to the mineral's resemblance to ice. Cryolite is an aluminum and sodium fluoride (Na_3AlF_6) and at one time was the only source of aluminum. Nowadays it is entirely superseded by bauxite.

Nonetheless it is still of great importance in the aluminum industry for it serves as a solvent for alumina in the electrolytic process of extracting aluminum from bauxite ore. Small amounts are also used as a whitener and opacifier in enamel, a constituent in white glazes, an insulating material, an insecticide, and a flux. Cryolite is also a source of fluorine.

Due to its scarcity the natural mineral has now been replaced by artificial cryolite.

Natural cryolite has only been mined in two places in the world, at Ivigtut in Greenland, and at Miask in the USSR.

The Ivigtut deposit, which was mined out in 1962, was a small pegmatite dike crossing a porphyritic granite. Accessory minerals were siderite, galena, chalcopyrite, sphalerite and fluorite.

There is a North American occurrence of this rare mineral at Pikes Peak, Colorado, and there is one reported Canadian occurrence.

DIATOMITE

Diatoms are microscopically small marine or fresh water algae, and diatomite consists of their siliceous remains, or tests. Diatoms extract silica from the water and secrete it to form an intricate microporous exoskeleton which is often symmetrical in design. A single cubic inch of diatomite can contain up to 70 million diatom tests.

Diatomite resembles chalk or clay but is chiefly made up of opaline silica, with minor amounts of water, alumina, iron oxides and alkalies.

When dry, diatomite can absorb more than three times its weight of water. In addition it is extremely light, insoluble in acids, soluble in alkalies, and has low thermal conductivity.

It is used as a filter and filler, as a sound and heat insulator, an absorbent, an abrasive, and as a lightweight aggregate.

Diatomite deposits range in age from the Cretaceous to Recent, but the most important ones are Tertiary. They occur in marine and fresh water sedimentary beds where they must have accumulated while the deposition of other sediments was inhibited.

The world's largest deposits are near Lompoc, California where beds up to 430 m thick are mined on a large scale. Other thick deposits occur in the California Coast Ranges. The remaining US production is from Washington and Oregon. Overseas producers include Denmark, Germany, Japan, Algeria and France.

There are three products: natural, calcined, and flux calcined. The natural product is dried and classified. Calcined products are sintered to modify particle size or permeability. Flux calcined products are sintered with a flux which has a stronger influence on permeability and also benefits colour.

The best grades are used as filters, and for this the important specifications are microscopic structure, particle size, chemical purity and inertness, density and filter performance.

The US is the largest producer and consumer, with production valued at US$130 million in 1986. Of this, 66% was used for filters, and 21% for fillers.

Until 1941 all Canadian diatomite production was from lake deposits in Nova Scotia, but since 1955 all production has been from the Quesnel area in British Columbia.

The Quesnel deposits, which are up to 35 m thick, are mined by Microsil Industrial Minerals Ltd which produces aggregate products for use as floor absorbents, soil conditioners, chemical carriers, and pet litters. Production statistics are not available.

Despite the British Columbia production Canada is a net importer of diatomite, importing 25 000 tonnes annually, mainly from the US and Denmark.

World wide demand for diatomite products is expected to grow steadily for although there are many substitute materials, diatomite's characteristics are unique. Of particular current interest is diatomite's unmatched filtration ability, a use which will see increased applications due to environmental and health concerns.

To date the market has been dominated by large producers, and the successful marketing of diatomite products depends on technical sales expertise backed by research and development.

YUKON OCCURRENCES

There are no documented deposits in the Yukon, though some diatomite may exist in the Tertiary coal basins in the south west.

FELDSPAR

Feldspars are the most common of the rock-forming minerals, being the chief constituent of igneous rocks. They form a group of aluminum silicates of potassium, sodium and calcium, but the most important commercial varieties are orthoclase and microcline (both potassium aluminum silicates), and albite (a sodium aluminum silicate).

Feldspars are used mainly in the manufacture of glass (54%) and ceramics (45%), though nepheline syenite is a strong competitor in the glass industry.

Deposits that can be worked commercially are usually granitic pegmatites. Quartz is the most common associated mineral, and this and other impurities have to be removed prior to marketing.

US production was more than 640 thousand tonnes in 1990 with an estimated value of US$25 million. North Carolina accounted for 70% of this production, with the remainder coming from South Dakota and Maine.

Recently quoted prices range between $34 and $65/tonne fob minesite.

At present there are no Canadian producers, though two western Canadian deposits have been investigated recently.

Bearcat Explorations Ltd explored a pegmatite in south-eastern British Columbia which contains 65% feldspar, 25%-30% quartz, 5%-8% muscovite, and 1% accessories. The pegmatite is 4 km long and 1.5 km wide.

In Manitoba the Tantalum Mining Corporation of Canada is investigating the possibility of recovering feldspar as a byproduct of its spodumene operation. The feldspar is rich in rubidium (1.3%), and potassium (9.5%) and could be used for the manufacture of high-voltage electrical insulators.

Canada imports more than 4000 tonnes/year of feldspar from the US and there is a definite need for a Canadian producer. Opportunities are especially good in the west, since all US production is from eastern states.

No large feldspar-rich pegmatites have been reported in the Yukon.

FLUORSPAR

GENERAL DESCRIPTION

Fluorspar is the commercial name for the mineral fluorite (CaF_2), a glassy transparent or translucent mineral which may be white, pale blue, violet, amethyst, deep purple, green or yellow in colour. If white light is passed through even colourless fluorspar a delicate violet colour usually results. This is known as 'fluorescence', so named after fluorspar.

Fluorspar occurs as a gangue mineral in association with lead-zinc deposits, and as replacement veins in Carboniferous limestone, shale and sandstone. Most commercially viable deposits are of the replacement type, and ore grades are around 20% fluorite. Ores are generally upgraded by jigging, tabling or flotation to produce a product containing 97% CaF_2 for acid and cryolite grades. Metallurgical grades are between 60 and 70%. Silica, sulphur, carbonate, iron, lead and zinc contents are penalized.

USES

70% of fluorspar is used to produce hydrogen fluoride and hydrofluoric acid, and 26% is used as a flux in the manufacture of steel. The remainder is an ingredient in welding rod coatings, enamels, and ceramics.

Hydrogen fluoride (HF) is made by heating acid-grade fluorspar with sulphuric acid to produce hydrogen fluoride gas and calcium sulphate. This is purified and distilled, and marketed either as anhydrous hydrogen fluoride, or when absorbed in water, as hydrofluoric acid.

HF is used in fluorocarbons (41%), aluminum production (31%), petroleum alkylation (4%), uranium processing (4%), and rare metal production (4%).

Fluorocarbons are refrigerants, foam blowing agents and solvents.

Many fluorine chemicals and compounds are obtained from fluorosilic acid (H_2SiF_6) which is produced as a byproduct of phosphate production. Fluorosilic acid is used in water fluoridation, and the manufacture of artificial cryolite and aluminum fluoride.

MARKETS and PRICES

World consumption of fluorspar is projected to grow steadily in the future. Though there is no indication of a shortage of acid-grade fluorspar at present, the supplies of metallurgical grade fluorspar, particularly from North American sources, are insufficient. One factor that has exacerbated the problem is the increased use of basic oxygen furnaces (BOFs) which are replacing the open-hearth furnaces. BOFs consume three times the amount of fluorspar per tonne of metal produced.

The US imports about half a million tonnes of fluorspar valued at some US$50 million annually from Mexico, South Africa, China and Italy. There is only one domestic producer still operating.

Two recent developments are of concern to fluorspar consumers and producers. Firstly, South African supplies may be curtailed depending on political stability in that country, and secondly, concern over ozone depletion is leading to replacement of fluorocarbons used in refrigerants, propellants, foam-blowing agents and solvents.

Recently quoted prices range between US$90 and US$175 depending on grade, fob the Mexican border.

CANADIAN DEVELOPMENTS

The reopened Canadian producer of fluorspar is St. Lawrence Fluorspar Ltd. near St. Lawrence, Newfoundland which operates a 200 tonne/day mill year round. Historical production was 2.8 million tonnes between 1933 and 1977, but stopped in 1978 due to economic pressures caused in particular by competition from Mexican production.

The St. Lawrence veins are in fault zones in or near an alaskite granite. The veins are up to 25 m thick and 2500 m long, with an average grade of 35% CaF_2.

Other past producers have been in southern British Columbia, Ontario, and Cape Breton, Nova Scotia. The British Columbia producer was the Rock Candy Mine which closed in 1942 after shipping 36 000 tonnes of 22% to 32% CaF_2.

At present the bulk of Canada's requirements are met by imports from Mexico and Spain.

Conwest Exploration Company Limited has a barite-fluorite deposit on Cape Breton Island containing 2.7 million tonnes of 28% barite and 19% fluorite.

Eaglet Mines Limited of Vancouver has delineated 24 million tonnes of fluorspar with an average grade of 11.5% CaF_2 near Quesnel Lake. A feasibility study indicates that the deposit could be mined at a rate of 5000 tonnes per day to produce acid grade (+97% CaF_2) and metallurgical grade (+83% CaF_2) products.

Consolidated Rexpar Minerals and Chemicals Limited has a uranium-bearing fluorspar deposit north of Kamloops, British Columbia reported to contain 1 million tonnes of 22% CaF_2, or 450 thousand tonnes of 29% CaF_2. There are other deposits in the Liard River area.

YUKON FLUORITE OCCURRENCES

Formational (MV*)

No.	NTS	Minfile No.	Name
41	105P14	9	DEE
42	105P14	38	DICK
43	105P14	39	ALF
44	106B08	4	SEREM
45	106E03	10	MAGIC

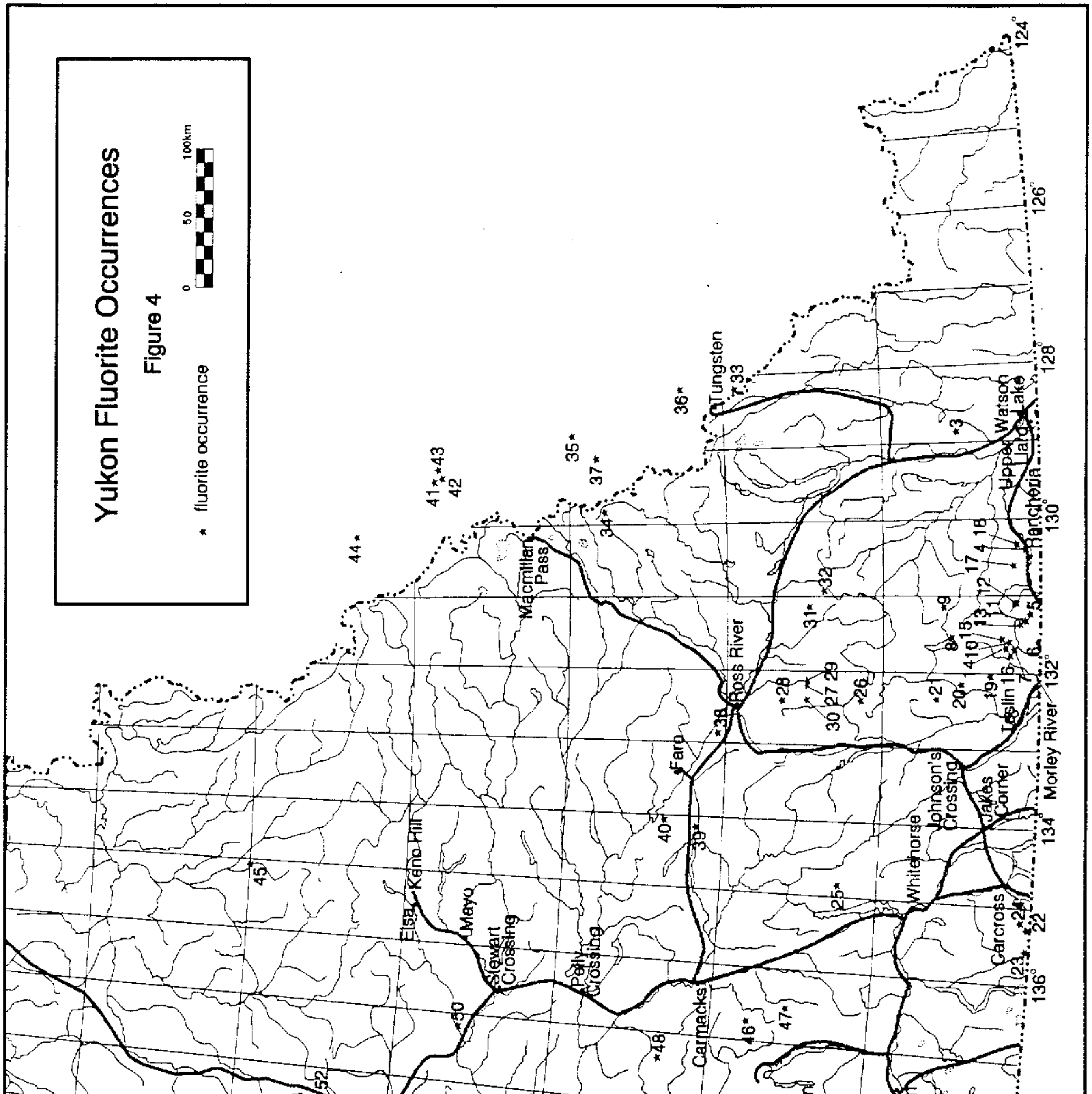
*Mississippi Valley

Porphyry

No.	NTS	Minfile No.	Name
6	105B04	39	LOGTUNG
15	105B05	87	McPRES
25	105E07	2	TUV
46	115H15	38	TAHTE

Skarn

No.	NTS	Minfile No.	Name
3	105A10	12	HUNDERE
5	105B03	30	PARTRIDGE
7	105B04	40	JC
10	105B04	70	CAN
11	105B03	73	CURRENT



Yukon Fluorite Occurrences
Figure 4
* fluorite occurrence
0
50
100km
Dawson
Elsa
Keno Hill
Mayo
Stewart Crossing
Pelly Crossing
Carmacks
Faro
Ross River
Macmillan Pass
Tungsten
Watson Lake
Upper Liard
Rancheria
Teslin
Morley River
Johnson's Crossing
Jakes Corner
Whitehorse
Carcross
Haines Junction
Destruction Bay
Burwash Landing
Koidern
Beaver Creek
66°
65°
64°
63°
62°
61°
140°
138°
136°
134°
132°
130°
128°
126°
124°

19	105C08	29	McCLEERY
21	105C9	38	MINDY
26	105F01	1	MOLLY
29	105F08	80	NOKLUIT
30	105F08	81	GUANO
33	105H16	60	BAKER
34	105I13	6	CLEA
39	105L01	3	LITTLE SALMON

Vein

No.	NTS	Minfile No.	Name
4	105B01	4	FIDDLER
8	105B12	42	TROUT
9	105B11	44	IRVINE
17	105B02	97	URP
18	105B01	123	HEAD
22	105D03	90	ADASTRAL
23	105D04	111	BOUDETTE
24	105D03	191	GLENLIVET
27	105F08	15	KAY
31	105G06	21	ZIELINSKI
35	105I15	11	ARROW
36	105I08	62	VULCAN
37	105I14	75	NUG
38	105K02	9	GREW
40	105L08	58	LITTLE FISH HOOK
47	115H10	42	SNAP
53	116B07	150	HESTER
54	116B07	151	TOMBSTONE

Volcanogenic

No.	NTS	Minfile No.	Name
28	105F09	71	CHZERPNOUGH

Unknown

No.	NTS	Minfile No.	Name
12	105B03	78	VERLEY
13	105B03	83	SIN
14	105B04	86	CUSP
16	105B04	88	SMITH
20	105C09	35	ENGLISHMAN
32	105G07	30	PIT
48	115I06	39	COM
49	115O12	81	SESTAK
50	115P11	16	MOOSE RIDGE
51	116B03	6	UNEXPECTED
52	116B07	109	TING
55	116B07	152	TETA
56	116O11	NW57	CARSWELL (not on map)

GEM STONES

GENERAL DESCRIPTION

All natural precious stones are minerals, and all are inorganic except for pearl, coral, amber and jet. The inorganic gemstones are crystals except for agate, opal and turquoise which are amorphous. To be considered a gem, a mineral must possess some or all of the following characteristics: beauty, durability, rarity, fashionability, and portability. There is no sharp distinction between precious and semi-precious gems, but it is usual to consider only the diamond, ruby, sapphire and emerald as precious stones because they are the most valuable and attractive of all gems.

