Proceedings

Focus on B.C. Industrial Minerals '95

Vancouver

October 17-19

British Columbia Geological Survey

INFORMATION CIRCULAR 1997-4

Proceedings
Focus on British Columbia Industrial Minerals

Contents:

Mineral Development

Zeolite Potential in British Columbia	P. Read, Consultant
Holnam West Materials Ltd. Limestone Quarry, Texada Is. B.C.	P. M. Stiles, Vice President; Holnam West Materials Ltd.
Garnet Market Potential in Western Canada and United States	D. G. Lobdell, Consultant

Focus on British Columbia Industrial Minerals
Thursday, October 19, 1995

8:00am Registration

Chair: D. Hora and D. Gunning

8:30am *Welcome /Information*
Ministry of Energy, Mines and Petroleum Resources with B.C. Trade Development Corporation

8:40am *Demand Defines Exploration Targets for Industrial Minerals*
P. W. Harben, Consultant

9:00am *Industrial Mineral Opportunity for B. C. Custom Processing*
B. Ainsworth, Consultant

9:20 am *Industrial Kaolin and Market Growth on the Pacific Rim*
C. C. Harvey, Consultant

9:40am *Challenges for the Pacific Northwest Cement Manufacturer*
E. Cardey, President; I.M.P.A.C.T. Minerals Inc.

10:00 am Coffee Break and Posters

Chair: D. Gunning and G. Simandl

10: 30am *B. C. Dimension Stone in* 1995
Z. D. Hora, Industral Minerals Specialist; B. C . Geological Survey

11:00am *Market Development and Business Growth Strategy for Light Weight Zeolite Concrete*
L. E. W. Hogg, President; Polar Powders and Technology Inc.

11:20am *Hat Creek Property - A Source of Calcium Montmorillonite*
N. Skermer, President; Pacific Bentonite Ltd.

11:40am *Economics of Various Industrial Minerals in B. C. for the Pulp and Paper Industry*
B. A. Slim, President; MineStart Management Inc.

12:00pm Luncheon and Posters

Chair: G. Simandl and D. Lefebure

1:30pm *Industrial Minerals and Bill 13*
D. Lieutard, Director and R. Conte, Assistant Director; Mineral Titles, B.C. Ministry of Energy, Mines and Petroleum Resources

1:50pm *Clayburn Industries Ltd.*
D. Harris, President

2:10pm *Resources, Applications and Market Trends of Calcium Carbonates in the Northern Pacific Rim*
C. C. Harvey, Consultant

2:30pm *Update on Perlite*
D. F. Gunning, Consultant; B.C. Trade Development Corporation

2:50pm Coffee Break and Posters

Chair: D. Hora and D. Lefebure

3:30pm *Short His tory of an Industrial Mineral Development*
P. B. Aylen, President; Western Industrial Clay Products Ltd.

3:50pm *Zeoli te Potential in British Columbia*
P. Read, Consultant

4:10pm *Holnam West Materials Ltd. Limestone Quarry - Texada Island, B. C.*
P. M. Stiles, Vice President; Holnam West Materials Ltd.

4:30pm *Garnet Market Potential in Western Canada and United States*
D. G. Lobdell, Consultant

5:00pm Posters on Display

5:30pm Meeting Adjourns

6:30pm Field Trip B Departure from the Pan Pacific Hotel Entrance

Post Meeting Field Trip

Tour B

Southern British Columbia Industrial Minerals Deposits

October 19 to 22

A three and a half day post-meeting tour to visit industrial mineral deposits and operations in the southern interior of the province. Highlights of the trip will include visits to Baymag's Mt. Brussiloff magnesite mine, Mountain Minerals' Moberly silica operation, and Westroc's gypsum mine.

Field Trip Hosts

Baymag Mines Co. Limited

Canmark International Resources Inc.

Jade West Resources Ltd.

Margranite Industry Ltd.

Mountain Minerals Co. Ltd.

Okanagan Opal Inc.

Tilbury Cement Limited

West Coast Granite Manufacturing Inc.

Westrock Industries Limited

Organizing Agencies

BC Ministry of Energy, Mines and Petroleum Resources

BC Trade Development Corporation

Natural Resources Canada (Mineral Development Agreement)

BC Ministry of Employment and Investment

Reception Hosts

BC and Yukon Chamber of Mines

Mining Association of BC

Reception Sponsor

Tilbury Cement Limited

INDUSTRIAL MINERALS '95

Vancouver

October 17-19

Focus on British Columbia Industrial Minerals

October 19, 1995
Pan Pacific Hotel
Vancouver, B.C.
Canada

Demand Defines Exploration Targets for Industrial Minerals

by

P. W. Harben,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Demand in Latin America Defines Exploration Targets for Industrial Minerals

Peter W. Harben

Peter W. Harben Inc., P.O. Box 800, Morris, NY 13808, USA

-INTRODUCTION

Without a market, a non-metallic mineral deposit is merely a geological curiosity. This market driver points to great opportunities for industrial minerals in Latin America, a region that encompasses more than 30 countries stretching from Mexico in the north to Argentina in the south and includes Caribbean countries such as Cuba, Jamaica, Haiti, and the Dominican Republic. Six countries --- Brazil, Mexico, Argentina, Colombia, Peru, and Venezuela -- account for 75% of the 450-million population. More importantly for future mineral consumption, this population level is expected to grow to almost 490 million by the year 2000 and 654 million by 2025.

Within this market is an increasing amount of intra-regional trade, particularly within trading blocks such as Mercosur, the Andean Pact, Caricom, and the Central American Common Market Free trade is expanding as, for example, Bolivia and Chile have been invited to join Brazil, Argentina, Paraguay, and Uruguay as members of Mercosur. The region's strength as a trading block may be fortified still further with the inclusion of the United States and Canada in a new trading club -- 34 countries comprising the Western Hemisphere minus Cuba have begun talks aimed at creating a free-trade zone of the Americas (FTAA) by the year 2005. If all goes to plan, custom officials will be made redundant from Alaska to Argentina in what would be the world's largest single market -- $13 trillion from a population of 850 million. Even now shipments to fellow North and South American countries account for 90% of the exports from Mexico, 80% from Canada, 50% from Argentina and Brazil, and 40% from the United States. A meeting in Denver in June 1995 reaffirmed the goal of establishing FTAA within ten years.