The term gemstone is restricted to uncut stones, and the term gem applies only to cut stones. Gems are usually sold by the carat, a unit of weight equal to 200 mg.

The better-known gems are:

Stone	Constituents	Colour	Chief Sources
Diamond	C	x	Africa, USSR
Emerald	Be, Al, Si, O	gr	Columbia, Egypt
Ruby	Al, O	r	Burma, Sri Lanka
Sapphire	Al, O	bl	Sri Lanka, Burma
Opal	Si, O	var	Australia, Mexico
Amethyst	Si, O	purp	India, Iran, Brazil
Benitoite	Ba, Ti, Si	bl	
Chrysoberyl	Be, Al, O	gr, y	
Feldspar	K, Na, Ca, Al, Si	var	
Garnet	Al, Fe, Mg, Si	r, gr	USA, South Africa
Jade	Ca, Mg, Fe, Si	gr	Burma, Canada
Jadeite	Na, Al, Si	gr	Burma, China
Kunzite	Li, Al, Si	lilac	California
Lapis lazuli	Na, Al, S, Si	bl	India, Greece, USA, Chile
Peridot	Mg, Fe, Si	gr	Middle East
Quartz	Si, O	var	worldwide
Spinel	Mg, Al	r	Sri Lanka, Burma
Topaz	Al, Fe, Si	y	Brazil, Sri Lanka, USA
Tourmaline	Bo, Si	gr	Urals, USA, Madagascar
Turquoise	Al, P, O, H	bl	New Mexico, Iran, Turkey
Zircon	Zr, Si	r, or	Sri Lanka, Thailand

(x,colourless; r,red; y,yellow; bl,blue; or,orange; var,various; gr,green; purp,purple)

Most gemstones are obtained from igneous rocks, pegmatites and alluvials. Metamorphism yields garnet, lapis lazuli, ruby, and nephrite. Hydrothermal solutions yield opal and agate, and supergene processes yield turquoise.

DIAMONDS are described under "Abrasives" p.1.

RUBY (red) and SAPPHIRE (blue, green, yellow) are gem varieties of corundum, and are generally produced from placer deposits. Exploration methods use corundum as a tracer mineral. Mining is carried out with heavy equipment and jigs.

EMERALD is the clear green variety of beryl and occurs in pegmatites and their resultant alluvial deposits.

JADE ranges in colour from white through all shades of green, to red. Bright greens are the most valuable. The Chinese believe jade possesses mystical properties such as the ability to ward off accident and ill fortune, and it is also a symbol of purity.

Jade is a generic term that includes two similar minerals, jadeite and nephrite.

Jadeite is a pyroxene ($NaAlSi_2O_6$), and is the rarest and most expensive jade mineral, sometimes referred to as 'Imperial Jade'. It is produced as stream boulders from Burma. The boulders have their source in an albite-jadeite dyke which intrudes a serpentenised ultrabasic. The dyke may be from magmatic segregation, or from metamorphism of an albite-nepheline rock.

Nephrite is a calcium magnesium amphibole $(Mg,Fe)_5(Si_4O_{11})_2(OH)_2$in the actinolite-tremolite series and is the most common variety of jade. It is formed by metasomatic alteration of serpentine with addition of calcium, silica, and possibly iron by gabbro and dioritic rocks, or by reaction of chemically dissimilar rocks in a shearing environment. Associated minerals are diopside, hydrogrossular, vesuvianite, talc, chlorite, prehnite, and actinolite-tremolite.

Nephrite jade deposits are often associated with small satellite bodies outside the main ultramafic mass.

YUKON GEM OCCURRENCES

Alluvial nephrite jade boulders are recovered near Dease Lake and Cassiar in British Columbia, and nephrite jade has been found in situ in the Yukon's Campbell Range north of Watson Lake, (KING and ARCTIC claims, Minfile #105H 034). Nephrite is also reported as float on the EKO-GREEN STUFF claims, (Minfile #105H 014), and 80 tonnes were shipped from Hasselberg Lake in 1982. In 1991 a 577 tonne jade boulder was discovered on the same property. The boulder may be the largest ever discovered. A few alluvial boulders have also been found in the Yukon River near Whitehorse.

Further exploration for nephrite, which weathers in such a way as to make it difficult to recognize in the field, will surely lead to more discoveries. In addition to the Campbell Range ultramafics, there are others near Teslin, Kluane, and Dawson City.

Canadian jade is exported to Germany, Japan, Taiwan, HongKong, China and the US. Prices vary greatly according to quality, and can reach up to $100/kg for the highest grades.

To date jadeite has not been identified in Canada, although other minerals resembling it have been sold as jadeite.

TOPAZ is a very minor constituent of placer heavy mineral concentrates in the Hunker Creek area of the Klondike, and an in situ occurrence is reported nearby on Germaine Creek (Minfile #116B 04) where topaz is associated with fluorite and cassiterite. Topaz is also reported to occur in a pegmatite on the GEM claims in the Wolf Lake map area, (Minfile #105B 32).

ZIRCONS of small size are found in placer concentrations of the Klondike.

RHODONITE, a pinkish manganese silicate, occurs on Mt. Grant in the Teslin area, (Minfile #105C 18). Limited mining from an open cut has taken place with the magnesite used for carving.

HEMATITE and JASPER, distinctively interbanded, occur in iron formations from the Blow River in north-central Yukon.

AGATES can be found in the Carmacks Group volcanics, and OPAL occurs near Frenchman Lake in the Mt. Nansen area.

LAZULITE ($MgAl_2(PO_4)_2(OH)_2$) occurs in the northern Yukon in the phosphatic iron formation of the Richardson Mountains which contains a suite of exotic complex phosphate minerals, many of which are extremely rare, and ten of which are new to science. Mineral specimens from the area are of great interest to collectors. However because lazulite is too soft to be cut and polished it has limited value as a gemstone.

Coarse bright nuggets of placer gold can command a premium when sold to jewellery manufacturers, and good specimens of crystalline gold have been sold for double the spot gold price.

GRAPHITE

GENERAL DESCRIPTION

Graphite is a very soft black mineral which can mark paper; hence its name which is derived from the Greek word 'grapho' to write. It was once mistaken for lead and called 'black lead', and pencils made from it are still referred to as 'lead' pencils. It is composed of carbon and is chemically identical to diamond, their markedly contrasting physical properties being due to their individual crystalline structures.

There are two varieties of graphite, a crystalline type composed of thin, nearly pure black flakes, and an amorphous variety which is finer grained and often not as pure.

Graphite is found principally in metamorphic rocks such as marbles, gneisses, schists, quartzites, and altered coal beds. The graphite flakes are oriented parallel to the foliation planes of the rock.

The carbon required to form the graphite was probably from organic matter in the original sediments or from the dissociation of carbonates during intense metamorphism. The exceptions are the Sri Lanka deposits which are probably of igneous origin. Associated minerals are quartz, chlorite, rutile, titanite and sillimanite.

Graphite deposits have grades from 2.5% to 7% graphite. High grade vein deposits can be mined by underground methods, but lower grade deposits are mined by open pit. Mine run ore is concentrated to 80%-95% carbon by grinding and screening.

Graphite has a high melting point (3600°C) and is insoluble in acid. These properties make it a very useful mineral in foundries and metallurgical plants. US statistics indicate that 30% is used as refractories, 20% in foundry dressings and moulds, 11% in brake linings, and 7% in lubricants. Other uses are as brushes in electric motors, and as a component of batteries, paints, pigments, glazing powder, and of course, pencils.

World production is from Korea, Austria, Mexico, West Germany, Madagascar, Sri Lanka, Norway, Japan and Italy.

Recent listed prices per tonne ranged from US$220 to US$440 for amorphous graphite powder, to US$1300 for high quality Madagascar graphite, fob source. However, listed prices are not representative of market prices which are contracted between suppliers and distributors or consumers. Future demand is expected to increase, but only slightly.

CANADIAN DEVELOPMENTS

Until recently Canada's only producer was Asbury Graphite Quebec Inc, which started production in 1983 from its mine near Notre Dame du Laus, Quebec. Production in 1984 was valued at $675 000 but since then the mine has been dormant. The Asbury ore is disseminated flake graphite in crystalline limestone associated with a biotite quartzite. Carbon content is between 7% and 12%, and reserves are estimated to be 600 000 tonnes.

In 1986 Bay Resources and Services Inc drilled the nearby Mont Laurier deposit in Lachaber Township, Quebec. The property was subsequently transferred to Stratmin Inc which continued exploration and entered production. It has defined probable and possible reserves of 23.7 million tonnes with an average graphitic carbon content between 7.2% and 8.1%. Production of 8 000-10 000 tonnes/year is mostly sold to the United States and Japan

In Ontario, Princeton Resources Corporation is developing a flake graphite deposit near Bissett Creek. Reserves are 10 million tonnes grading 3.5% to 5% carbon. Cal Graphite Corporation has a crystalline flake graphite deposit in Butt Township, and has announced that it will start production in 1988. Reserves are reported to be 29.5 million tonnes open pitable, and the mill product will be large crystalline flake graphite with a 97.5% carbon content.

Also in Ontario, Stewart Lake Resources is developing the Kirkham deposit near Kingston, which is said to contain 5 million tonnes carrying 7.6% graphitic carbon.

YUKON OCCURENCES

Although graphitic schists are common in many parts of the Territory, no particularly high-grade deposits have been reported. To date Canadian deposits are confined to the shield environment.

GYPSUM

anhydrite

GENERAL DESCRIPTION

Gypsum, with a composition $CaSO_4.2H_2O$, will lose more than half of its water when heated to 160°C. This 'hemihydrate', known as calcined gypsum, plaster of Paris, or gypsum hemihydrate, will absorb water and set into a comparatively hard mass. Plaster of Paris is a name derived from the gypsum deposits near Montmartre.

Gypsum was used by early civilizations for decorative carvings and plaster coatings. In the late eighteenth century it was discovered that it could be an excellent fertilizer and soil conditioner, and its agricultural uses came to dominate demand.

In the late 1880's a way was found to retard its setting rate, and as a result it soon became important to the construction industry. It is said that the first plasterboard was made in 1918, and this is by far the most important modern use for gypsum, accounting for 75% of gypsum consumption in North America.

Most gypsum deposits are sedimentary beds of saline residues precipitated during the evaporation of seawater in enclosed marine basins. For this reason salt is a commonly associated mineral. Uninterrupted evaporation of seawater in a dry climate results in the successive deposition of calcium and magnesium carbonates (as limestones), calcium sulphates (as gypsum and anhydrite), rock salt and potassium and magnesium salts which may form carnallite, kieserite, polyhalite etc.

A less common genesis of gypsum deposits is from the interaction of volcanically derived sulphuretted waters and limestones.

Most commercially exploited gypsum deposits have a gypsum content between 80% and 95%, with the remaining proportion occurring as anhydrite and other impurities such as shale, limestone dolomite, or clay.

MARKETS AND PLANTS

Gypsum deposits are generally mined as large volume highly mechanized open pit operations.

Benefication of lower grade deposits may be necessary using log-washing, sink-float, and selective crushing and screening both wet and dry to produce a product of 80% or better purity.

Plasterboard is made by crushing, pulverizing and calcining the gypsum, then mixing it together with water, foam, pulp and starch to form 'stucco'. The stucco is introduced as a slurry between two unwinding rolls of absorbent paper, so forming a continuous sandwich of wet board. This is cut to length, dried and bundled for shipment.

North American wallboard plants commonly have a capacity of 10 to 15 million sq m/annum, and a maximum capacity of 20 million sq m/annum. Since wallboard is heavy and friable, manufacturing plants are usually built close to markets. Wallboard plants are generally operated by integrated companies with captive mines scattered throughout North America at strategic locations close to markets.

The wallboard industry requires gypsum which meets the following specifications: 20% or less insolubles such as limestone, dolomite, anhydrite, clays and silica; less than 0.03% soluble chlorides; less than 0.02% hydrous minerals excluding clays; less than 2% hydrous clays; and a white colour.

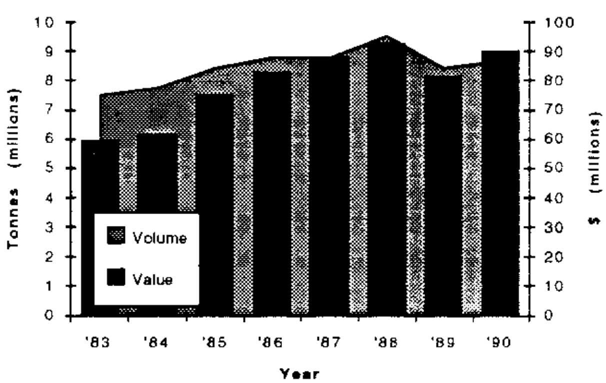
Other uses of gypsum are as a filler in paper and paints, as an ingredient in cement (it retards setting time and may comprise up to 5% by weight of the cement), as a soil fertilizer, flux, insulating material, and raw material for ceramic moulds.

World gypsum reserves are enormous and most countries have their own supplies. However since gypsum demand is so directly tied to construction markets, large scale gypsum production has been limited to the industrialized countries. An indicator of this is that the US and Canada together account for 24% of the world's output.

CANADIAN DEVELOPMENTS

Canada is the world's second largest producer of gypsum, after the US. The Atlantic Provinces, principally Nova Scotia and Newfoundland, produce 75% of this gypsum and account for some 80% of Canada's exports.

Canadian Gypsum Production



In British Columbia gypsum is presently produced from three mines. Domtar Construction Materials produces an estimated 120 000 tonnes annually from its Lussier River deposit to supply its wallboard plant in Alberta. Westroc Industries mines between 300 000 and 500 000 tonnes at Windermere for its wallboard plant in New Westminster. Canada Cement Lafarge produces a smaller amount from its deposit at Falkland for use in its cement plant at Kamloops.

There are 18 other recorded gypsum deposits in British Columbia, most of which are in the southern and southeastern parts of the province.

Since industrial applications and renovations consume substantial amounts of wallboard, housing starts alone are no longer an accurate guide to gypsum demand.

The present structure of the Canadian industry is unlikely to change because wallboard and building material plants have sufficient capacities to meet short term regional demands and also to supply some of the demand in the US.

Any new western Canadian producer will have to be able to supply a high-quality product at very competitive prices in order to penetrate the existing integrated market.

ANHYDRITE

Anhydrite has the composition $CaSO_4$ and is found associated with gypsum deposits.

Compared to Gypsum, anhydrite has few commercial uses and it is generally considered a nuisance mineral.

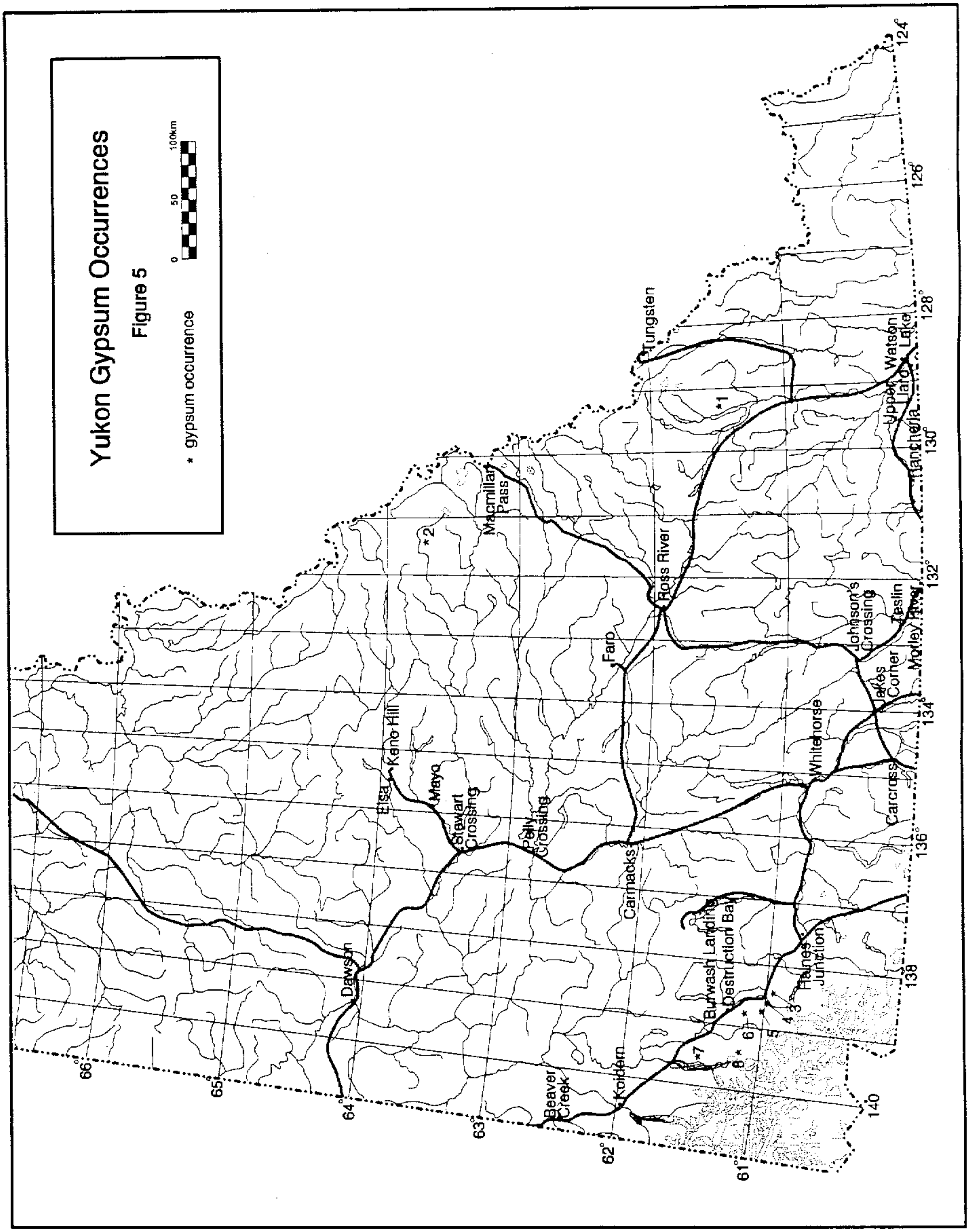
When treated with ammonia it forms the fertilizer ammonium sulphate. It can also be reduced to sulphur dioxide and used in the manufacture of sulphuric acid. It is an ingredient of Portland cement, and a fertilizer for peanut crops.