THE MARKET IS DRIVEN

Latin America has already emerged as an important supplier of a variety of industrial minerals to regional and world markets. For example, Mexico accounts for about half of the world's celestite production which is used as a feedstock to produce most of the world's strontium carbonate so that there is a little piece of Mexico in most television sets. Unlikely candidates such as gypsum (5 million t/y) and salt (7 million t/y) are exported from Mexico to North America and Asian markets. Unique natural nitrate deposits found in the arid northernmost Chilean provinces of Tarapaca and Antofagasta are mined and exported all over the world; in addition, these deposits yield 33% of the world's iodine supply. Chile also exploits multimineral-rich salars containing lithium, soda ash, potash, sodium sulphate, salt, and magnesium. Production of lithium from the Salar de Atacama brines in Chile has gradually replaced supplies from US pegmatites, and this will be strengthened with the start-up of production from Salar de Hombre Muerto, Argentina, in 1997. Argentina, Chile, Bolivia, and Peru share a 880-km-long boron-rich stretch of the Andes. Increased production and exports from this region have disrupted the traditionally neat pattern of boron supply from the United States and Turkey which between them control 70% of the world's known borate reserves.

Brazil is one of the few large-scale producers of paper coating-grade kaolin in the world. Although the current refined kaolin capacity of 820,000 t/y is relatively small compared with the United States (9 million t/y) and United Kingdom (3.7 million t/y), most of the Brazilian production serves an extremely wide geographic area and capacity is expanding rapidly. Latin America contributes almost 30% of the world's bauxite production, largely from Jamaica (11 million t/y), Brazil (9 million t/y), Surinam, Guyana, and Venezuela (3 million t/y each). Although not the largest producer, Guyana is particularly important since it sets the standard for calcined refractory-grade bauxite and feeds the refractory industry throughout North America, Europe, and the Pacific-Rim region.

Other important, industrial minerals produced within the region include asbestos in Brazil and Colombia; barite, bentonite, feldspar, magnesite/magnesia, manganese, and phosphate rock in Brazil and Mexico; chromite in Brazil; fluorspar in -Mexico; salt in Argentina, the Bahamas, Brazil, and Mexico; sulphur in Brazil, Chile, and Mexico; and talc -in Brazil. A table of historical production of industrial minerals in Latin America with its percentage of world production is given in the Appendix.

MARKET DEVELOPMENT

Although Latin America has a long history of mining and plays an important role in the international industrial minerals industry, it is future production from yet-to-be discovered mineral deposits that will sustain its growth into and through the next century. Targeting these minerals deposits will be the key to commercial success. Ironically, studying the past may well provide an indication of what minerals will be required in future at what stage of a country's development.

As a nation's economy evolves from a largely rural through an urban and eventually to an industrialised base, the pattern of mineral consumption alters drastically. There is a fairly good correlation between per capita mineral consumption and per capita GDP which in turn reflects the stage of a country's development (that is degree of industrialisation). This correlation can be illustrated through a series of graphs plotting the GDP per capita in 1992 US$ against the consumption of a particular mineral in kilograms per capita. The original graphs for some 30 minerals published by Richard N&staller for the World Bank in 1987 where recalculated and redrawn during a consulting project for BHP Minerals Inc." N&staller used the United States as the base since consumption data was readily available and the economy had developed through all of the various stages, that is early (GDP per capita of <$2,400), middle (GDP per capita of $2,400 - $8,000), and advanced development (GDP per capita of > $8,000). Using these graphs, the GDP/capita of selected countries can be superimposed to indicate their positions on the development curves. Examples for Latin America are outlined below.

STAGE OF DEVELOPMENT	GDP/Capita
EARLY	< $2,400
Guatemala	$1,079
Ecuador	$1,137
Colombia	$1,345
Paraguay	$1,460

Cuba	$1,580
Peru	$2,191
Middle	**$2,400 - $8,000**
Brazil	$2,525
Chile	$2,828
Venezuela	$2,972
Uruguay	$2,935
Argentina	$3,250
Trinidad & Tobago	$3,600
Mexico	$3,690

This exercise is particularly useful for a company that is seeking growth prospects within a broad range of industrial minerals throughout the world. The graphs may be used to identify (or more often to confirm) specific minerals or industries and particular regions where growth may be expected in the future. One example is to justify to company management the selection of a number of target minerals in a given region. Clearly, more detailed work is required on both the minerals and regions selected, but it is a useful first step in the selection process.

A slightly more sophisticated approach is to plot mineral consumption per thousand dollars of GDP versus GDP per capita, that is "mineral intensity of use" or IOU. Most industrial minerals show a peak in the rate of consumption, for example, crushed stone and sand & gravel tend to peak during the early development period following the initial rush to build infrastructure whereas cement, soda ash, and feldspar peak in the middle development period as the construction and glass and ceramic industries begin to mature. Gypsum, vermiculite, and perlite, on the other hand, survive because of their use in the more sophisticated forms of buildings. Several minerals tend not to peak and decline, for example nitrogen, phosphate, and potash which are primary nutrients in fertilisers.

INDUSTRY APPROACH

Rather then focusing on individual minerals, an industry approach can be taken. As a country's economy develops and matures, certain industries grow in somewhat of an orderly sequence which is the real driver for mineral demand. The sequence could be:

- ☐ Construction raw materials
- ☐ Fertilisers and agricultural minerals
- ☐ Glass ceramic raw materials
- ☐ Chemical raw material
- ☐ Metallurgical, foundry, and refractory minerals
- ☐ Pigments and Fillers
- ☐ Energy materials
- ☐ Human consumption raw materials

For the purposes of this paper, the graphs of the individual minerals have been combined into the first three industries, that is:

- ☐ Construction *(Figure I)*
  - ◆ **Crushed stone**
  - ◆ **Sand & gravel**
  - ◆ **Cement**
  - ◆ **Gypsum**
  - ◆ **Vermiculite**
  - ◆ **Perlite**

- ☐ **Fertilisers** *(Figure 2)*
  - ◆ **Phosphates**
  - ◆ **Potash**
  - ◆ **Nitrogen**
  - ◆ **Sulphur**

- ☐ Glass and ceramics *(Figure 3)*
  - ◆ **Clays**
  - ◆ **Feldspar**
  - ◆ **Talc & pyrophyllite**
  - ◆ **Soda ash**
  - ◆ **Boron**

CONSTRUCTION

A sound infrastructure is the foundation of commercial development. Adequate shelter is necessary for the growing population and a reliable transportation system is necessary to get the goods to market. Imports and exports require improved and efficient port facilities and airports need to be built and enlarged (it was recently announced the new Hong Kong airport would cost $23 billion!). This growth is fed by large quantities of various construction raw materials.