The O'Connor River gypsum deposit located just to the south in British Columbia provides a model for Yukon occurrences. This deposit, which has been evaluated in detail in the last few years, occurs in faulted early Permian to late Triassic carbonate rocks. The gypsum is in three zones, the most accessible of which is Zone 1 with a strike length of 400 m and irregular widths between 30 m and 110 m. The deposit contains up to 8% anhydrite.

YUKON GYPSUM OCCURRENCES

No.	NTS	Minfile No.	Name
1	105H11	75	MAXI
2	105O12	10	HORN
3	115B15	9	BULLION

GYPSUM


Yukon Gypsum Occurrences
Figure 5
* gypsum occurrence
0
50
100km
Tungsten
Watson Lake
Upper Liard
Rancheria
Macmillan Pass
Ross River
Johnson's Crossing
Teslin
Morley River
Faro
Jakes Corner
Whitehorse
Carcross
Keno Hill
Elsa
Mayo
Stewart Crossing
Pelly Crossing
Carmacks
Burwash Landing
Destruction Bay
Haines Junction
Dawson
Beaver Creek
Koidern
124°
126°
128°
130°
132°
134°
136°
138°
140°
66°
65°
64°
63°
62°
61°

4	115B16	12	KUL
5	115G02	1	METALLINE
6	115G02	84	BOCK
7	115G05	85	MAPLE
8	115G06	86	GYPSUM

LIME

Lime is produced from limestones ($CaCO_3$), most of which are organic in origin, frequently containing parts of organisms such as shells of mollusks and coral skeletons.

Quicklime (CaO or CaO.MgO) is formed by the process of calcination in which limestones are heated to 903°C, the dissociation temperature of the carbonates, and held at that temperature long enough to release carbon dioxide. Slaked lime is a mixture of quicklime and water, and hydrated lime is slaked lime dried and reground. One hundred pounds of pure limestone yields fifty-six pounds of lime.

The largest consumption of lime is by the metallurgical industry which requires it as a flux, and the increased application of basic oxygen furnaces is resulting in a rising demand by this sector. The second largest user of lime is the pulp and paper industry which requires it in the preparation of digesting liquor and in pulp bleaching.

Other users include the uranium industry, sugar beet industry, and the manufacturers of cement, calcium carbide, calcium chloride, calcium cyanamide, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia, and magnesia metal.

The construction industry, surprisingly, only accounts for 6% of lime consumption.

One probable growth area for the use of lime is in environmental applications which are predicted to increase as concern grows over acid rain and related issues. Environmental uses include desulphurizing stack gases of thermal power plants, smelters, refineries and chemical plants and the neutralizing of sewage and industrial effluent waters.

Lime is a high bulk low cost commodity not usually shipped any great distance. The preferred location for a lime plant is near a principal market, adjacent to a source of high quality raw material, and close to a supply of energy. The latter is important because lime production is energy intensive, consuming 6.7 million BTU per tonne of lime produced.

CANADIAN PRODUCERS

Most Canadian plants are in Ontario and Quebec, and those two provinces account for 80% of domestic production. In western Canada lime is quarried from Texada Island by Ash Grove West Inc (formerly Oregon Portland Cement Co). Being on tidewater, this deposit supplies the entire Pacific Northwest.

Other western lime quarries are near Pavillion Lake (between Lillooet and Clinton), near Rock Creek and Kootenay Lake, at Dahl Lake near Prince George, and at Ptarmigan Lake also near Prince George.

YUKON CONSUMPTION

In the recent past Yukon's hard rock producers, United Keno Hill, Curragh, and Erickson are reported to have consumed a total of 10 thousand tonnes of lime per year, all of which was imported into the Territory.

Presently Curragh continues as a consumer and in addition there is a considerable consumption of calcium chloride for highway dust control.

There are large accessible limestone beds in a belt running through southwest Yukon from Atlin to Carmacks, and it is possible that the present level of combined consumption would justify the development of a local lime plant.

Curragh and others have claims over limestone deposits in the Carmacks area.

MAGNESITE

hydromagnesite, dolomite, brucite, meerschaum

GENERAL DESCRIPTION

Deposits of Magnesite ($MgCO_3$) are of two major types, amorphous and crystalline. The amorphous deposits are veins and stockworks in serpentine which are the result of the interaction of carbonated waters and the magnesia-rich sepentine. Crystalline deposits, which can be enormous, are formed by the replacement of dolomite or limestone by hydrothermal solutions. To be economically viable a deposit must have a grade of some 80% magnesite with a maximum 4% calcium oxide and 8% iron oxide.

Magnesite is used in refractory linings for steel furnaces in the form of 'dead burned' magnesite, which has been heated to above 1500°C to form magnesia (MgO).

Magnesite is also used in the manufacture of rubber, as a medicinal salt, in the ceramics industry, in paper manufacture, and as a fertilizer.

A recently quoted price was US$265/tonne for bulk dead burned magnesite fob Luning, Nevada.

CANADIAN DEPOSITS

Baymag Mines Co Limited produced high grade magnesite from its deposit on Eon Mountain (Mount Brussilof), near Radium Hot Springs, British Columbia. The deposit is reported to contain 9.5 million tonnes of 95% MgO, 13.6 million tonnes of 93%-95% MgO, and 17.6 million tonnes of better than 92.4% MgO.

Another deposit near Radium Hot Springs is the Brisco property which contains 31.5 million tonnes of 90% to 95% magnesite.

Further information on these and other British Columbian deposits can be found in 'Magnesite, Brucite and Hydromagnesite Occurrences in British Columbia' by B. Grant; British Columbia Ministry of Energy, Mines and Petroleum Resources, Mineral Resource Division, Open File 1987-13.

No large deposits of magnesite are known in the Yukon though carving-grade magnesite has been reported near Dawson City.

Hydromagnesite$[Mg_4(OH)_2(CO_3)_3.3H_2O]$ may contain up to 43% magnesia. It forms sheet-like bodies in swampy areas.

Dolomite $[(Ca,Mg)(CO_3)_2]$ occurs as beds of dolomitic limestone that are common worldwide. Some have formed by direct deposition from seawater, but most are the result of the interaction of magnesium salts in seawater which have converted calcium carbonate into calcium magnesium carbonate.

Like magnesite, dolomite can also be used for refractory purposes in open hearth furnaces and basic converters. Though not as effective as magnesite it is far cheaper due to its relative abundance. It is also one of the sources of magnesium in the production of magnesium metal compounds. Rock dolomite is used agriculturally as a soil neutralizer.

Brucite $(MgO.H_2O)$ is used in the production of metallic magnesium and magnesia.

Meerschaum, also called sepiolite, is so light that when dry it will float on water. It is a compact spongy hydrous magnesium silicate formed as an alteration product of magnesite or serpentine. It is used mainly in the manufacture of pipe bowls and cigarette holders. Most of the world's supply is from Turkey where it occurs as scattered nodules in a cemented valley fill. There has also been limited production from New Mexico.

MAGNETITE

The types of deposits that can contain significant amounts of magnetite are skarns, differentiated magmatic intrusives, ultramafic bodies and placer accumulations. Usually only the skarns are of high enough grade to be mined primarily for their magnetite content.

Finely divided magnetite is used in a slurry of controlled density as a heavy medium in coal preparation plants to separate low ash coal from waste rock.

In the past western Canadian coal mines have been supplied from British Columbia magnetite deposits such as the Texada Island mines, the Brynnor mine at Kennedy Lake, and the Jedway mine on South Moresby Island. At present these mines are shut down, and all the required magnetite is produced from stockpiled material at the Craigmont mine near Merritt.

Demand for magnetite in British Columbia is 50 000 tonnes per year, and in 1981 Craigmont also supplied 50 000 tonnes to Australian coal processing plants. The present price is $40 to $50 per/tonne fob supplier, and the typical shipping cost is a further $40 to $50/tonne, so that end users are prepared to pay at least $80/tonne. Present reserves are very limited and future supplies are necessary.

The most noteworthy Yukon magnetite supply is contained in Whitehorse Copper's accumulated tailings. These have been evaluated by Denison Mines as a potential source of magnetite for Quintette Coal.

All of the Yukon's placer heavy mineral concentrations contain magnetite, but accumulated volumes are too small to have any realistic sale value.

MANGANESE OXIDE

psilomelane, pyrolusite

GENERAL DESCRIPTION

Manganese does not occur naturally in its metallic form but is obtained from mixtures of manganese oxides. Psilomelane is the field term for a massive hard mixture of various oxide minerals, pyrolusite the term for soft black earthy mixtures, and wad is the common term for impure brown earthy oxides and hydrated oxides. Accessory manganese minerals are braunite, manganite, rhodochrosite, rhodonite, hausmannite, and bementite.

Most manganese ore bodies are either sedimentary or residual in origin. Sedimentary deposits are thought to be the result of manganese precipitation directly from sea water by algal and bacterial processes. Such deposits are found in the USSR.

Residual deposits are the result of decomposition of primary manganese minerals such as spessartite, a manganiferous garnet, and reconcentration of the residual manganese oxides as near surface nodules, lenses and layers. Examples are found in India, Brazil and Ghana.

MARKETS and PRODUCERS

About 95% of all manganese produced is used as a deoxidizer and desulphurizer in the steel industry and demand generally fluctuates in conformity with steel production. Metallurgical grade ore must have a minimum of 46% Mn, a maximum of 8% SiO_2, a maximum of 8.5% Fe, and a maximum of 0.18% P.

Other uses for manganese are in the manufacture of manganese chemicals and dry cell batteries. Ores for this purpose should contain at least 70% MnO_2, a maximum of 2% FeO, and be free of Cu, Sb, As, Ni, Pb and Co.

The world's largest producers of manganese ore are USSR, India, China, Brazil and South Africa. South Africa has 75% of the non-communist world's reserves. The US consumes 640 thousand tonnes of contained manganese per year and relies entirely on imports from South Africa, France and Brazil.

Demand for manganese is expected to remain steady for the foreseeable future, since there is no satisfactory substitute in its major applications. Extensive accumulations of manganese nodules on the ocean floors may have future commercial significance.

CANADIAN DEVELOPMENTS

Canada produces no manganese. The largest identified reserve is near Woodstock, New Brunswick which contains 45 million tonnes grading 11% Mn and 14% Fe.

Though manganese-bearing minerals are common alteration products in the Yukon, no ore-grade deposits have been found.

MICA

muscovite, biotite, phlogopite, vermiculite

GENERAL DESCRIPTION

The four commercially important micas are muscovite (white mica) which is a hydrated silicate of aluminum and potassium; biotite (black mica) which is a ferro-magnesian variety; phlogopite (amber mica) which carries magnesium and potash; and vermiculite (jeffersite) which is a magnesium-iron-potash variety.

Other micas which are unimportant commercially include lepidolite and zinnwaldite, both lithium-bearing, roscoelite which carries vanadium, and fuchsite which contains chrome.

The outstanding physical characteristic of micas is their almost perfect basal cleavage. Theoretically a crystal of mica can be split into films one millionth of a millimeter thick, but in actual practice the films are 25 microns thick (.025 mm).

The commercial value of mica is largely dependent on 1) its perfect basal cleavage, 2) the hardness, flexibility and elasticity of the laminae so produced, 3) very low electric and heat conductivity of the laminae, and 4) to some extent on the colour.

Mica deposits fall into three main categories, muscovite and biotite deposits which are associated with granitic pegmatites, phlogopite deposits which are associated with diopsidic pyroxenite and crystalline limestones, and vermiculite deposits.

Vermiculite deposits occur in a number of different settings including: on the contact between basic and ultrabasic rocks and an intruding aplite or syenite dyke; in association with asbestos deposits; as a replacement deposit in carbonates generally with diopside, magnetite and apatite; as massive bodies of vermiculite and serpentine.

MARKETS and SPECIFICATIONS

Mica products are marketed as sheet mica, scrap flake and ground mica, and vermiculite.

SHEET MICA is primarily used as an electrical insulator and the US consumes one million kg/year.

The grading, classification and preparation of sheet mica for marketing is a highly specialized industry of extreme importance to the success of any mining venture. Grading and classification is divided into two parts, visual methods and electrical methods. Visual methods include size grading (width and thickness), quality (clarity, staining, inclusions etc), and degree of flatness.

In preparation for marketing mica 'books' are cobbed at the mine site to remove obvious impurities such as quartz and feldspar and then split with a knife blade into sheets 0.5 cm thick.

Consumption of sheet mica has been declining in recent years due to a number of factors such as the difficulty in obtaining quality supplies, the increase in solid state technology, and the availability of substitutes. Substitutes include products made from scrap, flake or ground mica such as built-up mica, reconstituted mica, and glass and phosphate bonded mica. However consumption has now levelled off and appears to have stabilized.

India produces three quarters of the world's sheet mica, all as muscovite from pegmatites that are exploited by numerous small mines that rely on plentiful cheap labour. Other producers are Brazil and Madagascar.

The US market is supplied entirely by releases from the Government stockpile and imports from India, Belgium, France and Japan.

SCRAP, FLAKE and GROUND MICA are components of joint cement, paint, roofing, oil well muds and rubber products. Though consumption of ground mica in the US closely follows gypsum consumption, paints and plastics provide the main markets for wet-ground micronized and specially treated micas. In recent years there has been a steady increase in the use of ground mica in plastics and rubber as a filler and reinforcer, and as a replacement of asbestos in brake shoes.

Production is from mica and sericite schists, from phlogopite deposits, and as a by-product of sheet mica, feldspar, kaolin or lithium benefication. The US consumes 136 thousand tonnes/year and has several domestic producers.

VERMICULITE has a peculiar characteristic which makes it an excellent light-weight thermal insulator; it exfoliates and expands as much as thirty times when it is heated to about 250°C. Vermiculite is also used by nurseries as a bedding material for plants, and is a component of insulating plasters, cements and lightweight concrete aggregates.

Transport costs are high in comparison to unit values so that markets are defined largely by transport distances. In addition vermiculite is open to substitution by glass fibre, perlite, peat and sawdust.

The US has several producers in Montana, Wyoming, Colorado, and South Carolina. Other producing countries are Kenya, Uganda, Tanzania, South Africa and Australia.

CANADIAN DEVELOPMENTS

There are numerous muscovite and biotite pegmatite occurrences in Canada. They have been found within the Grenville Series in Eastern Canada, within the Yellowknife Group of meta-sediments and meta-volcanics in the North West Territories, and in the para-gneisses and schists of the Shuswap complex in British Columbia.

However due to the small size and low grade of the deposits, and difficulty of mechanizing production so as to reduce costs, none of these deposits is economically viable.