***Early days*: In the early stages of a nation's development there is a sharp increase in the consumption of sand and gravel reflecting the initial stages of infrastructure building, the availability of local sand and gravel using simple mining techniques, and a lack of expertise and equipment to crush stone to the required specifications. Although slower to start than sand & gravel, crushed stone, cement, and gypsum show moderate increases in demand during this period because of the generally widespread availability of crushed stone (some of which is used in cement production), increasing supply of cement initially through imports and then domestic supplies, and the gradual beginning of a more sophisticated building industry using gypsum wallboard (as well as the use of fertilisers and soil amendments in agriculture). Wallboard production may require technology transfer and/or joint ventures with international wallboard producers such as USG in the United States, Yoshino Plasterboard in Japan, and British Gypsum in the UK. Perlite and vermiculite show a very slow initial growth rate reflecting lack of facilities requiring such sophisticated building materials.**

***Middle Age:* During the middle development stage sand and gravel tends to continue its sharp increase followed by slight slowdown after mid-middle development reflecting a maturing of initial**

infrastructure building activity. At the same time crushed stone shows a sharper growth rate than sand and gravel although still unspectacular (a.k.a. steady?) increase without the slowdown experienced by sand and gravel; this reflects the broader based availability of crushed stone gradually replacing depleted and less widespread sand and gravel reserves and the establishment of facilities designed to supply customised grades of various sizes. Cement and gypsum both show a similar pattern based on increased availability of domestic supplies and downstream products gradually replacing imported material, and possibly reduced price through economies of scale and supply availability. Perlite and vermiculite show a moderately steep and steady growth reflecting a gradual increase in industrial sophistication including the insulation and fireproofing of buildings.

Maturity: As development advances sand and gravel continue to slow down slightly followed by a fairly sharp slowdown reflecting continued maturity of initial infrastructure building, the depletion of easily mined sand and gravel deposits often through urban sterilisation of reserves, and the increased availability and popularity of cement. Crushed stone continues its increase without the slowdown experienced by sand and gravel reflecting the establishment of crushed stone as the main construction raw material and the increased use of crushed stone for use with cement such as ready mixed concrete. Consequently, cement demand continues to increase with a later and less rapid slowdown compared with sand and gravel reflecting development of alternative building materials such as dimension stone, bricks, etc. Gypsum has a similar pattern to cement because of the establishment of wallboard plants and increased popularity of the product and the introduction of more diverse building materials (plus the application of calcia and sulphate via more complex fertilisers). Perlite and vermiculite show increased consumption rate followed by a marked slowdown reflecting rapid diversification of use into non-building uses, for example, filter media and horticulture, and competition from other materials such as diatomite. There is a continued increase in industrial sophistication including the insulation of buildings.

Taking gypsum as an example, a detailed apparent consumption table can be produced for the region based on production plus imports minus exports for individual countries (Table 4). Overall, Latin America is a net supplier of 2.5 million tons/year virtually all from Mexico. The table highlights several 50,000 t/y shortfalls including Colombia, Ecuador, and Honduras.

FERTILISERS

It would seem logical that with urbanisation, farming becomes more intensive and efficient in order to feed more sophisticated people using less and more expensive land which in turn increases the demand for fertilisers. The limited sources of supply of phosphates and potash often means that most countries have to rely on imports. in addition, when one nutrient is used, the others have to be added in order to maintain the nutrient balance (the ratio depends on the crop and on the background level of nutrients). Therefore, all three primary nutrients -- phosphates, potash, and nitrates -- have a similar consumption pattern.

Early days: During the period when the country's economy is largely agricultural, phosphates, potash, and nitrates have a moderate consumption rate followed by an increase midway through the period. This pattern reflects expanding fertiliser demand as urbanisation and population growth increase the demand for food which in turn increases the sophistication of the agricultural industry and need for fertilise. This is served initially through imported finished and blended products and/or the use of direct application phosphate rock due to the lack of facilities to process crude phosphate rock. In the case of lime, there is a fairly rapid initial increase reflecting the same criteria. The rapid and consistent increase in sulphur consumption reflects its widespread use in virtually every manufacturing process.

Middle age: The increased and steady growth in demand of all fertiliser raw materials reflects urbanisation and population growth increasing the demand for food, the escalating price of land forcing efficiency methods including fertiliser application, the availability of facilities to convert phosphate rock into more concentrated products, and the increased availability of blending facilities to produce mixed fertilisers. Except for nitrogen products which can be manufactured through chemical means, the main fertiliser raw materials are imported. Sulphur tends to continue its rapid and consistent increase reflecting the use of sulphur in the manufacture of fertilisers, particularly the treatment of phosphate rock, as well as the foundation of the chemical industry.

Maturity: Shows a continued increase with little sign of a consistent slowdown reflecting continued urbanisation and demand for food, an increased need for fertilisers to increase crop yield per acre, the increased sophistication of fertilisers including mixed fertilisers. Sulphur demand continues to increase with an almost imperceptible slowdown reflecting the broadbased use of sulphur, the beginnings of the maturity of the basic chemical industry, increased production costs (land and labour) and concern over environment and worker safety driving a preference to import basic chemicals, and movement away from manufacturing and towards the service industry.

Data is available to generate an apparent consumption table for phosphate rock and potash (Table 5). As would be expected with fertiliser raw materials, there is a marked deficit in Latin America. Mexico imports over 2 million t/y of phosphate rock and Brazil takes about 1.75 t/y of potash. There are numerous smaller consumers that could be fed from within the region. Most countries except for Mexico have a deficit of sulphur, although there is a great deal of potential from by-product sources.

GLASS AND CERAMICS

Urbanisation encourages the construction of buildings which in turn requires products such as glass (windows), ceramic plumbing fixtures (toilets, wall and floor tiles), and possibly gypsum wallboard and plaster (see construction). It would seem logical that these products are first imported, but given a reasonable domestic demand, local production is encouraged. This may well require the assistance of large overseas manufacturers together with technology transfer and joint ventures. Some glass examples are PPG Industries, Guardian Industries, and OCF from the United States, Pilkington of the UK, Saint-Gobain in France, and Asahi Glass and Nippon Sheet Glass from Japan.

Once again, this growth could initially be based on imported raw material, but more likely domestically produced minerals. This is particularly true for low-priced minerals such as silica sand, although those less common minerals requiring more exact specifications such as kaolin, feldspar, soda ash, and asbestos may be imported.

Early days: During the early stages of economic development, demand for soda ash, feldspar, and clays is slow but then tends to pick up in the second half of the period reflecting small-scale uses such as water treatment, the early establishment of domestic glass production capacity in order to serve the fast-growing construction industry. Soda ash and feldspar are generally served through imports with clays sourced locally. Borates have a steady but slow growth reflecting their early use as chemicals and in agriculture rather than fibreglass.

Middle Age: Soda ash shows increasing growth because of the expansion of the domestic glass industry including flat glass and fibreglass plus container glass serving the food and beverage industry, increased availability of soda ash through regional or even domestic Solvay plants, and diversification of use into pulp and paper, soaps & detergents. Feldspar has a similar steady growth with a slowdown near the end of the period reflecting expansion of the domestic glass industry and increased availability of feldspar from domestic operations. Borates continue to grow steadily reflecting the development of a speciality glass industry including fibreglass and borosilicate glass and continued diversification. Clays experience increasingly rapid growth in demand particularly in the second half of the period reflecting continued development of domestic ceramics, refractories, and similar industries, establishment of a domestic refractory production capacity based on clays to serve the steel and foundry industries, a wider availability of various types of clay through domestic production, and diversification into more sophisticated uses.