Canada's only mica producer is a phlogopite deposit developed by Marietta Resources International Ltd which was bought by Lacana Mining Corp in 1985. The Marietta deposit is near Parent, Quebec, and it contains reserves of 27 million tonnes of 85% phlogopite.

The ore is mined and crushed on a contract basis for one summer in every three years. It is trucked 13.5 km to railside and stockpiled until required at the processing plant near Montreal.

In the processing plant it is crushed, dried, screened, delaminated and packed. The final products, marketed under the trade name 'Suzorite', vary according to density, particle size, and coatings.

The Suzorite markets are 25% within Canada, 50% in the US, 20% in Japan and the remainder in Western Europe.

All other reported Canadian phlogopite deposits are in Ontario and Quebec.

Canada produces no vermiculite but relies on imports from Montana, South Carolina and Georgia. Vermiculite occurrences are reported in the Grenville rocks of eastern Ontario, and near Kamloops, British Columbia, though the latter is said to be a deposit of hydrobiotite rather than true vermiculite.

There are no commercially significant Yukon mica occurrences.

MINOR METALS

Though not strictly a part of this study, some of the more common minor metals will be reviewed briefly by way of general information.

ANTIMONY is recovered from stibnite (Sb_2S_3), an antimony sulphide. Major world producers are Bolivia, South Africa, China and the USSR. It is used mainly as an alloy with lead and in its oxide form as a fire retardant. Canada's only antimony mine in New Brunswick, owned by Dominion Explorers Inc., was sold to Amspec Chemical Group in April 1990. It shut down in 1981, reopened in 1988 and shutdown again in January 1991. Remaining reserves are reported to be 10 000 tonnes of 4.15% antimony.

At present all Canada's antimony production is as a byproduct of lead refining. Antimony was produced briefly in the past in the Yukon by the Yukon Antimony Company from its property in the Wheaton River area.

BERYLLIUM is derived principally from the mineral Beryl, ($Be_3Al_2Si_6O_{18}$). It is found chiefly in coarse-grained pegmatites and in cavities in granites, and is often mined as a byproduct of feldspars and micas. Gemstone varieties of beryl are aquamarine (clear blue), emerald (clear green), and morganite (rose coloured). The other commercial source of beryllium is the mineral bertrandite (($Be_4Si_2)_7(OH)_2$).

Beryllium is important to the nuclear industry for its property of not absorbing neutrons. It is used for lining reactors and nuclear weapons. It is however, toxic and zirconium is used in preference in nuclear plants.

In 1990 the US consumption of beryllium was 200 tonnes, used 40% in nuclear reactors and aerospace applications, 35% as an alloy and oxide in electrical equipment, and 17% as an alloy or oxide in electronic components.

Mining beryl pegmatites traditionally involves hand picking and hand cobbing, a benefication process which is difficult to mechanize due to the similarities between beryl and its associated gangue minerals. Since the production was so labour intensive, most mines were restricted to developing countries, with China and Brazil supplying the greater part of US demand.

US domestic production is limited to Brush Wellman Inc's Topaz-Spor Mountain mine in western Utah, where reserves are reported to be 4.5 million tonnes with a grade of 0.22% Be. This occurrence is a low-grade disseminated deposit of bertrandite in tuffs and limestones.

Other world producers are Argentina, India, Mozambique, Zaire, Zimbabwe and USSR.

Canada has no domestic production, though exploration by Highwood Resources at Thor Lake in the North West Territories has delineated deposits of the beryllium mineral phenacite ($BeSiO_4$), which occurs with niobium, tantallum, zirconium, gallium and rare earths. Published reserves in the two T zones are as follows: the North T Zone contains 0.51 million tonnes grading 1.11% beryllium oxide, 0.17% yttrium oxide, 0.028% rare earth oxides, and 0.58% niobium oxide, and the South T Zone contains 1.25 million tonnes grading 0.62% beryllium oxide, 0.1% yttrium oxide, 0.2% rare earth oxides, and 0.46% niobium oxide. The company has delayed taking a decision to develop the property until market conditions improve.

In 1984 Bearcat Explorations drilled a deposit at Hellroaring Creek near Kimberley, British Columbia, said to contain 500 thousand tonnes at 1% BeO, again occurring as the mineral phenacite.

There are no reported Yukon beryllium occurrences. The most promising exploration areas would be near known occurrences of tin, fluorspar, topaz, or rare earths.

Beryl is sold as short ton units (1% of a short ton, or 20 lb) of contained BeO, or as hectograms (1% of a metric ton). Prices are determined through negotiation between buyer and seller.

BISMUTH is generally produced as a byproduct of some lead, copper and tin mines. Alloyed with tin, lead or cadmium, it has a wide range of uses as a fusible alloy, mould material, and solder, and it is also used in the pharmaceutical, cosmetic and chemical industries.

In the Yukon, United Keno Hill's ores contained minor amounts of bismuth and revenue in 1986 was reported to be $7000 from 1000 kg.

CADMIUM is a relatively rare element which is soft, ductile and electro-positive. It is used primarily in the coating of iron and steel products to prevent oxidation. Other uses are as a pigment, in chemicals, and in the manufacture of alkaline batteries. It is recovered mainly as a by-product of zinc smelting and refining.

United Keno Hill's ores contained minor amounts of cadmium and the company reported earnings of $7000 from 2000 kg in 1986.

Into the 1990's cadmium prices fell and have remained flat at around US$1.50/lb, which is down from prices in excess of US$5/lb. at the start of the decade.

CALCIUM metal is highly reactive and does not occur in nature in the pure state. The metal is soft, ductile and easily shaped. It is used as a reducing agent and as an alloying element with other metals. Calcium metal is produced by briquetting high-purity quicklime (CaO) and pure aluminum and retorting under vacuum. The aluminum reduces the quicklime and calcium is liberated as a vapour which crystallizes in a condenser.

The only Canadian producer is Timminco Limited with a plant near Renfrew, Ontario.

CESIUM has a very low melting point of 28.5°C. It has three major uses: in density gradient solutions for separation of macromolecules such as DNA, photoemissive uses, and scintillation uses. Cesium will shed its outer electron with relative ease when exposed to light and is therefore used either to produce electricity from light (photoemission), or light from electricity (scintillation). Other minor uses are in alkaline batteries, oxygen scavengers, magnetohydrodynamic power generation, sewage sludge irradiation, and catalytic applications. Cesium consumption in the western world is estimated to be 45 tonnes/year.

There are only three significant deposits in the western world: Bernic Lake, Manitoba, Bikita Minerals, Zimbabwe, and the Karibib area in Namibia. The Bernic Lake deposit is owned by the Tantalum Mining Corporation of Canada Limited (Tanco). The deposit's principal value is in its tantalum and lithium contents, but it also has reserves of pollucite grading 24% Cs_2O. The cesium is mined as required to fill orders, but the mine has been on standby since 1982. Bernic Lake's pollucite is exported to the US and West Germany.

CHROMIUM is derived from the mineral chromite which occurs almost exclusively in differentiated ultramafic intrusives and in beach sands derived from them.

The principal use of chromium is in the production of ferroalloys for the manufacture of stainless steel and heat-resistant steel. The refractory industry also uses considerable amounts in the manufacture of refractory bricks, castables, mortars and ramming gun mixes, though the phasing out of open hearth furnaces has resulted in a decline in the use of chromite as a refractory.

The world's major chromite producers are the USSR (2.7 million tonnes/year), South Africa (2.5 million tonnes/year), Albania (1.0 million tonnes/year), Zimbabwe, Finland and India. Concern in recent years that the western world is dependent on South African supplies has prompted a search for deposits in more stable countries.

Canada's annual consumption of ferrochromium is about 27,000 tonnes, all of which is imported. Steel companies are the largest users. Though there are no operating chromium mines in Canada, there are large low grade reserves in the Bird River area of Manitoba and in the Eastern Townships of Quebec.

In the Yukon chromite is reported east of Whitehorse on the MARSH and MICHIE properties, (Minfile #105D 069, 071)

See also 'Chromite', page11.

COBALT is used in superalloys to impart strength and corrosion resistance to parts used in the manufacture of jet engines and gas turbines. In base alloys it is combined with tungsten, chromium, and molybdenum to impart abrasion resistance.

Cobalt is recovered as a byproduct of nickel and copper mines, and Zaire, Zambia, Botswana and Australia are major producers. In Canada cobalt is produced from nickel-copper ores in the Sudbury area. Recent exploration by Geddes Resources Limited on the Windy-Craggy copper-cobalt deposit in British Columbia generated reserves of 318 million tonnes of ore containing 1.5% copper and 0.08% cobalt.

In the Yukon cobalt has been identified as a component of copper-silver occurrences in the Bonnet Plume Range on the DOLORES, KEY MOUNTAIN, and CIRQUE claims, (Minfile #106C 09, 010, 012). It is also reported associated with uranium, copper, silver and gold on the ARCTOS claims, (106-D-16#), with gold, silver, copper and bismuth on the HAMILTON property (Minfile #116A 012), and as a minor component of the WELLGREEN (Minfile #115G 024) nickel-copper-PGM deposit. Future exploration in the Yukon may bring to light occurrences similar to British Columbia's Windy Craggy deposit.

COLUMBIUM (Cb), and NIOBIUM (Nb), are interchangeable terms. Of the world's columbium production, 90% is from the mineral pyrochlore which is an end member of the pyrochlore-microlite isomorphous series $(Na,Ca)_2(Cb,Ta)_2O_6(OH,F)$, pyrochlore having a maximum of 65% columbium. The other important columbium mineral is columbite, an end member of the columbite-tantalite series $(Fe,Mn)(Cb,Ta)_2O_6$, with a maximum of 78% Cb_2O_5.

The steel industry is the largest consumer of columbium in the form of ferrocolumbium which is an additive to high-strength-low-alloy steels, carbon steels, and stainless steels. Columbium is also used in superalloys in the manufacture of jet engines.

Brazil and Canada are the world's foremost columbium producers from deposits of pyrochlore in carbonatites. The Canadian producer is Niobec Inc with its mine near St Honore, Quebec, with a 1987 output of 2630 tonnes of Cb_2O_5 in pyrochlore concentrates. The mine had a nine week shutdown in 1987 due to depressed demand and growing inventories. Reserves are in excess of 50 million tonnes with grades between 0.4% and 0.8% Cb_2O_5 .

In the North West Territories at Thor Lake, Highwood Resources has delineated deposits of the beryllium mineral phenacite ($BeSiO_4$), which occurs with tantallum, zirconium, columbium, gallium and rare earths. Published reserves in the two T Zones are as follows: the North T Zone contains 0.51 million tonnes grading 1.11% beryllium oxide, 0.17% yttrium oxide, 0.028% rare earth oxides, and 0.58% columbium oxide, and the South T Zone contains 1.25 million tonnes grading 0.62% beryllium oxide, 0.1% yttrium oxide, 0.2% rare earth oxides, and 0.46% columbium oxide.

The Iron Ore Company of Canada has a property at Strange Lake on the Quebec-Labrador boundary which contains a large tonnage of yttrium, zirconium, rare earths, columbium and tantalum.

In western Canada carbonatites and related alkaline ultrabasic rocks are found in a broad zone parallel to and encompassing the Rocky Mountain Trench. Further north in the Yukon this trend continues along the Tintina Trench. British Columbium carbonatites are generally enriched in columbium but have a low tantalum content, with a Nb:Ta ratio around 100:1.

In the Yukon columbium is reported associated with rare earth elements on the NOKLUIT and GUANO properties (Minfile #105F 080, 081).

Prices for Canadian pyrochlore concentrates are traditionally volatile, and at present range from US$5 to US$7/kg of contained Cb_2O_5. Future demand is predicted to grow at about 3% per year.

GALLIUM is produced as a minor byproduct of bauxite and zinc refining. It is used primarily as a gallium arsenide compound to produce semiconductors, light-emitting diodes, and laser diodes.

Some gallium is contained in Highwood Resources Ltd's Thor Lake deposit in the North West Territories, and it is produced as a by-product from the Con mine in Yellowknife.

GERMANIUM is a metal produced primarily as a byproduct of zinc ores. It is used in night-vision systems and as a catalyst in the production of plastics. Cominco Ltd, whose Pine Point zinc concentrates contained germanium, constructed a germanium refining facility at its Trail plant with a production capacity of eight tonnes per year, with provision for expansion to 15 tonnes. World germanium consumption has fallen from 12O tonnes to 76 tonnes over the last five years.

INDIUM is a silver-white metal which is highly malleable and has a low melting point (156^{o}C). It is mainly used in low-melting or fusible alloys used to manufacture fusible links, solders, bearings and glass sealants. It is also a component of semi-conductors, light-emitting diodes, nuclear rods, dental alloys and automobile windshield de-misters. The world consumption of Indium was estimated to be 133 tonnes in 1990.

Indium occurs as a minor constituent of polymetallic sulphide ores of zinc, lead and copper and is generally produced in association with the processing of sphalerite. World producers are therefore the major zinc and polymetallic mines of Canada, Australia, Peru and Mexico.

In Canada Cominco's Sullivan mine contained indium which was concentrated and refined at the company's Trail smelter.

Quoted prices for indium are steady around US$230/kg.

LITHIUM is supplied chiefly from the minerals spodumene ($LiAlSi_2O_4$), amblygonite [Li(AlF)PO_6] and lithia mica, lepidolite. Lithium minerals are usually found in granitic pegmatites, and often occur together.

The largest end use for lithium is in the ceramic and glass industries, while other major applications are in the manufacture of aluminum, lubricants, welding fluxes, and photographic supplies.

The world has three major lithium producers: Tanco in Manitoba, Bikita in Zimbabwe and Lithium Australia in Western Australia. North America, Western Europe and the Far East are the only major consumers.

There is an abundance of lithium reserves and production capacity well past the year 2000.

In Canada, the Tantalum Mining Corporation (Tanco) has a tantalum lithium deposit at Bernic Lake, Manitoba which reopened in mid 1988. It produces a spodumene concentrate from a flotation circuit. The spodumene is marketed to the ceramics industry.

MAGNESIUM is used in the manufacture of lightweight alloys with aluminum, beryllium, thorium and lithium. The metal is produced by electrolysis of magnesium chloride and by electric smelting of magnesium bearing ores. Sources of magnesium metal are enormous and include magnesite, dolomite, brucite, seawater and brines.

In Canada Norsk Hydro AS has a magnesium plant near Becancour, Quebec, and a joint venture between MPLC Holdings SA and Alberta Natural Gas Company Ltd built a magnesium plant at Alderyde near High River, Alberta. These plants have impacted on the world market through their use of proprietary technology and low-cost power and feedstock. Other Canadian producers are upgrading their facilities.

MERCURY is liquid at room temperatures and has high electrical conductivity making it useful in the production of electrical controls, batteries, and mercury vapour lamps.

Spain, the US, Mexico and Algeria are the major western world producers. The principal ore is cinnabar (HgS), a bright red, soft sulphide mineral from which the mercury is recovered by heating. Further purification is by distillation and filtration.

Mercury is sold by the flask, (34.473 kg), and average price continues to fall from US$310/flask to US$150/flask over the last five years.

Canadian mine production ceased in 1975 when Cominco Ltd's Pinchi Lake, British Columbia, mine was shut down although Cominco continued to produce mercuric chloride from SO_2 gas at its smelter in Trail, British Columbia.

There are several minor mercury occurrences in the Yukon and mercury is a useful pathfinder element in the search for epithermal metal deposits.

In general there is a world oversupply of mercury and little price increase can be expected.

MOLYBDENUM is often grouped with the major metals and is a conventional exploration target about which much is known. Though not strictly speaking a part of this report, a brief review is included.

Molybdenum does not occur in its metallic state in nature, but has to be extracted from three minerals, molybdenite (MoS_2), wulfenite ($PbMoO_4$), and powellite (Ca(MoW)O_4). It is used primarily in metallurgical applications such as steel, cast iron and special alloys. Its non-metallurgical uses are in chemicals, catalysts and lubricants.

Most molybdenum is produced as a byproduct of porphyry-type copper mines, and the present oversupply which keeps prices depressed is likely to continue for at least another decade.

There are several Canadian molybdenum-bearing deposits, most of them in British Columbia. Among them are Noranda's Boss Mountain mine, Brenda Mines' Peachland deposit, Teck Corporation's Highmont mine, and the neighbouring Lornex mine. Placer Dome Inc has the Endako Mine and the Equity Silver Mine, and Amax owns the Kitsault mine. Many of these operations are mothballed at the moment due to low prices.

Numerous molybdenum-bearing properties have been discovered in the Yukon but none have been taken to production. In the face of continuing weak prices and oversupply it is unlikely that this situation will change in the foreseeable future.