Maturity: soda ash continues to grow but at a slower pace reflecting a gradual maturity of the glass and chemicals manufacturing sectors, a reduction in the consumption of raw material per unit of glass produced through increased efficiency and recycling, and competition from aluminium and PET containers. However, consumption is helped by a lack of substitutes for soda ash in the glass industry and any slowdown is less severe compared with say feldspar since soda ash uses are more diversified. Feldspar and clay have a fairly rapid slowdown in consumption for the same reasons as soda ash plus increased competition in the ceramics sector from synthetic material such as cultured marble, fibreglass, and PVC pipes, increased availability of cheap imported ceramics and glass, and a lack of diversification in the uses (some 95% of feldspar is used in glass and ceramics). In the case of clay there is increasing sophistication of refractories utilising high-grade magnesia, alumina, and graphite rather than refractory clays. Boron continues to grow steadily as fibreglass and borosilicate glass demand increases with little opportunity for substitution.

LEARNING FROM THE NICs

Studying the successes and failures of the Newly Industrialised Countries (NICs) such as Hong Kong, Singapore, South Korea, and Taiwan can help foretell the path of the Rapidly Industrialising Countries (RICs) such as Brazil, Mexico, and Chile. Since 1965 these four Asian NICs have quadrupled their share of world production and trade and quintupled their per capita incomes. Between 1965 and 1986 the per capita GNP in each country grew at least 5% per annum compared with 4.3% for Japan and just 1.6% for the United States. Positive effects of the growth included increased levels of education and health care promoting a more literate and healthier population (the literacy rate in South Korea, for example, increased from 30% in 1953 to 80% in 1963), a highly skilled workforce, improved income distribution, and in certain cases land reform. On the negative side, this phenomenal growth came at a high environmental price which only now is being tackled at a huge financial cost.

The contribution to GPD by industry has changed over the period 1963 to 1988 for three countries at different stages of development -- Japan, Korea, and Indonesia.

Japan

Industrialisation for Japan started well before World War II and was boosted by the "special procurements" of the Korean War which in 1951 increased industrial production by 50%, pushed exports to unprecedented levels, and generated a positive balance of payments. In the 1960s, during a period of import substitution and domestic investment, Japanese GDP grew at an annual compound rate of 10.4% and almost tripled within the decade. The oil shocks of 1973 and 1979 slowed growth, although a shift to the manufacture of value-added products encouraged exports to increase and formed the foundation for Japan's dominance in automobiles and electronic goods (the ultimate in value-added goods). In the 1980s exports of value-added goods continued to grow, albeit at a slower rate due to exchange rate fluctuations, to reach 15% of GDP. Over this entire period, agriculture fell from 12 to less than 3% of GDP.

South Korea

South Korea trailed Japan in this industrialisation process. After World War II, Korea was an agrarian country and in the 1950s it concentrated on its natural resources sector as the basis for economic development. In 1963 agriculture accounted for 42% of real GDP and manufacturing just 8.2%. In an effort to reduce imports, Korea developed its light manufacturing industry. The next step in industrialisation was kick started by a government policy change that encouraged exports and foreign investment (mainly by US and Japanese multinationals seeking cheap labour). This resulted in an average annual growth rate of 8% in the 1960s. Success in the export market provided employment in the growing cities and provided the capital for re-investment. Despite the oil shocks of the 1970s, growth has continued to exceed most industrialised countries and by 1988 manufacturing accounted for 38.2% compared with agriculture at 10%.

Indonesia

In 1963 Indonesia was still farther behind in the industrialisation path with agriculture accounting for 36.5% of the country's GDP. Industrialisation really began to take off in 1966 when the Suharto government came to power and adopted the "New Order" economic policy designed to liberalise trade and foreign exchange and to encourage foreign investment. It is reported that manufacturing increased at 13.9% per annum for 1970-1981 which was the driver behind the 7.7% annual growth of the real GDP. Consequently, the manufacturing share of GDP doubled in ten years to reach 21.6% in 1988. Indonesia remains one of the fastest growing economies in the world feeding off its large population and revenues from natural resources.

CONCLUSIONS

Latin America offers investors an opportunity to participate in a rapidly escalating market. Only parts of Asia can offer similar growth prospects. In contrast, the traditional markets of North America, Europe, and Japan are mature, and consumption is flat or even declining because of the lack of population growth and the need to conserve dwindling resources. Investment is discouraged by high labour rates and production costs, punitive taxation schedules, and an increasingly vociferous anti-mining sector. In contrast, the market in Latin America will grow based on its expanding population and the increasing buying power of the people. Investment is being encouraged by governments that see the responsible exploitation of natural resources as a means to improve the country's standard of living. Reform of trade, tax, and mining laws, industrial deregulation, and large-scale privatisation have spurred private sector investment and opened up

the market for foreign capital. Since most Latin American countries are somewhere between the late stages of the Early Development Period (GDP/capita of $1,000) and the early stages of the Middle Development Period (GDP/capita of $3,600), there is a strong possibility that economic growth will speed up still further in the early part of the 21st century just as the Korean economy expanded in the 1970s and 1980s.

Although certain refined industrial minerals like paper-coating grade kaolin and strontium carbonate will continue to find extensive markets outside the region, increased manufacturing capacity within the RICs of Latin America will require large volumes of raw materials. At the same time, imports of finished goods like fibreglass and ceramic toilets will be replaced by domestic products manufactured in factories set up through joint ventures or technology transfer. All this will encourage the exploitation of indigenous raw materials, even the relatively low-cost items like silica sand and ceramic clay. As illustrated in an earlier section, construction, fertilisers, and glass and ceramics are the first industries to grow with an expanding economy.

As well as the potential for business development in Latin America, there is also the potential for business disaster. Regional growth rates provide a firm foundation for increased demand of industrial minerals, and the natural mineral wealth and diversity of many countries allow for the possibility of self sufficiency and export market share. However, the political instability and currency devaluations experienced recently in Venezuela and Mexico can be regarded as a reminder of what could happen. It quickly creates a feeling of uncertainty that can interrupt the flow of investment dollars. Nevertheless. while the opportunities are spiced with danger there is no denving that industrial minerals, being market driven, are prime targets for development as well as the crucial means to develop this challenging region.

* *the author wouid like to acknowledge BHP Minerals Inc. for some of the data and concepts outlined in this presentation.*

REFERENCES

Alatorre, A., Harben, P., McVey, H., and Santini, K., 1995, "Mexico: Opportunities in Industrial Minerals" in Proceedings, 29th. Forum on the Geology of Industrial Minerals, Long Beach CA (1993), M. Tabilio & D. Dupras, Eds., California Dept. of Conservation, Div. of Mines & Geology, Sp. Pub. 110, pp. 269-312.