The PLATINUM GROUP METALS (PGMs) are, strictly speaking, precious metals rather than minor metals. PGMs are chemically inert and resistant to corrosion. In addition they have peculiar magnetic, catalytic, and thermo-electric properties. They are used in a great variety of applications including automobile catalysts, chemicals, jewelry, and petroleum refining.

The two main PGMS are platinum and palladium, the latter being less valuable. The minor PGMS are rhodium, ruthenium, iridium, and osmium. Major world producers are the USSR, South Africa, and Canada. Both Soviet and Canadian production is from nickel-copper mines, but South Africa's is from deposits mined primarily for their PGM content.

A dramatic price increase in 1986 prompted aggressive worldwide exploration, and in Canada most layered ultramafic intrusions have been evaluated. In the Yukon PGMs have been found in ultramafics on the WELLGREEN property (Minfile #115G 024). 'Reserves' are reported to be 20.4 million tonnes grading 0.67% copper, 0.36% nickel, 0.026 opt platinum, and 0.014 opt paladium.

Also in the Yukon the platinum reported to occur in placer concentrates from Scroggie Creek is thought to have a source near Pyroxene Mountain, (115O-I).

RHENIUM is recovered from molybdenum concentrates as a byproduct and there are no deposits mined solely for their rhenium content. Copper mining determines the production of byproduct molybdenum, which in turn determines rhenium production. The chief use of rhenium is in rhenium-platinum catalysts used in petroleum refining. The sole Canadian producer is Island Copper near Port Hardy, British Columbia.

SELENIUM is not strictly a metal, but it has many of a metal's characteristics. It is used in the manufacture of electronic and photocopier components, in glass manufacturing, and in the production of selenium chemicals used in explosives, batteries, animal feeds, fungicides, and pigments.

It is produced as a byproduct of base metal refining, and in Quebec, Noranda Inc has the world's largest selenium facility with an annual capacity of 325 tonnes/year. A second Canadian producer is Inco with a selenium plant at Copper Cliff, Ontario. Other world producers are the US, Japan, the USSR, Belgium, Mexico, Sweden, Finland, Australia, Zambia, Yugoslavia and Peru.

SCANDIUM was originally produced from the mineral thortveitite which contains 30%-40% Sc_2O_3, and was mined in Norway and Madagascar. Later it was found that uranium mill wastes contained scandium, and these have become the present source of supply. Scandium has properties similar to yttrium and is still only used in very small amounts.

SILICON is used as a hardener and deoxidizer, a component of carbon alloy steel, and in the production of electrical steels. The production of silicon and silicon carbide is energy intensive and the three Canadian silicon producers, Chromasco, Union Carbide, and SKW Electro-Metallurgy Canada Ltd, are located in Quebec which has a surplus of hydro power.

STRONTIUM is produced from the mineral celestite, which is covered in this report under its own heading. It is used in the manufacture of television picture tubes, fireworks and flares, and in ceramic magnets. It is produced from celestite beds in Cyprus, and another deposit in Qatar which contains 63 000 tonnes containing 75%-85% strontium sulphate.

TANTALUM is mostly produced as a byproduct of tin smelting, and major producers are Thailand, Australia and Brazil. The major use of tantalum is in the manufacture of electrical capacitors. Other uses are in alloys with metals such as tungsten, titanium, vanadium and columbium, in superalloys with nickel and cobalt, and in chemically inert sheatings and coatings.

Canada's tantalum producer, the Tantalum Mining Corporation (Tanco), has a tantalum - lithium deposit at Bernic Lake, Manitoba. A second potential producer is Highwood Resources Ltd from its Thor Lake deposit in the North West Territories which contains tantalum, columbium, beryllium and rare earths. Reserves of the Lake Zone are reported to be 70 million tonnes with an average grade of 0.04% Ta_2O_5, 0.57% Cb_2O_5, 4.73% ZrO_2, and 1.99% rare earth oxides. An additional zone to the north of this contains 1.8 million tonnes of 0.85% BeO.

TELLURIUM, like selenium, is recovered as a byproduct of copper refining. Its main uses are as an alloy in steel production, an accelerator in rubber compounding, and as a semiconductor in thermoelectric and photoelectric devices. Noranda's Quebec copper deposits contain significant amounts of selenium.

THALLIUM is recovered as a byproduct in the smelting of base metals. It is used in limited amounts in the manufacture of photoelectric components.

THORIUM is recovered as a byproduct in the processing of monazite for its rare earth content. It is a component of nuclear fuels, lamp mantles, magnesium-thorium alloys, and welding electrodes. Monazite placers are mined in Australia, Malaysia, South Africa and Florida.

TUNGSTEN exploration in the Yukon has been intense, and strictly speaking it is not a part of this report. Nonetheless a brief review will be included.

Tungsten is recovered from four minerals, scheelite ($CaWO_4$), wolframite ($(FeMn)WO_4$), ferberite

($FeWO_4$) and hubnerite ($MnWO_4$). Most tungsten is used in the production of tungsten carbide and tool steel products. Other uses are in superalloys and nonferrous alloys, as a pure metal in electrical components, and in tungsten-bearing chemicals and compounds.

In the past the world's largest producers have been the People's Republic of China, and the USSR, followed by Bolivia, Australia and Canada. The present oversupply of tungsten has led to the closing of all North American mines including Canada Tungsten and Mount Pleasant Tungsten. With the Mactung deposit on the Yukon - North West Territories boundary, which contains 30 million tonnes of 0.9% WO_3, Canadian tungsten reserves are enormous.

In addition to the above deposits, intense exploration for tungsten in the 1970s led to the discovery of numerous smaller Yukon occurrences. An example is the MAR property, (GARNET, Minfile#106D 27), owned by Queenstake Resources reported to contain 1.36 million tonnes grading 1.2% WO_3.

VANADIUM minerals include:

carnotite
$(K_2O.2U_2O_3.V_2O_5.3H_2O)$,

roscoelite
$[2K_2O.2Al_2O_3(Mg,Fe)O.3V_2O_5.10SiO_2.4H_2O]$,

titaniferous magnetite
$[FeO.TiO_2.FeO(Fe,V)O_3]$
and V_2O_5 in solid solution

descloizite
$[4(Cu,Pb,Zn)O.V_2O_5.H_2O]$,

phosphate rock
$[Ca_5(PO_4)3(F,Cl,OH)]$ with
VO_4 replacing PO_4.

Vanadium is used as a component of steel alloys, titanium alloys, and catalysts in sulphuric acid and petroleum production. High-strength-low-alloy steels and full alloy steels account for 60% of consumption. Other minor uses include pigments in glass and ceramics, driers in paints and varnishes, and in the processing of colour film.

The world's major production is from titaniferous iron ores in the Bushveld Complex of South Africa, and the Ural Mountains in the USSR. Typically these deposits contain about 1.8% V_2O_5. The titaniferous magnetite is smelted to produce iron and a vanadium rich slag.

Other deposit types are vanadium-bearing phosphates found in Idaho, uranium-vanadium carnotite ores in Colorado which carry 1% V_2O_5, and vanadiferous clays in Arkansas.

Canada has no domestic vanadium production. A titaniferous magnetite deposit at Lac Dore, Quebec, contains 0.6% V_2O_5, but this is unlikely to be exploited due to a world oversupply of iron ore. In various parts of the country sedimentary beds such as sandstones, limestones and shales carry small amounts of vanadium, generally less than 0.3% V_2O_5, which is too low a grade to be worked.

The Alberta Tar Sands contain small amounts of vanadium, and a limited recovery from fly ash is possible. Indeed Carbovan Inc. is planning to produce 2 to 2.3 million pounds a year of V_2O_5 from a plant it is constructing in the Fort McMurray area for the processing of feed purchased from Suncor Inc.

Prices are currently around US$1.85/lb. In the long term, demand for vanadium is expected to show a steady growth. Consumers are particularly aware that the western world's supplies are largely dependent on South African production.

YTTRIUM is generally classed with the rare earth elements and is covered under the rare earths heading.

ZIRCONIUM is recovered primarily from placer deposits, and is referred to separately under the heading zircon (p. 45) with some mention under gem stones (p.20) as well.

NEPHELINE SYENITE

GENERAL DESCRIPTION

Nepheline is often grouped with feldspar because both minerals are used primarily in glass manufacture. However nepheline is too deficient in silica to be a true feldspathoid. Its formula is $K_2O.3NaO.4Al_2O_3.9SiO_2$. It is favoured over feldspar in glass making due to its lower fusing point, higher alumina content, absence of free silica, and low iron content.

Nepheline is the most characteristic mineral of the alkaline rocks and is produced from nepheline syenite intrusives. The glass industry consumes 75% of the nepheline syenite production. It is also used as a component of ceramic glazes, and as a filler in plastics, paint, rubber and paper.

The glass industry has suffered in recent years from substitution by plastics, aluminum and paper, particularly in the container sector, and many container glass plants have closed.

WORLD PRODUCERS

Nepheline syenite production and export trade is dominated by two countries; Canada, which is the world's largest producer, exporting to the US, and Norway, which exports to Europe and the USSR. A small amount is also produced by Brazil and the USSR.

CANADIAN PRODUCTION

The two Canadian producers are Indusmin Limited, (a Falconbridge subsidiary) and IMC

Chemical Corp, both mining the extensive Blue Mountain deposits in Methuen Township, Ontario.

The nepheline syenite is a uniform, foliated, fine to medium grained rock composed essentially of 20% to 25% nepheline, 48% to 54% albite, and 18% to 23% microcline. Accessory minerals are 0.2% to 0.6% magnetite, 0-4% biotite, 0-3% hastingsite, and 0-2% muscovite and aegerine.

The mine product is upgraded to low-iron and high-iron glass grades by crushing, drying, screening, high intensity magnetic separation, and pebble milling. For filler grades further benefication is achieved through the use of fluid energy mills and air classification.

Listed prices are between $25/tonne for glass grade and $105/tonne for extender and filler grades.

WESTERN CANADIAN DEVELOPMENTS

Since all Canadian production is in the eastern part of the country there are opportunities for production in the west, with the potential for markets in the Pacific Rim.

In general, the impurities present in a deposit should be readily liberated by crushing to 30 mesh. Ring-complex and carbonatite deposit types are usually too variable in composition and can contain deleterious trace elements.

Nepheline syenites of the sheet, gneissic and border phase of granite and syenite intrusive types are more likely to have the required uniform composition and quality.

Nepheline syenites, carbonatites, kimberlites and ultramafic lamprophyres are alkaline rocks which in Western Canada are found in a broad zone which parallels and contains the Rocky Mountain Trench. To the north this trend continues into the Yukon following the Tintina Trench.

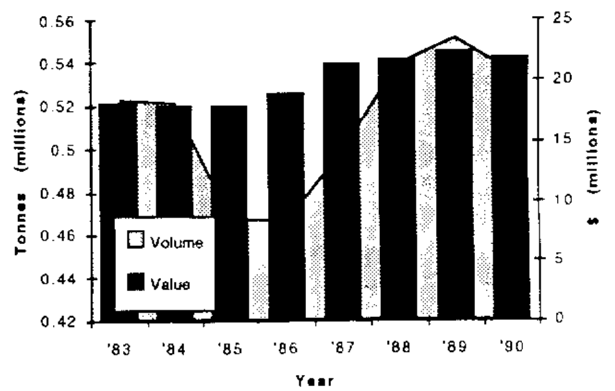
Examples of British Columbian nepheline syenites are found in the Ice River complex, Bearpaw Ridge, Paradise Lake, Trident Mountain, and the Perry River area. Though some of these syenites are very similar in composition to the Blue Mountain deposit, their remote locations severely limit their economic potential.

YUKON OCCURRENCES

In the Yukon documented nepheline syenite occurrences are rare. One examples is on the VISTA property (95C 05 Minfile#SE 051) where a nepheline syenite stock hosts radioactive and rare earth elements.

Though more detailed work in the future will no doubt identify additional nepheline syenites in the northward continuation of the cordilleran alkaline trend, the comparative isolation of such deposits will hamper their development.

Canadian Nepheline Syenite Production



NITRATES

nitre, nitratine, saltpetre

Nitrogen is a necessary component of fertilizers. Plants and bacteria absorb nitrogen from the air. Some plants such as alfalfa and clover are able to fix nitrogen in the soil, but most other crops deplete the soil's reserves and nitrogen deficiencies have to be made up by crop rotation or fertilizer application. Fertiliser use consumes 85% of nitrogen production.

The two naturally occurring nitrogen minerals that are of commercial importance are nitratine ($NaNO_3$), also called Chile saltpetre or soda nitre, and nitre (KNO_3) also known as saltpetre.

Natural nitrates are very soluble in water, and the only commercially exploited deposits are in the Atacama Desert in northern Chile where they are confined to a strip of barren desolate country which runs parallel to the coast for 700 km and is 20 to 80 km wide.

The nitrate beds, called caliche, are up to 25 m thick, at or near surface, and contain about 25% nitratine and 3% nitre. Accessory minerals are common salt, sulphates of sodium, calcium and magnesium, and minor amounts of iodates, borates, bromides, phosphates, lithium and strontium. All these soluble salts occur as a cementing material in a red-brown sandy gravel.

Several theories have been put forward for the origin of these deposits including leaching of bird guano, bacterial fixation, oxidation of vegetable matter, and leaching of volcanic rocks under unusually arid conditions.

Originally all commercial nitrogen was obtained from the Chilean deposits, but then a process was developed to produce nitrogen during the coking of coal. The demand for nitrogen for the manufacture of explosives increased during World War I and Germany developed a method of fixing nitrogen from the air. Shortly afterwards came the direct synthesis of ammonia from nitrogen and hydrogen, and this process now yields most of the worlds supply.

There are, then, five sources of commercial nitrogen compounds:

1) Chilean nitrate deposits.

2) Ammonium sulphate from coke and coal gas.

3) Synthetic combination of nitrogen and hydrogen to form ammonia.

4) Synthetic production of calcium cyanamide ($CaCN_2$) from atmospheric nitrogen.

5) Organic refuse and bird guano.

The third and fourth sources account for 75% of all nitrogen consumed, and Chilean deposits now account for less than 10%. In addition to Chile small amounts of nitrates are produced by India, Egypt, China and Spain. Other deposits are known in Bolivia, Argentina and South Africa and one US occurrence is reported near Safford, Arizona.

Fertilizers are marketed as ammonium sulphate, sodium nitrate, and calcium cyanamide. Other uses of nitrogen compounds are in the manufacture of explosives such as trinitroluene (TNT), nitroglycerine, and nitrocellulose; the manufacture of nitric acid; and the production of chemical salts and ammonia compounds.

OLIVINE

Olivine is the main component of dunite, an ultramafic rock type often associated with pyroxenites. Olivines form an isomorphous series from forsterite (Mg_2SiO_4) to fayalite (Fe_2SiO_4) and to be industrially useful olivine must be less than 15% fayalite.

Olivine is a refractory mineral which can replace chromite in steel furnaces and be used above the slag line in nonferrous furnaces. Olivine is also mixed with magnesite to form refractory bricks, and used for moulds for casting brass, bronze, aluminum and magnesium.

World production is from dunite deposits in Norway, Sweden, Austria, Japan, New Zealand, Zimbabwe, and South Africa. Canadian production is from Ste. Anne des Monts Quebec.

In order to be economically viable a dunite deposit should contain at least 40% MgO, and accessory minerals such as serpentine, chlorite and vermiculite must be readily removable.

Recently listed prices are between US$50 and US$75/tonne for foundry sand grade olivine.

In the Yukon dunites have been mapped in the south west of the Territory in the Kluane Range, and on Dunite Mountain in the Quiet Lake area (105-F). Other dunites could be expected in areas of ultramafics, and possible associated minerals would be asbestos, chrome and platinum.

PEAT

Peat is an accumulation of partly decomposed vegetable matter formed under anaerobic conditions. It represents the first stage in the formation of coal. Canadian deposits generally started to form 11 000 years ago and accumulate at a rate of 0.5 to 1.7 mm per year.

Horticultural peat is composed of poorly decomposed sphagnum moss, while fuel peat must be more thoroughly decomposed.

Peat materials are usually separated according to their botanical composition. Examples are sphagnum peat, sedge peat, brown moss sedge peat, woody sedge peat, woody peat, feather moss peat, sedimentary peat and amorphous peat.

In 1986 the US consumed about 1 million tonnes of peat valued at US$21 million. The principal producers are Florida, Michigan, Illinois, Indiana, and Colorado.