Bourne, H.L., 1994, "Glass Raw Materials" in *Industrial Minerals and Rocks,* 6th ed., D.D. Carr, Editor, SME, Littleton, CO, pp. 543-550.

Chang, J.C., 1993, *The Role of Major Nonfuel Minerals in the Asian Pacific Rim Economies,* Mineral Issues, US Bureau of Mines, 51 pp.

Crozier, R.D., 1987, "The Chilean nitrate industry vs the US Department of Commerce", *Industrial Minerals,* no. 237, June, pp. 62-67.

Dickson, T., and Harben, P., 1986, "Refractory bauxite" in *Raw Materials for the Refractories Industry,* 2nd. Ed., E.M. Dickson, ed., Industrial Minerals, pp. 70-75.

Ericksen, GE., 1981, "Geology and origin of the Chilean nitrate deposits", US Geol. Sur-v. *Prof. Paper-* 1188, 37 pp.

Hinds, S.A., 1983, "Refractory bauxite" in *Proceedings, Minerals in the Refractories Industr-y -- assessing the decade ahead,* E.M. Dickson and P.W. Harben, eds., Industrial Minerals, no. 187, April, pp. *55-60.*

Harben, P.W., and Bates, R. L., 1990, Industrial Minerals - Geology and World Deposits, Industrial Minerals Div., Metal. Bulletin PLC, London, 3 12 pp.

Harben, P.W., 1995, *Industrial Minerals HandyBook: A Guide to Markets, Specifications, & Prices, Second Edition,* Metal Bulletin plc, London, 254 pp.

Harben, P.W., 1995, "Industrial Minerals South of the (Mexican) Border", 31st. Forum on the Geology of Industrial Minerals, New Mexico Bureau of Mines and Mineral Resources, El Paso, Texas, in press.

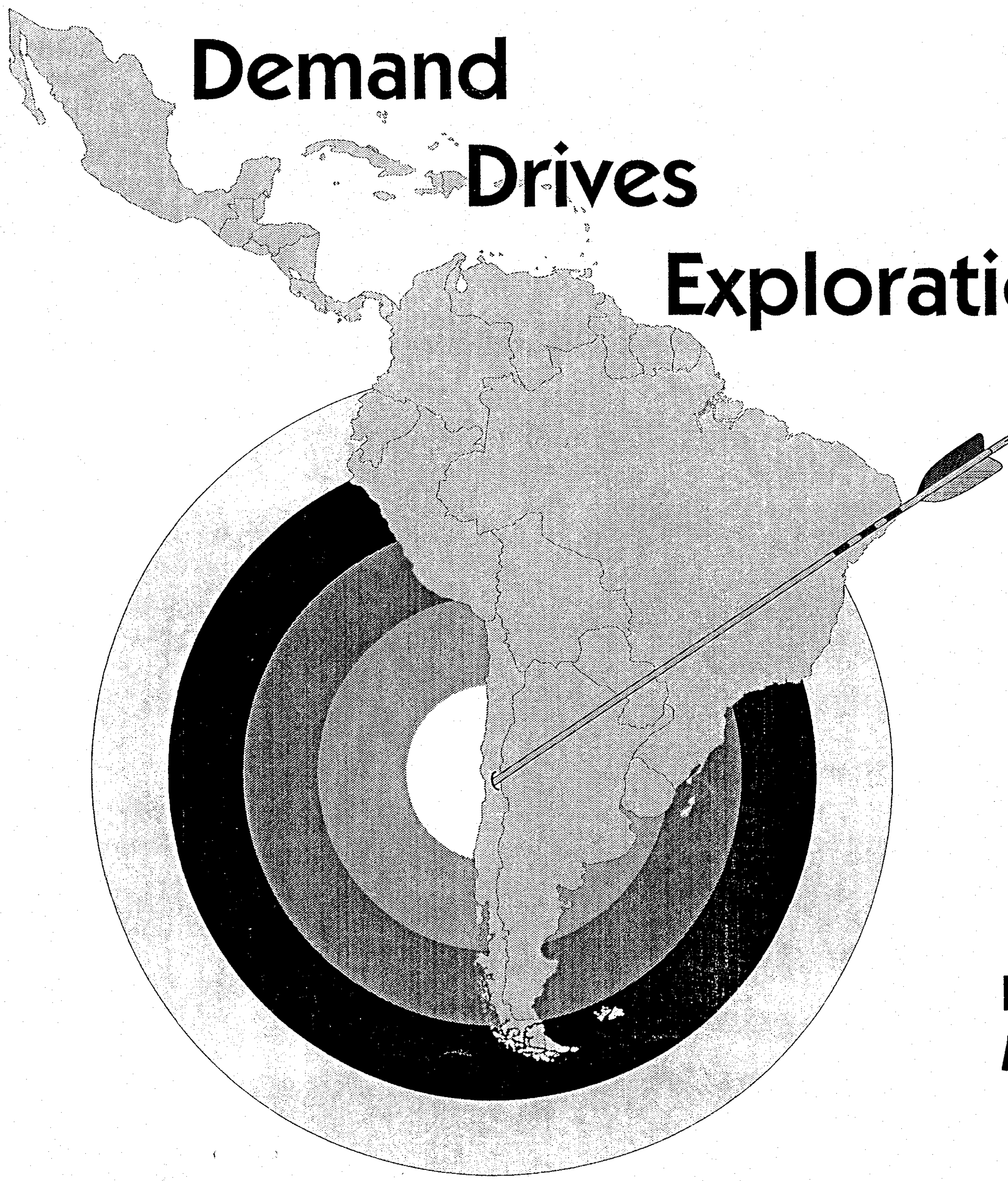
Kistler, R.B., and Smith, W.C., 1983, "Boron and borates" in *Industrial Minerals and Rocks,* 5th ed., S.J. Lefond, ed., AIME, New York, pp. *533-560.*

Notstaller, R., 1987, *Industrial Minerals - A Technical Review,* World Bank Technical Paper No. 76, 117 pp.

Patterson, S.H., 1967, "Bauxite reserves and potential aluminum resources of the world", US Geol. Surv. Bull. 1228, 176pp.

Pickering, S.M. and Murray, H.H., 1994, "Kaolin" in *Industrial Minerals and Rocks,* 6th ed., D.D. Carr, Editor, SME, Littleton, CO, pp. 255-277.