Packaged peat marketed for potting soil and soil improvement accounted for 55% of of the consumption. The remainder was sold in bulk for similar applications by nurseries and golf courses.

Recent trends have been to try and find new uses for peat. A diesel-like fuel has been synthesized from peat, but it is too expensive to produce. Some US states are experimenting with power generation from peat supplies .

The US imports 450 thousand tonnes of peat each year, most of this from eastern Canada.

In British Columbia it is estimated that 1% of the total land area is covered by peatland, though the resource has not been studied in any detail. Production is confined to accessible and populated regions, in particular from Burns Bog which in 1980 produced 26 000 tonnes with a value of $3.9 million.

Very little is known of the Yukon's peat deposits, and it would seem that an inventory of the territory's peat land resource is necessary. However remoteness, a cool climate, and permafrost will limit development. Climate has a strong impact on the feasibility of peat mining because the air temperature and the amount of sunshine and rainfall affect field drying of milled peat. Perennially frozen peatlands, permafrost, and a high ice content can be expected to cause additional technological and environmental problems.

PHOSPHATES

rock phosphate, apatite, guano

GENERAL DESCRIPTION

Plants and animals cannot exist without phosphorus, and of all the substances necessary for plant growth, phosphorus compounds are the most likely to be deficient. This is not because phosphorus is scarce in nature, but because before it can be assimilated by a plant's roots it must be in a very fine form.

Rock phosphate can be finely ground and spread directly on the land, but this natural material is not readily soluble in water so that it decomposes slowly and is not immediately available to the plants.

Treating natural mineral phosphate with sulphuric acid produces 'superphosphate', a readily soluble form of fertilizer. 'Superphosphate' can be upgraded to 'double superphosphate' or 'concentrated superphosphate' containing up to 54% phosphoric acid.

DEPOSIT TYPES

Phosphate deposits and sources are:

1) Phosphate rock, including 'land pebble', 'river pebble', 'hard rock', and 'brown rock' deposits.
2) Phosphatic marls and limestones.
3) Marine phosphate beds.
4) Apatite deposits.
5) Guano.
6) Basic blast-furnace slag.

Phosphate rock deposits are all residual concentrations of phosphates. The phosphate mineral is one of the members of the fluorapatite-chlorapatite-hydroxylapatite series with a general formula $Ca_5(PO_4,CO_3)3(F,OH,Cl)$.

'Land pebble' deposits are the result of marine reworking of phosphatic limestone to produce resistant phosphate pebbles that accumulate in a gravel bed. Such deposits occur in Florida and supply most of the US's phosphate. 'River pebble' deposits are accumulations of hard pieces of phosphate in a stream channel where the stream crosses a phosphatic bed. 'Hard rock' and 'brown rock' are accumulations of pieces of phosphate derived from the erosion of phosphatic beds.

Phosphatic Marls and Limestones are sedimentary beds with unusually high phosphate contents. They are usually of too low grade for commercial exploitation, though they may be used locally for fertilizer. They are, however, important source materials for the secondary residual 'rock' deposits.

Marine phosphate beds are chemical accumulations of phosphate formed in enclosed marine basins. They occur in the western US and are important commercially.

Apatite deposits are concentrations of the mineral apatite ($3CaP_2O_8CaF_2$) which occur in pegmatites and veins, in carbonate-alkaline (carbonatite) complexes, and in magmatic segregations in gabbros and nephelines. Though these deposits are the original source of phosphorous, they are usually low grade and too expensive to work.

Guano deposits are formed when phosphatic solutions from bird droppings react with coral to form tricalcic phosphate. The phosphates accumulate in hollows between pinnacles of resistant coral rock.

Commercially exploitable phosphate deposits generally contain more than 66% Tri Phosphate of Lime (TPL). Grades are also expressed as % Bone Phosphate of Lime (BPL) which is the same as % TPL. A third way of reporting grade is as % P_2O_5, and TPL or BPL = 2.185 x % P_2O_5 .

The richest deposits are the guanos of Nauru, Ocean, Angaur and Makatea Islands which carry up to 90% BPL. Florida 'rock' deposits contain around 70% BPL.

PRODUCERS and MARKETS

The world's leading phosphate exporters are Morocco (16.3 million tonnes/year), the US (14.1 million tonnes/year), the Pacific Islands of Ocean, Nauru and Christmas (3.1 million tonnes/year), Togo (2.7 million tonnes/year) and Tunisia (1.9 million tonnes/year).

US production is mostly from Florida and North Carolina which account for 86%. The remainder is from Idaho, Utah, Montana, and Tennessee.

Fertilizer accounts for 91% of phosphate consumption. The remaining 9% is used in the production of chemicals such as fluorosilicic acid, and vanadium and uranium.

There is a world oversupply of phosphate at present, and the industry is export dependent. Factors that have contributed to the oversupply include depressed agriculture prices and the barter of cheap imports as payment for grain sales. Prices are negotiated between producer and consumer and generally depart from listed prices in consideration of transportation costs and local competition. The average 1986 price of exported rock was US$ 27.50/tonne fob Florida. No short term increase of demand versus supply is anticipated.

CANADIAN FERTILIZER PRODUCTION FROM IMPORTED PHOSPHATES

Canada has no domestic phosphate production and imports all its requirements, 2.3 million tonnes in 1986, from Florida, South Carolina, Montana, Idaho, Morocco, Togo and Jordan.

Canadian fertilizer plants produce DAP (di-ammonium phosphate) and MAP (mono-ammonium phosphate). They are designed to process phosphate rock with a grade between 31% and 33% P_2O_5 and they have a combined annual capacity of 1.14 million tonnes of 100% P_2O_5. Most plants operate at less than their capacities and several have been mothballed.

Western Canadian plants are at Kimberley and

Trail, British Columbia; and Redwater, Fort Saskatchewan, Calgary and Medicine Hat, Alberta.

Phosphate rock destined for western Canada is transported mainly as a backhaul to Canadian lumber exports to the US and potash exports to South America. The railhaul inland from Vancouver is a backhaul to potash from Saskatchewan, and total shipping costs from Florida through the Panama Canal are competitive with rail haul from the western US.

CANADIAN DEPOSITS

Canadian phosphate deposits can be divided into four types. 1) apatite deposits in the Grenville terrain of eastern Ontario and southwestern Quebec, 2) apatite deposits in carbonatite complexes in Ontario and Quebec, 3) sedimentary deposits in the southern Rocky Mountains near Fernie, British Columbia, and 4) phosphatic iron formations in the Richardson Mountains, Northern Yukon.

The deposit given the most attention is the Cargill (Kapuskasing) carbonatite which was explored by International Minerals and Chemical Corp in 1978, and by Sherritt Gordon Mines in 1979. It was found to contain 22 million tonnes of 27% P_2O_5 and 6 million tonnes of 33% P_2O_5. This property is now controlled by a joint venture between Sherritt Gordon Mines, Campbell Resources, and New Venture Equities. It has been concluded that the grades are too low at present and that phosphate prices will have to rise to around $70/tonne before the deposit can be mined.

A second carbonatite is near Martinson Lake, north of Hearst, Ontario. It is reported to contain 57 million tonnes of 23% P_2O_5.

The sedimentary deposits in British Columbia are narrow steeply-dipping beds which would require underground mining and are therefore uneconomic at the present time. They occur from Fernie to the headwaters of the Elk River. Typical deposits contain up to 4 million tonnes with a maximum grade of 26% P_2O_5.

YUKON DEPOSITS

The Yukon's Rapid Creek-Big Fish River phosphatic iron formation in the Richardson Mountains is unique. It consists of cyclicly interbedded Lower Cretaceous sideritic mudstones and shales, montmorillonitic shales, phosphatic mudstones, pelletal phosphorates and carbonates deposited in a shallow marine environment. Sections containing numerous siderite beds are up to 450 m thick and contain 15% to 25% iron and 13% P_2O_5. Some individual layers contain up to 20% P_2O_5. The dominant phosphate minerals are satterleyite, $[(Fe,Mg,)_2(PO_4)(OH)]$, and arrojadite $[KNa_4CaMn_4Fe_{10}Al(PO_4)_{12}(OH,F)_2]$.

The suite of exotic complex phosphate minerals includes over 30 species, most of which are extremely rare, and ten of which are new to science. They include alluaudite, apatite, arrojadite, augelite, baricite*, brazilianite, childrenite, collinsite, diadochite, garyansellite*, gorceixite, gordonite, gormanite*, goyazite, kryzhanovskite, kulanite*, lazulite, ludlamite, maricite*, messelite, metavauxite, metavivianite, nahpoite*, penikisite*, phosphosiderite, rapidcreekite*, satterleyite*, souzalite, vivianite, wardite, whiteite, wicksite*, and wolfeite. (* indicates a new mineral.)

The siderite beds are of too low a grade to be economically viable as iron ore deposits but more detailed exploration may enhance the area's potential as a future phosphate producer. Being the type locality for so many exotic phosphate minerals the area is also of great interest to mineral collectors.

POTASH

GENERAL DESCRIPTION

The name potash is derived from the iron pots once used to evaporate the solutions leached from plant ashes and lime. Potash refers to potassium oxide (K_2O), a compound which does not occur in nature but is artificially prepared from natural minerals

Potassium is present in most rocks in combination with aluminum and silica as orthoclase feldspars, muscovite and biotite micas and others. Feldspars are readily weathered and the released potassium is carried away in solution to the sea. Evaporation of sea-water in enclosed basins results in the concentration of the chlorides and sulphates of potassium and magnesium as saline residues.

The largest accumulations are the Saskatchewan deposits of Canada, the Stassfurt deposits of Germany, and the Solikamsk deposits of the USSR.

In these deposits the main potassium minerals are sylvite (potassium chloride), kainite (potassium chloride and magnesium sulphate), and polyhalite (sulphate of potassium, magnesium and calcium). Potash is also recovered from brines of the Dead Sea; Searles Marsh, California; and Saldura Marsh, Utah.

USES

The majority of potash production (95%) is used as an agricultural fertilizer. Potassium increases photosynthesis and food formation, improves root growth and drought resistance, reduces respiration and energy loss, builds stronger stalks and stems and retards disease.

In addition to its major use as a fertilizer, potash compounds are also important in the chemical industry though the volumes used are relatively small. Chemical uses include soap, glassware, preservatives, explosives, fireworks, dyes, medicine, photography, and metallurgical flux.

The world's major exporters of potash are Canada, Israel, West Germany and the USSR.

CANADIAN PRODUCERS

Canadian annual production is around 7 million tonnes, with an average value fob minesite of \$83/tonne. Due to present weak demand plants are operating well below their rated capacities which total 9.82 million tonnes/year in Saskatchewan and 750 thousand tonnes/year in New Brunswick. Canada exports 95% of it's production, 60% of the exports going to the US.

The Saskatchewan mines are in the Prairie Evaporite geological formation. The potash seams are 2.5m to 5.0m thick, cover an area of 29 km^2. and contain the world's largest known potash reserves in continuous orebodies. They are low in impurities, have very high grades, are structurally simple, and easy to mine, and present no insurmountable environmental problems.

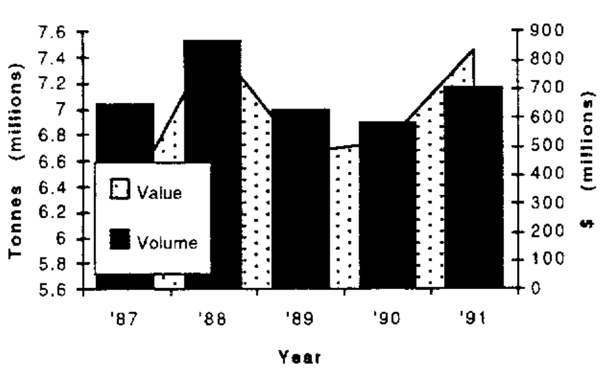
The potash beds are mined conventionally to depths of 1070 m, and given a 30% recovery factor, reserves are calculated to be 14 billion tonnes. In addition there are an estimated 42 billion tonnes available for solution mining.

Outside Saskatchewan the Potash Company of America has a deposit near Sussex, New Brunswick, which contains 30 years reserves at a production rate of 0.9 million tonnes/year. Production started in 1983 after capital expenditures of \$225 million on the mine and \$40 million on port facilities.

A second New Brunswick mine owned by Denison and the Potacan Potash Company is the Cloverleaf mine near Salt Springs. Reserves are 254 million tonnes of 28.5% K_2O. This mine went into production in 1985 for a capital cost of \$425 million.

Canadian potash is marketed by Canpotex, which is owned by and markets on behalf of Central Canada Potash, a division of Noranda; Cominco; International Minerals and Chemical Corporation (Canada); Kalium Chemicals; Kidd Creek Mines; Potash Company of America; and PCS Sales, a subsidiary of the Potash Corporation of Saskatchewan.

Canadian Potash Production



World potash consumption is forecast to grow 1.5% to 3.8% a year for the next ten years. Free world consumption is expected to reach 26 million tonnes in the year 2000, of which 15 million tonnes will be supplied by Canada.

RARE EARTH ELEMENTS (REEs)

GENERAL DESCRIPTION

Rare-earths is a convenience term to include those minerals that were until recent times largely unknown, and considered to be rare. Also called lanthanides they are all chemically similar and have atomic numbers 57 through 71. They include lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolimium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.

Yttrium, though technically not a rare-earth element is classed with them because it invariably occurs with them in nature and has similar chemical properties.

USES and PRODUCERS

Rare-earths are used principally in petroleum cracking catalysts, iron and steel alloying agents, glass polishing compounds, glass additives, permanent magnets, and phosphors for television and lighting. Recent use of these metals in super conductors has increased their demand.

Commercial production of rare-earths is from a primary bastnaesite deposit, monazite placers and beach sands, a primary monazite deposit, carbonatite occurrences, uranium ores, and phosphatic rocks.

Bastnaesite contains 75% rare-earth oxides and .05% yttrium and has been mined from vein deposits, contact metamorphic zones, pegmatites and other igneous rocks. A large bastnaesite deposit discovered in 1949 at Mountain Pass, California, accounts for about half the world's rare-earth production.

Monazite contains 70% rare-earth oxides and about 1.5% yttrium oxide. Most monazite is a byproduct from rutile-ilmenite and zircon placers, usually beach sands, containing as much as 80% heavy minerals with 1% to 20% monazite. There are extensive monazite-bearing placers in Brazil, Australia, India, Sri Lanka, and Madagascar.

It is forecasted that world demand for rare-earths will increase, but that present supplies are adequate to meet future demands.

Recently quoted prices include US\$1.05/lb of rare earth oxide (REO) content for bastnaesite concentrates, A\$700/tonne for monazite concentrates containing 55%

REO fob Australia, and US$35/kg for yttrium concentrates containing 60% Y_2O_3 fob Malaysia.

CANADIAN DEPOSITS

Canada has substantial rare-earth reserves but no production at present. The Elliot Lake uranium ores contain about 0.057% rare-earth oxides (REOs), and the Agnew Lake uranium deposits about twice as much REOs, but recovery of the rare-earth content is currently considered uneconomic.

Highwood Resources Ltd's Thor Lake property 100 km southeast of Yellowknife contains significant amounts of REOs with tantalum, columbium, zirconium, beryllium, uranium and thorium. Published reserves in the two T Zones are as follows: the North T Zone contains .51 million tonnes grading 1.11% beryllium oxide, .17% yttrium oxide, .028% rare earth oxides, and .58% niobium oxide, and the South T Zone contains 1.25 million tonnes grading .62% beryllium oxide, .1% yttrium oxide, .2% rare earth oxides, and .46% niobium oxide.

The Strange Lake deposit owned by the Iron Ore Company of Canada, located some 250 km northeast of Schefferville on the Quebec-Labrador border is reported to contain large tonnages of zirconium, yttrium, columbium, beryllium and REOs.

Niobec Inc's pyrochlore-bearing carbonatite near St. Honore, Quebec, and other similar carbonatites also contain significant amounts of REOs.

In British Columbia rare earth elements are confined to a belt of alkaline rocks which runs parallel to and contains the Rocky Mountain Trench. In the Aley complex narrow carbonatite dykes are enriched in REE's and fluorite, and at Rock Candy Creek, some 40 km east of Canal Flats, a fluorite showing contains up to 10% fluorite, 2.3% REE's, 2.7% barium, and minor amounts of niobium, strontium and yttrium.

YUKON OCCURRENCES

The cordilleran alkaline trend continues into the Yukon from British Columbia and recently a few rare earth occurrences have been discovered in the southeast part of the territory.