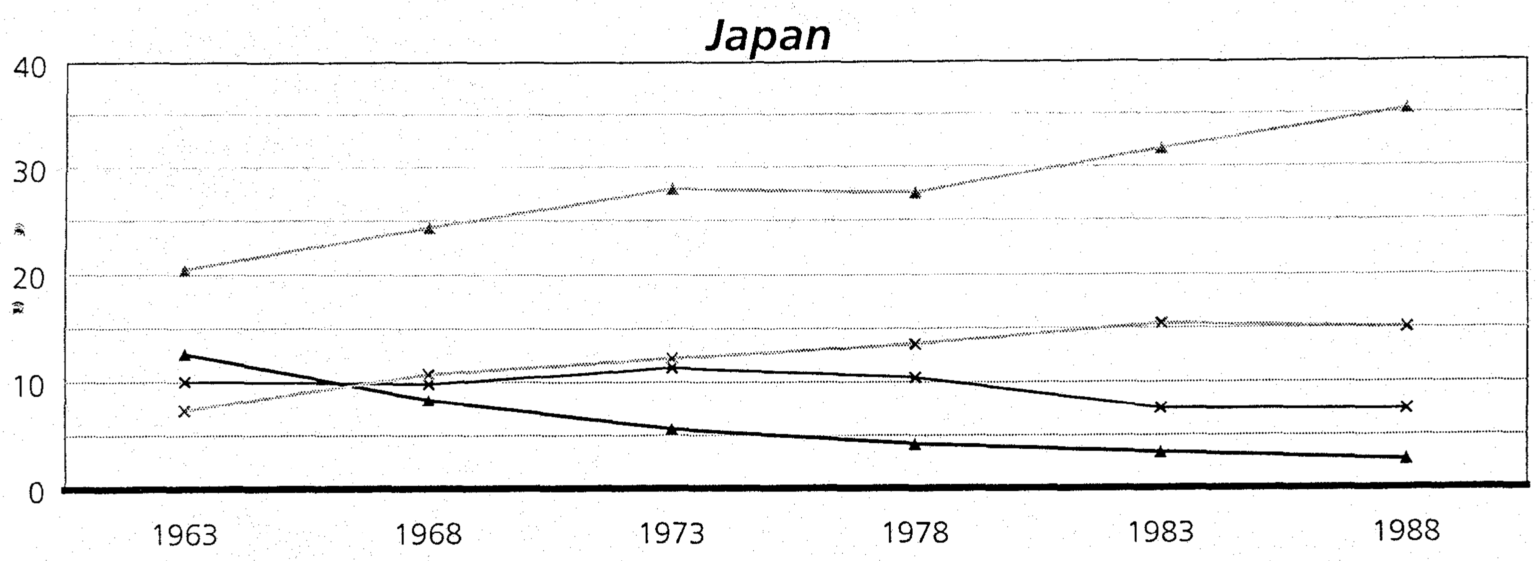
Demand Drives Exploration Targets

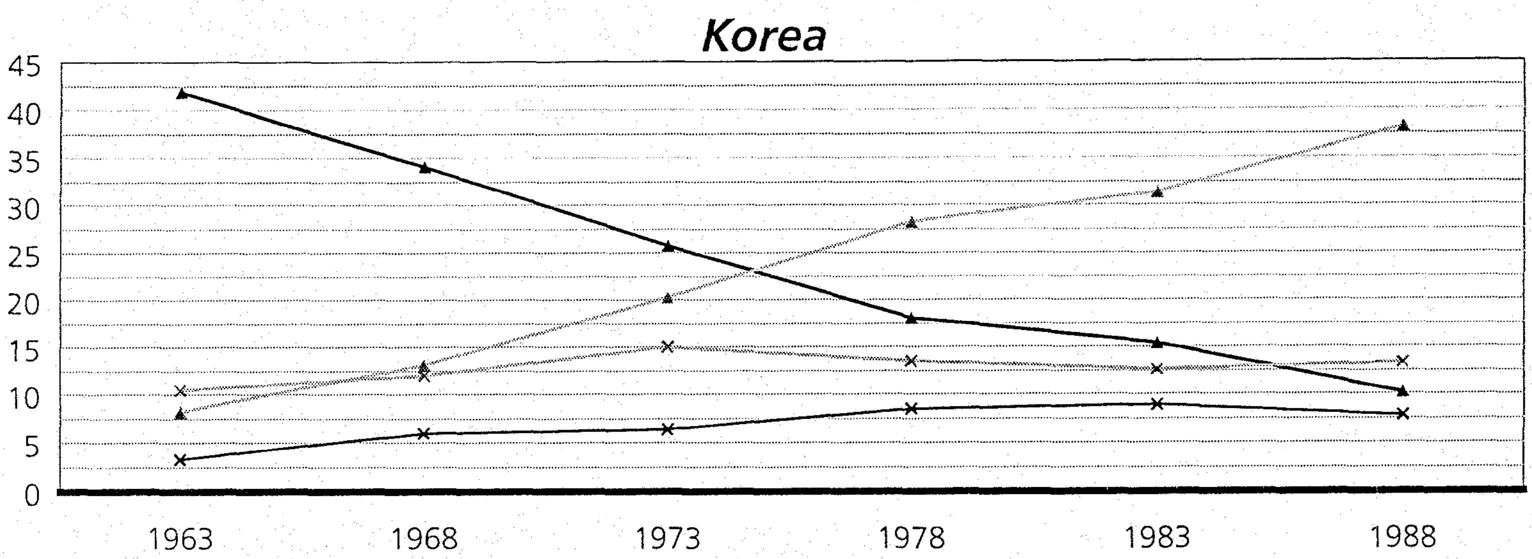


Peter W. Harben
Morris, NY, USA

17

GDP by Industry (%)