On the VISTA property in south-east Yukon (95C 5 Minfile #SE 051) owned by Consolidated Silver Standard Mines Ltd, a Cretaceous nepheline syenite intrudes Paleozoic shales and carbonates. The syenite is enriched in radio-active and rare earth elements and several samples contain more than 1% combined REEs.

On Noranda's NOKLUIT property on the Quiet Lake Map sheet (Minfile #105F 080) REEs, thorium and niobium are associated with a syenite breccia pipe.

On the nearby GUANO property (Minfile #105F 081) REEs and niobium are associated with skarns composed of serpentine, actinolite, tremolite, idocrase and magnetite.

Anomalous REEs have also been recorded from uranium and copper bearing breccias in the Wind River-Bonnet Plume River area, (106D,E).

SALT

GENERAL DESCRIPTION

Common salt, sodium chloride, is near indispensable to man, so much so that in some countries it has served as a basis for taxation under government monopoly to ensure monetary contribution from every family. Roman soldiers were paid partly with salt, hence the word 'salary'.

Despite its use in preserving and seasoning food, most salt is consumed by the chemical industry. It is used in the preparation of many chemicals such as sodium hydroxide (caustic soda), chlorine, hydrochloric acid, sodium carbonate (soda ash), sodium bicarbonate, sodium silicate, sodium bichromate, and sodium hypochlorite.

The chemicals industry consumes 49% of US salt and 24% is used for highway de-icing. In Canada the chemical industry and highway applications account for 90% of total consumption.

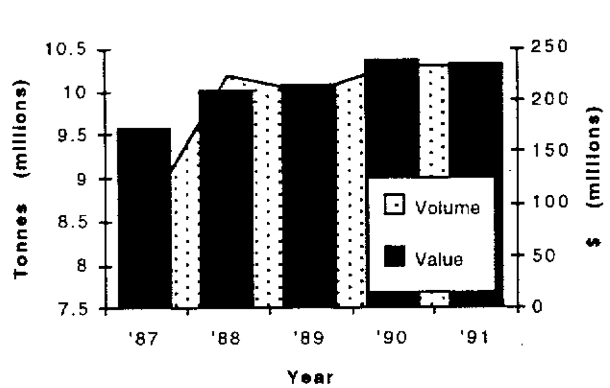
Natural occurrences of salt occur as rock salt or halite, usually with impurities such as calcium and magnesium sulphates and chlorides. There are unlimited world supplies.

CANADIAN PRODUCERS

Canada's salt producing provinces are Nova Scotia, Ontario, Manitoba, Alberta and Saskatchewan. The Atlantic Provinces' production comes from sedimentary deposits within the Mississippian Windsor Group which are exploited on a large scale. The salt deposits are associated with potash enrichments, and grade up to 97% sodium chloride. Reserves are in the billions of tonnes.

Ontario also has sedimentary salt beds which

Canadian Salt Production



underlie much of the southwestern part of the province and are worked by underground mines and brine wells.

The Prairie Provinces are underlain by salt beds from the southwest corner of Manitoba across Saskatchewan and into north-central Alberta. The salt beds are contained in the Prairie Evaporite Formation which also hosts Saskatchewan's potash reserves.

British Columbia has no salt production and chloralkali plants in Prince George, North Vancouver, Squamish and Nanaimo depend on imports from Mexico and the US valued at more than $4 million/year.

No salt deposits have been found in the Yukon to date and the Territory's consumption is negligible.

SILICA SAND

quartz crystal, lascas, silicon

GENERAL DESCRIPTION

Silica sand refers to high quality industrial sand containing 95% to 99% silica usually produced from relatively pure sandstones with some additional exploitation from pegmatites and quartz veins

USES and MARKETS

The North American industry is dominated by a few large producers which are secretive about grades, capacities and prices. There is intense competition on a regional basis particularly since unit prices preclude distant transport.

Markets are concentrated in industrial areas, and deposits are generally within two hundred miles of them unless the product is specialized.

The largest consumption is in the manufacture of container glass. This use was under attack due to metal, plastic and paper substitution, but the introduction of container laws may revitalise the industry. The second largest user is the flat glass sector which includes automobile and architectural glass. In total, glass manufacture accounts for 40% of North America's silica sand consumption.

Other uses include abrasives, fluxes, roofing granules, fillers in asphalt rubber and paint, water filtration, coal washing, and the production of silicon, ferrosilicon and silicon carbide.

Fiberglass manufacture is a recent growth market, as is the use of frac sand required in the hydraulic fracturing of hydrocarbon formations to promote oil and gas production.

CANADIAN PRODUCERS

Canadian producers are Indusmin, with operations at Badgeley Island, Ontario, and St Canut and St Donat in Quebec; Steel Brothers with production from Black Island in Lake Winnipeg; and B. Miller, Chemtech Enterprises, and Mountain Minerals with operations in British Columbia.

The Black Island deposit is a poorly consolidated sandstone of the Winnipeg Formation. The pit run material is washed, screened, dewatered, scrubbed, laundered, separated, and dewatered again. The end product is pure white, sized to -20 +100 mesh, containing 99.58% SiO_2, 0.02% Fe_2O_3, 0.22% Al_2O_3, 0.005% TiO_2, 0.018% CaO, 0.037% MgO, and 0.106% LOI (loss on ignition).

An example of a British Columbian quartzite used for silica production is the Mount Wilson formation quartzite which can be followed along the eastern ridge of the Rocky Mountain Trench for 50 km. At Brisco it is 70 m to 100 m thick, and analyses are better than 97.94% SiO_2, less than 1.25% Al_2O_3, less than 0.08% CaO, and less than 0.12% Fe_2O_3. The product is used in the manufacture of ferrosilicon and glass.

Total Canadian silica consumption is some 2.5 million tonnes per year, of which some 1 million tonnes are imported from the US.

Prices depend on local markets, sand grades, and transportation distances, and vary from $8/tonne to $13/tonne for glass sand, and up to $23/tonne for frac and fiberglass sand.

There is the potential for the establishment of a flat glass producing facility in western Canada since good quality silica sand is available together with relatively cheap natural gas and electricity.

However, with no local glass or fiberglass manufacturers it is unlikely that a silica sand deposit could be successfully developed in the Yukon.

Quartz crystal is essential for making piezoelectric filter devices that separate desired from undesired portions of the frequency spectrum, and oscillators that provide single frequency signal sources. Filters and oscillators are used for a wide variety of communications and instrumentation purposes.

Crystals of quartz suitable for electrical purposes are rare. They are found in cavities and on joint planes in quartzites that have been invaded by granitic rocks. World reserves are limited, but the increasing acceptance of cultured crystal is reducing the dependence on these reserves. Nonetheless natural crystals are still important because they are needed as seed material for growing cultured quartz.

The major producers are Brazil, Uganda, and Madagascar. There is no North American production of quartz crystal.

As far as is known none of the Yukon's quartz crystal occurrences have the characteristics required for development

Lascas is a natural non-electronic grade of ultra-high purity quartz used as feedstock for growing cultured quartz crystal and for the production of fused quartz.

The US is a net exporter of lascas from deposits in Arkansas.

Japan is the leading producer of cultured quartz crystal, deriving most of its lascas from Madagascar.

Cultured quartz producers have their own strict grade requirements and sampling and analysis of a potential lascas source should be carried out in close co-operation with end users.

Some of the Yukon's quartz deposits may have the characteristics necessary to be exploited as a lascas source.

SILLIMANITE

andalusite, kyanite, dumortierite

Sillimanite, andalusite, and kyanite all have the same composition, Al_2SiO_5; they differ only in crystal form. Dumortierite is an aluminum borosilicate with the composition $Al_8BSi_3O_{19}(OH)$. When fused at temperatures between 1100°C and 1600°C these minerals are converted wholly or partly into mullite, $Al_3Si_2O_{13}$.

Mullite remains stable to 1810°C, has a low coefficient of expansion, is resistant to check, and has low electrical conductivity. These properties make it an ideal material for the manufacture of spark plugs, laboratory ware, and refractory bricks.

The sillimanite group occurs as accessory minerals in metamorphic rocks such as gneisses and schists, and less importantly in granitic pegmatites.

Commercial deposits of kyanite are rare. They occur as disseminations and small masses in gneiss or schist, or as lenses in pegmatite dykes or clots in quartz veins.

Annual world production is about 120 000 tonnes. World producers are the US, from deposits in Virginia and Georgia, and South Africa, India and Kenya. The US kyanite deposits contain 15%–40% kyanite, and producers are said to be searching for new supplies. Lower grade deposits that are no longer economic are found in California, Nevada and North Carolina.

Andalusite occurs in rocks and in pegmatites. It is often associated with tourmaline, garnet, corundum, topaz, quartz and mica.

Dumortierite is found in pegmatites and quartz veins that cut aluminous rocks, and is generally associated with andalusite.

Although the US imports 6 thousand tonnes of andalusite from South Africa annually, the supply of sillimanite group minerals is so enormous that any new deposit would have to be of exceptional quality and be well placed with respect to the markets before it could be considered for production.

Recently listed prices include US$70–US$137/tonne for raw US kyanite. US$123–US$172/tonne for calcined kyanite, US$130–US$170/tonne for South African andalusite, and US$330/tonne for South African sillimanite.

CANADIAN DEPOSITS

There are no Canadian producers, the known occurrences being of too low a grade for exploitation. In Ontario kyanite is associated with garnets in gneisses at Crocan Lake. In Quebec, Mazarin Inc has a property near Lac Croche, 32 km south of Fermont, which is reported to contain 20% to 40% kyanite as large blue crystals 1 to 2 cm in size.

Both kyanite and sillimanite can be found in the Yukon, but only as accessory minerals in the Yukon-Tanana metamorphic terrain, or in narrow contact zones around the higher temperature intrusions.

SODIUM CARBONATE

(soda ash), sodium sulphate

Sodium carbonate is marketed as soda ash (Na_2CO_3), and washing soda ($Na_2CO_3.10H_2O$), and as a bicarbonate for baking soda, carbonated water and fire extinguishers. Co-products from sodium carbonate production are sodium sulphate, potassium chloride, potassium sulphate and borax.

The two chief naturally occurring carbonates of sodium are trona ($Na_2CO_3.NaHCO_3.2H_2O$) and natron ($Na_2CO_3.10H_2O$).

Major deposits are at Lake Magadi in Kenya, and in Wyoming. Other producing countries are Australia, Bolivia, Botswana, Brazil, Chad, China, Egypt, Ethiopia, India, Kenya, Mexico, Namibia, Nigeria, Pakistan, South Africa, Tanzania, Turkey, Uganda, USSR, and Venezuela.

The Wyoming trona deposits contain some 33 billion tonnes of soda ash. Additional US production is from Searles Lake and Owen's Lake, California. Huge potential producers are the Colorado oil shale deposits which contain an estimated 29 billion tonnes of nahcolite (sodium bicarbonate), and 17 billion tonnes of dawsonite (sodium aluminum bicarbonate).

The proportionate uses of sodium carbonate in the US are glass manufacture 50%, chemicals 23%, soaps and detergents 4%, and pulp and paper 4%.

In the past Canada has produced small amounts from alkaline lakes as a byproduct of sodium sulphate production.

Sodium sulphate is produced from brines and alkaline lakes, and as a byproduct from the manufacture of various chemicals.

Canada has a large natural sodium sulphate resource in the alkaline lakes of Saskatchewan and Alberta which are estimated to contain 51 million tonnes of sodium sulphate. Exploitation currently takes place on Whiteshore Lake, Horseshoe Lake, Chaplin Lake, Ingebrigt Lake, Alsask Lake, East Coteau Lake, Snakehole Lake, and Verlo Lake, all in Saskatchewan, and Metiskow Lake in Alberta.

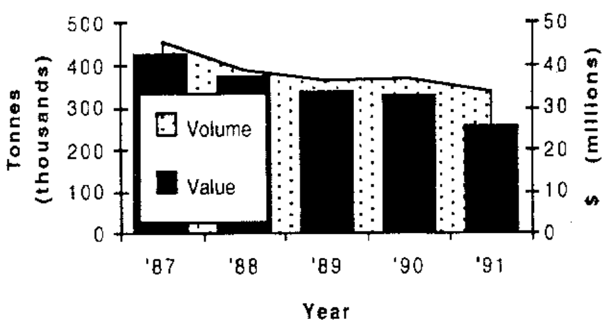
Other North American deposits are Texas and Utah.

Sodium sulphate is used primarily in the Kraft pulp process, in glass manufacture, and as a component of detergents. However the pulp and paper industry which has traditionally required a chemical pulping agent consisting of two thirds caustic soda and one third sodium sulphate is replacing the sodium sulphate with emulsified sulphur.

Canada is a net exporter of sodium sulphate, supplying some 500 thousand tonnes/year to the US, but the industry currently suffers from oversupply and substitution. Increased use in detergents may bolster weak demand.

Prices fob plants range from $80/tonne for salt cake to $100/tonne for detergent grade.

Canadian Sodium Carbonate Production



SULPHUR

GENERAL DESCRIPTION

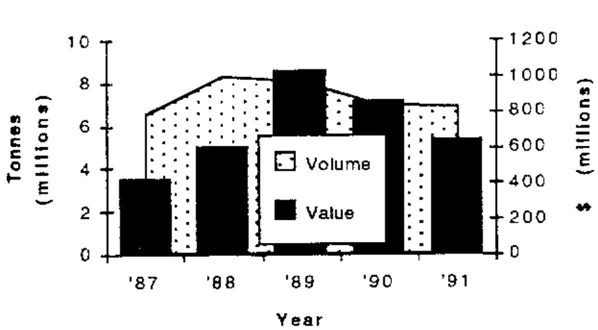
It has been said that a nation's consumption of sulphur is a good measure of it's industrial progress. Sulphuric acid is the most important single commodity in the chemical industry; it has no effective substitute, and few important manufacturing processes do not use it.

A total of 85% of sulphur is converted to sulphuric acid. Of the remainder, 67% is used in fertilizers, 9% in chemicals, 7% in petroleum refining, and 2% in metal mining.

World consumption is exceeding supply and shortages may occur by 1990. Nearly two thirds of the world supply is as a byproduct of petroleum and natural gas refining and processing and is therefore dependent on the demand for fuels rather than the demand for sulphur.

Identified world reserves of elemental sulphur in evaporites, volcanic deposits and associated with natural gas, petroleum, tar sands and metallic sulphides amount to 5 billion tonnes. There are almost limitless additional supplies in gypsum and anhydrite, coal, and oil shale but no cost effective recovery methods have been developed.

Canadian Sulphur Production From Natural Gas



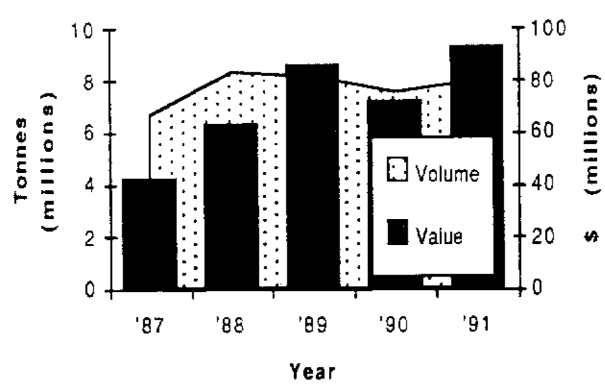
CANADIAN PRODUCTION

Canada is the world's leading exporter and responsible for 35% of world trade.

There are three sources for Canada's sulphur: a) elemental sulphur from natural gas, petroleum, and tar sands, b) sulphur from smelter gases recovered as sulphuric acid, and c) sulphur in pyrite concentrates. By far the most important source is the hydrogen sulphide in Alberta natural gas which has to be removed in any case because of its toxicity and corrosivity.

Prices range from $5–$37/tonne fob Alberta, and $100/tonne fob Vancouver.

Canadian Sulphur Production From Smelter Gas



TALC

steatite (soapstone), pyrophyllite

GENERAL DESCRIPTION

TALC is a hydrous magnesium metasilicate [$Mg_3Si_4O_{10}(OH)_2$] usually intimately associated with numerous other minerals such as serpentine dolomite and quartz. Its colour is characteristically pale green grey or creamy white, it has a pearly lustre, low hardness, greasy feel and extreme smoothness.

Talc is derived from the alteration of magnesia rich basic igneous rocks such as peridotites and dunites, and the metamorphism of magnesia-rich calcareous rocks such as dolomite, marble, and magnesian limestone. It can also occur as interlaminates in mica schists where the talc represents replacements of magnesian limestones in the schistose rock.

STEATITE (soapstone) is an impure massive compact form of talc which can be sawn or machined easily. 'Steatite grade' is a special block talc suitable for manufacturing ceramic insulators.

PYROPHYLLITE is a hydrous aluminum silicate ($Al_2SiO_4O_{10}(OH)_2$) formed by the hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. Its physical properties are practically identical to those of talc.

DEPOSIT GRADES

The characteristics that make talc useful are low conductivity to heat and electricity, fire resistance, hardening at high temperature, resistance to acids, and whiteness in powdered form. Of these whiteness is often the most critical, but oil absorption, density, etc. are also relevant.

The properties of a given deposit that should be determined are: whiteness, softness, smoothness, the fibrous or flaky component particles, hiding power, suspension, lustre, sheen, lubricating power, water, oil and grease absorption, chemical inertness, fusion point, shrinkage, electrical and thermal conductivity, dielectric strength, resistance to heat shock, and retention. In addition toilet grade talc must contain no lead, and after milling no more than 2% should be greater than 75 microns.

The presence of other minerals such as tremolite, magnesite, dolomite, chlorite, serpentine, chromite, quartz, calcite and iron oxides should be determined, and a chemical analysis for SiO_2, MgO, Fe_2O, FeO, Al_2O_3, CaO, MnO_2, K_2O, Na_2O, and LOI (loss on ignition) is necessary.

In general whiteness should be better than 86, SiO_2 60%–65%, free silica 3%–5%, MgO 28%–32%, Fe_2O_3 1%, Al_2O_3 less than 4%, and LOI about 5%.

USES

Ground talc is used in the pulp and paper industry for pitch control and as a paper coating, and as an extender in paint, in ceramics, electrical insulation, roofing materials, rubber filler, plasters, and textiles. Talc blocks (steatite) are also used for carving.

Pulp mills in British Columbia and Alberta use a total of 2.3 tonnes of talc per day, all of which is imported, mostly from Montana.

Recently listed prices range from US$35 to US$200/tonne fob minesite, depending on grade.

In the US the end uses of ground talc are ceramics 37%, paints 19%, paper 10%, roofing 9%, plastics 7%, cosmetics 5%, and rubber 3%.

CANADIAN DEPOSITS

There are four Canadian talc producers: Canada Talc Industries Limited of Madoc, Ontario; Broughton Soapstone & Quarry Company Limited of Broughton Station, Quebec; Baker Talc Limited of South Bolton, Quebec; and Steetley Industries Limited of Timmins Ontario.

The Baker Talc mines were first worked in 1871, and full scale production started in 1938. Individual talc-soapstone lenses have widths up to 60 m and lengths less than 100 m. The deposits are zoned from a serpentine core, surrounded by a talc-magnesite zone, followed by talc schist and soapstone. The mined material is crushed to -325 mesh, and high grade products are upgraded by four steps of flotation and regrinding.

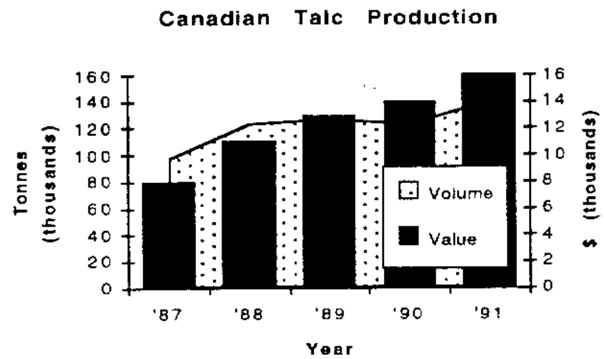
In western Canada Clayburn Co produces a small amount of low grade talc for its refractory plant at Coalmont, British Columbia. The International Marble and Stone Company has investigated a low grade talc deposit near Greenwood, British Columbia. A high quality talc deposit was found in the Banff area, Alberta, in the 1930s, and Trifco Minerals Ltd has recently evaluated a talc deposit near Quesnel, British Columbia.

Canada's only pyrophyllite producer is near Foxtrap on the Avalon Peninsula in Newfoundland. This deposit is a rhyolite which has been greatly altered to microcrystalline quartz, sericite and pyrophyllite. Associated minerals are diaspore, barite and rutile. To be acceptable shipping grades must contain 12%–20% Al_2O_3, 0.7%–3% $K_2O + Na_2O$, and less than 1% Fe_2O_3.

Western Canadian pyrophyllite deposits are reported near Ashcroft and on Kyoquot Sound on the west coast of Vancouver Island. The latter has been mined intermittently since 1912.

Further information on British Columbian deposits is contained in 'Talc and Pyrophyllite in British Columbia' by M. MacLean, British Columbia Ministry of Energy, Mines and Petroleum Resources, Mineral Resource Division, Open File 1988-19.

Prices are between $48 and $220/tonne depending on the grade. In general the outlook for Canadian producers is good, particularly for high grade products for use in the paper, paint, cosmetic and plastics industries.



YUKON OCCURRENCES

Though talc is a fairly common alteration mineral, no deposits of any size have been found in the Yukon though there have been reports of a talc dike near Fire Lake, Ross River (G. Gilbert, pers. comm.)

Due to its softness, talc seams are unlikely to outcrop, and will therefore remain undetected by casual prospecting. The most likely environment for the formation of talc deposits is in the ultramafic terraines of the Campbell Range, Kluane Range, and Teslin and Dawson City areas.

TITANIUM DIOXIDE

rutile, ilmenite, anatase

GENERAL DESCRIPTION

The principal titanium minerals are rutile (TiO_2), ilmenite ($FeTiO_3$, nominally 53% TiO_2), and anatase (TiO_2).

Occurrences of titanium bearing minerals are among the most ubiquitous, but generally too sparsely disseminated to be of economic importance.

Rutile occurs in feldspathic pegmatites with ilmenite in Virginia, US; as disseminations in an albite aplite in southern Norway; and as placer beach sands in Australia, South Africa, Madagascar and Sierra Leone.

Primary ilmenite deposits occur as ilmanite-magnetite and ilmanite-hematite bodies associated with gabbros and anorthosites from which they have segregated during crystallization of the magma. Secondary placer accumulations occur as beach, bar, dune and stream sands.

USES

As much as 85% of the world's titanium dioxide production is used as a white paint pigment which has substituted for lead and zinc oxides because of its superior opacity, covering properties, cheapness, inertness, and non-toxic qualities. Other uses include the manufacture of paper, plastics, rubber and ceramics, welding rod coatings and the production of titanium metal.

PRODUCERS and MARKETS

Because they are resistant to weathering and of high specific gravity, titanium-bearing minerals, where available, can be concentrated in beaches, bars, dunes and streams by the action of currents, waves and winds. The requirements for the formation of beach deposits are: 1) a hinterland of crystalline rocks with constituent heavy minerals, 2) deep weathering of the source rocks, 3) uplift and rapid erosion of the weathered source and quick dumping of the erosion products into the sea, and 4) emergence of a coastline with longshore drift and high-energy waves to concentrate the heavy mineral.

Australia produces 60% of the world's rutile and 25% of the world's ilmenite from sand deposits which are mined with dredges or bulk earth-moving equipment. Heavy minerals are recovered using sluices, cones and spirals to produce a concentrate containing at least 80% heavy minerals.

Eastern Australian deposits that are currently being exploited contain an average of 3% heavy minerals, mostly as rutile. In order to be considered economic, a new deposit must contain a reserve of 300 thousand tonnes of rutile recoverable from a raw grade of 1% heavy minerals and a cut-off of 0.2%. Rutile concentrates should contain more than 95% TiO_2, less than 1.5% ZrO_2, and less than 0.2% S

Because the main titanium mineral in the Western Australian sand deposits is ilmenite (rather than rutile), the heavy mineral content must be higher. The average grades of the Western Australian deposits that are currently being mined are 10% ilmenite, 1% rutile, and 1% zircon.

New deposits have to contain a reserve of 3 million tonnes of recoverable heavy minerals from a raw grade of 5% heavy mineral content and a cut off of 2.5%. In order to be saleable the ilmenite concentrates should have a low (0.03% to 0.04%) Cr_2O_3 content, a minimum of 52% TiO_2, and a maximum 1% ZrO_2.

Low product prices, environmental constraints and competition from new production at Richards Bay, South Africa, have led to a recent decline in Australian production.

Current listed prices are between A$570 and $A600/tonne for pigment grade rutile concentrates containing 95% TiO_2, and A$70 to A$80 for ilmenite concentrates containing 54% TiO_2, fob Australia.

QIT-Fer, the only Canadian ilmenite producer, has a South African subsidiary, Richards Bay Minerals, which produces 650 thousand tonnes/year of 85% TiO_2 slag.

Elsewhere in the world Sierra Leone produces nearly 72 thousand tonnes/year of rutile; the Companhia Vale do Rio Doce has built a pilot concentrator in Brazil and plans to process some 180 thousand tonnes/year to produce an anatase concentrate containing 90% TiO_2; QIT-Fer is investigating Madagascar beach sands and plans to produce high quality ilmenite concentrates; a joint venture between Kenmare Resources and the Yugoslav Geological Survey has reported dredgeable reserves of 123 million tonnes of 3.9% heavy minerals containing more then 90% ilmenite with associated zircon, rutile and monazite in the Angoche-Sangage deposit on the northern Mozambique coast; and in Norway NL Industries Inc is building a titanium smelter with a capacity of 200 thousand tonnes/year of 75% TiO_2 slag.

CANADIAN PRODUCTION

QIT-Fer et Titane Inc is Canada's only titanium dioxide producer, mining an ilmenite - hematite ore at Lac Tio, Quebec. The sill-like ore body occurs in anorthosite and anorthositic gabbro and is thought to be a late magmatic gravitational accumulation of oxides injected into the parent anorthosite. With reserves of 113 million tonnes grading an average of 32% TiO_2 and 36% Fe, it is the largest known ore body of its type in the world.

The ore is rail hauled to Havre St. Pierre where it is upgraded to 92.5% Fe and Ti oxides before smelting. The products are a slag (sorelslag) containing 80% TiO_2, pigiron (sorelmetal), and flux (sorelflux). The smelter operates at its full capacity of 850 thousand tonnes/year slag.

YUKON OCCURRENCES

Ilmenite and rutile, and to a lesser extent anatase are common constituents of Yukon placer concentrates but the volumes recovered are far too small to be considered saleable. In general the Yukon appears to lack the necessary host rocks for a primary deposit, and there are no known placer accumulations of the necessary size and grade.

WOLLASTONITE

Wollastonite is a metasillicate of calcium ($CaSiO_3$). It is generally found in skarns and contact metamorphosed limestones. The world's largest producers are in New York State, where reserves are more than 10 million tonnes containing 55% to 60% wollastonite.

Wollastonite is used by the ceramics industry as a filler.

In addition to the US other producers are India, Finland and China. Production capacity exceeds demand.

Near Deloro, Ontario, Platinova Resources Inc and Cominco plan to bring a wollastonite deposit to production. Reserves are 500 thousand tons of open pit ore with a grade of 47% wollastonite, and a further 750 thousand tons of 39% wollastonite

Depending on grade, average prices are between US$125 and US$235/short ton fob US plant.

Throughout the Yukon trace amounts of wollastonite are found in skarns. The best documented occurrence is the MONDAY (MINFILE #115F 050). A 70 m wide exposure of calcsilicate skarn consists of nearly massive wollastonite with few impurities. It is associated with a strong magnetic anomaly that parallels the zone where a Cretaceous granodiorite has intruded Upper Triassic carbonates within Upper Triassic Nikolai basic volcanics.

ZEOLITES

Zeolites are hydrated aluminum silicates of the alkalis and alkaline earth metals. Their contained water can be removed by heating to 350°C in a vacuum. They are used as molecular sieves to separate elements that differ in size and shape of molecules, for instance cesium and strontium in radioactive waste, in the catalysis of hydrocarbon reactions such as cracking, and as microporous sorbents in various gasses.

Synthesized zeolites are produced with aluminum silicate gel and NaOH.

There are more than 30 natural zeolites but the most abundant are analcime, clinoptilolite, mordenite, phillipsite, erionite, chabazite, laumontite and ferrierite.

Other uses of zeolites are as a filler in paper in place of kaolin, an additive to poultry feed, for drying gasses, and the separation of oxygen and nitrogen from the air.

Most zeolite deposits are volcanic tuffs that have been altered by the action of ground water, connate water, or hydrothermal activity.

Examples are in Hungary, and Yugoslavia.

There are unconfirmed reports that zeolites have been found associated with the Carmacks basalts.

ZIRCON

baddeleyite

GENERAL DESCRIPTION

Zircon ($ZrSiO_4$) is an accessory mineral in most igneous rocks but particularly granites, pegmatites and nepheline syenites. Baddeleyite (ZrO_2) is produced in small quantities from primary deposits in South Africa and Brazil.

Since it is resistant to weathering and heavier than most associated minerals zircon accumulates in placer deposits with other heavy minerals such as monazite, rutile, and ilmenite. Such deposits are found in Australia, which produces 70% of the world's zircon, and Brazil, India, Madagascar, and Florida.

USES

Zircon is a refractory mineral used in firebricks, crucibles, and other materials subjected to high temperatures and rapid fluctuations in temperature. It is also used as an opacifier in enamels and in the manufacture of paints and lacquers, abrasives and polishing powders. In addition it is the only significant ore mineral of zirconium and hafnium (see rare earths).

Zirconium is now also in demand for yttrium-stabilized zirconia ceramics used in automotive oxygen sensors in exhaust gas pollution control and in high temperature rotating and reciprocating engine parts.

Candu nuclear reactors use zirconium for pressure tubing and fuel rod sheathing, the materials being imported from the US.

PRODUCTION, GRADES and PRICES

World production of zircon is about 500 thousand tonnes/year, and Australia accounts for some 70% of this amount from placer deposits where it is associated with ilmenite and rutile.

Minimum ore grades for established mines are about 0.4% (rutile + zircon). Two Queensland producers are Consolidated Rutile Ltd with an annual production of 10.7 million tonnes/year of sand containing 0.86% (rutile + zircon) with a rutile-zircon ratio of 1.2:1, and Cudgen R.Z. Ltd with annual production of 347 thousand tonnes/year containing 2.8% (rutile + zircon) with a zircon-rutile ratio of 2.2:1.

In Western Australia low grade heavy mineral sand deposits contain about 10% ilmenite, 1% rutile, and 1% zircon, and high grade deposits can carry as much as 55% ilmenite, 15% rutile, and 10% zircon.

When sold, zircon concentrates usually grade better than 99% zircon. Zircon sand with 66%–67% ZrO_2, less than 0.1% TiO_2, and less than 0.1% Fe_2O_3 is of premium quality.

Prices, currently between $A550 and $A850/tonne of zircon sand are expected to increase significantly in the coming years due to inadequate world production capacity.

CANADIAN DEPOSITS

There are no Canadian zirconium producers. The Iron Ore Company of Canada's Strange Lake deposit on the Quebec-Labrador boundary contains zirconium in the form of gittinsite, with yttrium, niobium, beryllium and rare earths, but development of the property has been suspended.

A second potential producer is Highwood Resources Ltd from its Thor Lake deposit in the North West Territories which contains zirconium in addition to tantalum, columbium, beryllium and rare earths. Reserves of the Lake Zone are reported to be 70 million tonnes with an average grade of 0.04% Ta_2O_5 , 0.57% Cb_2O_5, 4.73% ZrO_2, and 1.99% rare earth oxides. An additional zone to the north of this contains 1.8 million tonnes of 0.85% BeO.

Highwood Resources Ltd is also a partner with Platinova Resources in a property in Greenland's Ilimaussaq complex near Julianehab, where zirconium yttrium and rare earths occur in the acid soluble mineral eudialyte. Contained grades are reported to be 1.5% zirconium oxide and 0.15% yttrium oxide.

The Athabasca tar sands of Alberta could produce an ilmenite-rutile-zircon concentrate as a byproduct of bitumen extraction.

In British Columbia zircon is frequently found in carbonatites and nepheline syenites within the alkaline trend which parallels and contains the Rocky Mountain Trench. Examples are the Aley complex, the Paradise Lake syenite, the Verity carbonatite, the Trident Mountain syenite and the Lonnie and Vergil complexes all of which contain more than 1% zircon.

YUKON OCCURRENCES

Though it is likely that zircons will be found in the northern extension of the cordilleran alkaline trend in association with syenites and carbonatites, the grades of primary deposits are generally too low to be commercially important.

No significant placer accumulations of zircon have been found in the Yukon, though small zircons have been identified in heavy mineral concentrates from the Klondike.

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