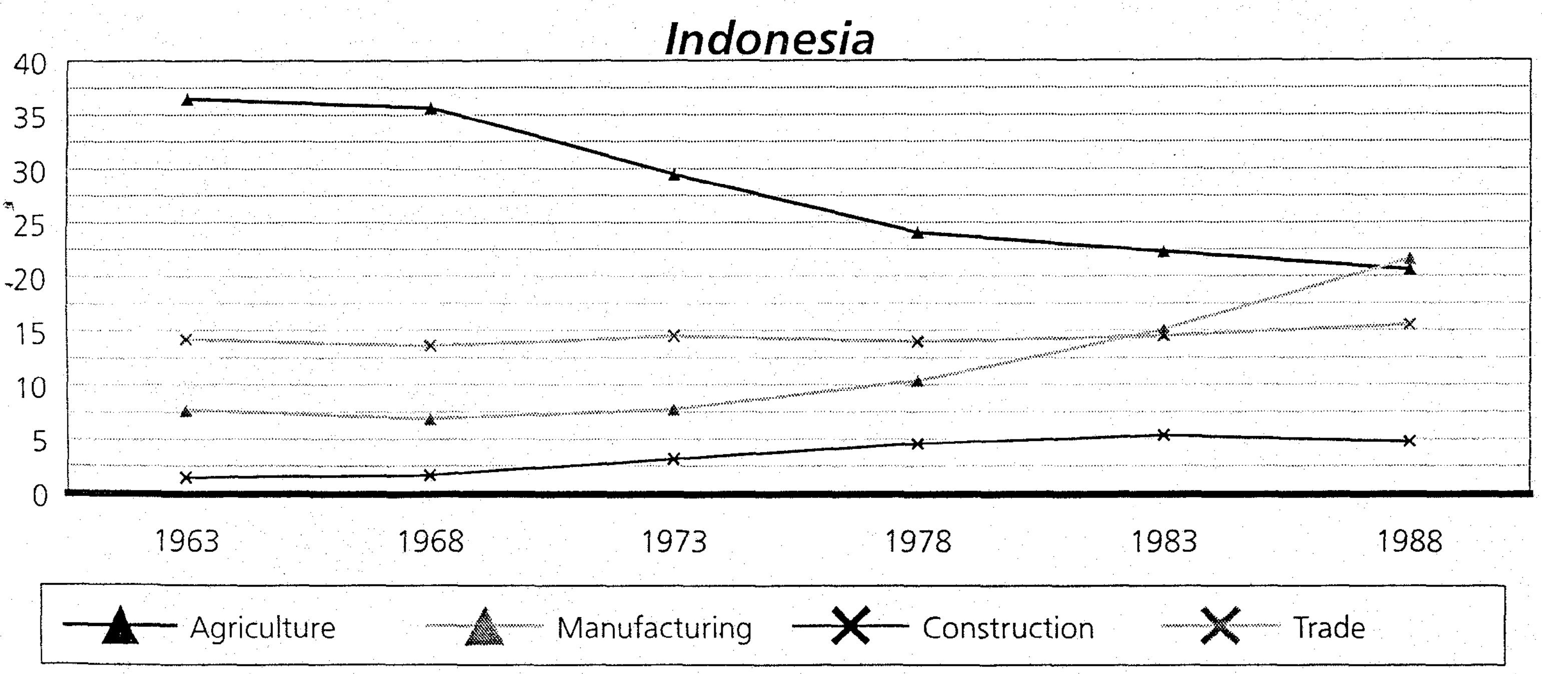
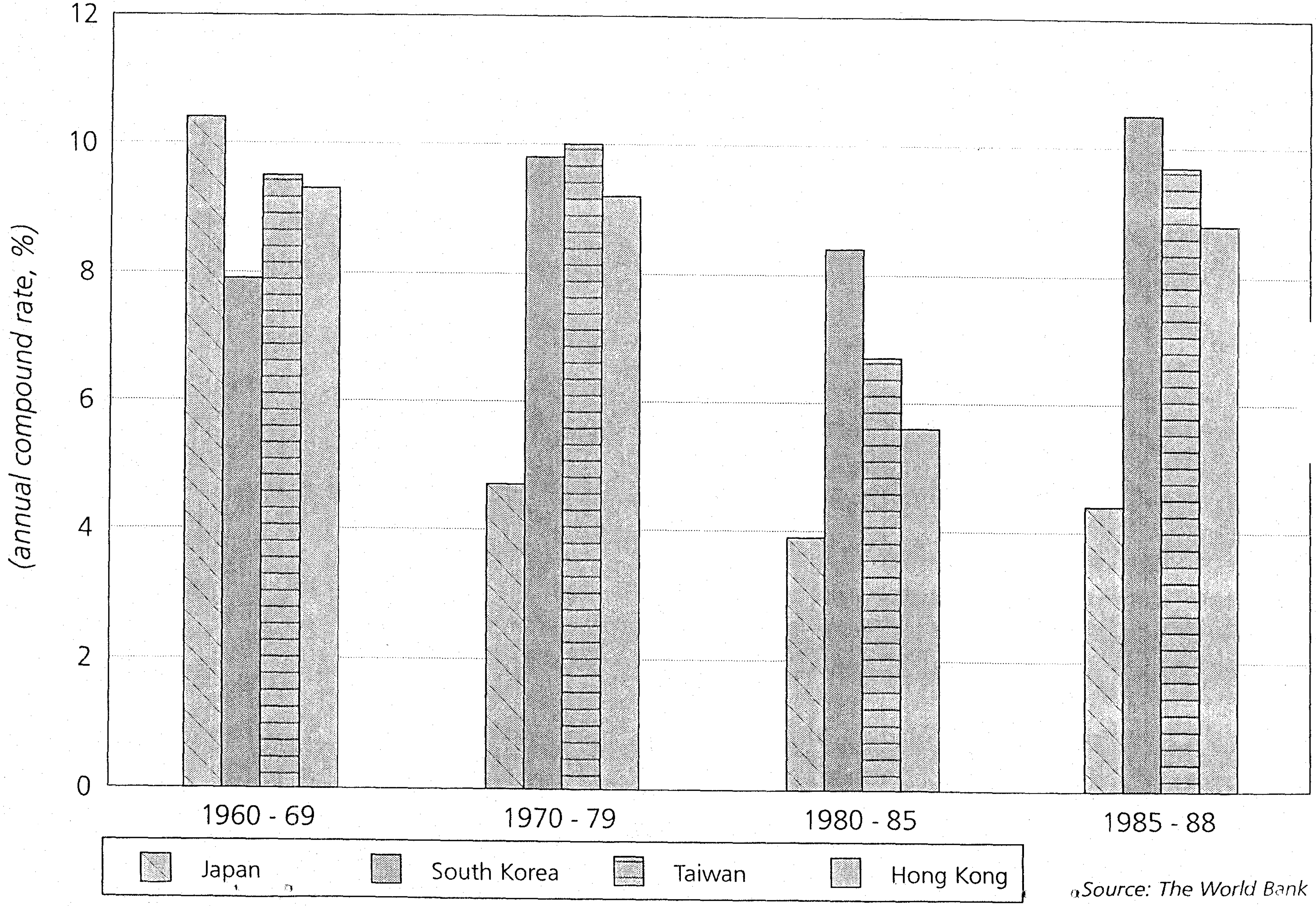


Figure 6
Real GDP Growth in Asia



Source: The World Bank

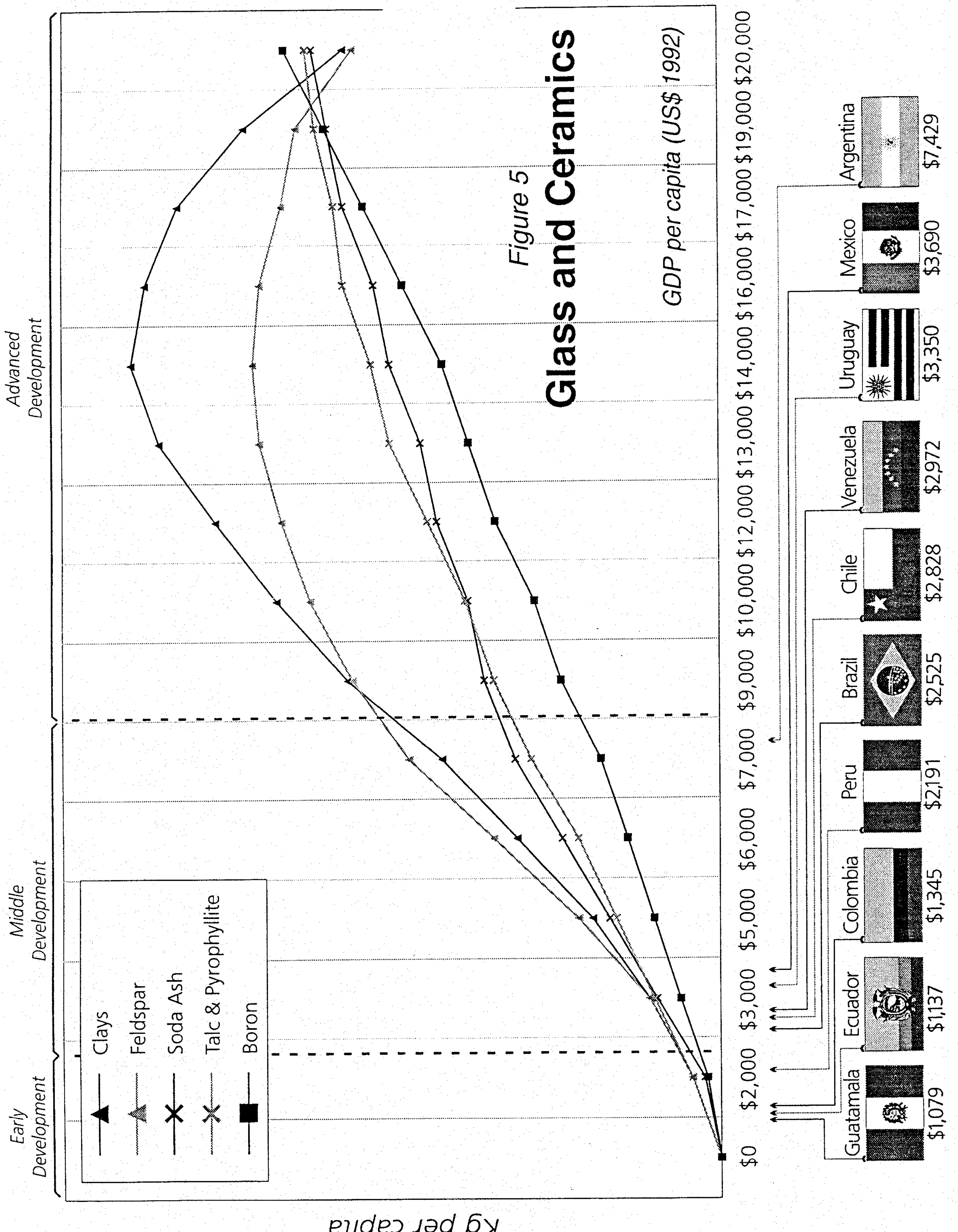
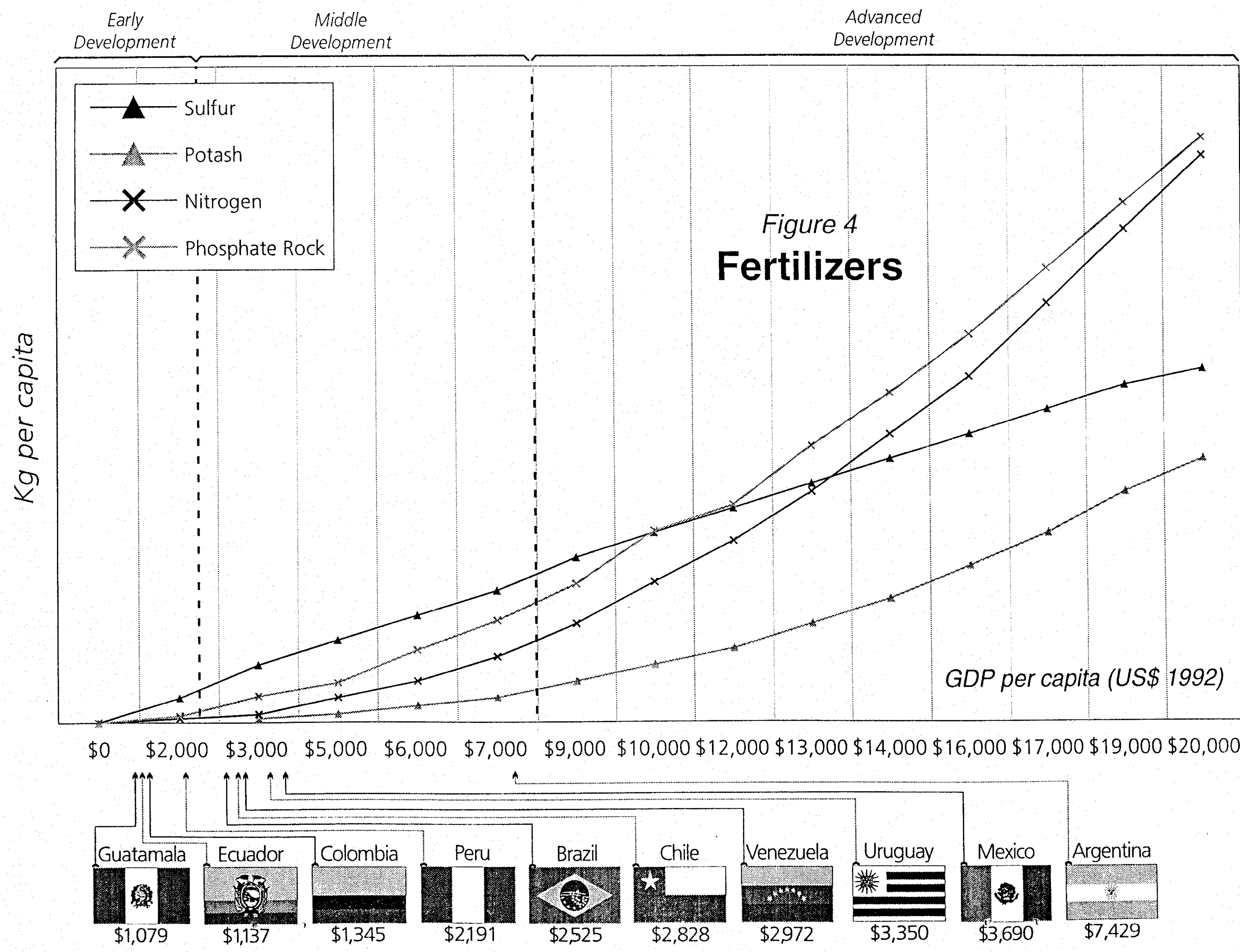


Figure 5
Glass and Ceramics
GDP per capita (US$ 1992)
Kg per capita
Early Development
Middle Development
Advanced Development
Clays
Feldspar
Soda Ash
Talc & Pyrophyllite
Boron
$0
$2,000
$3,000
$5,000
$6,000
$7,000
$9,000
$10,000
$12,000
$13,000
$14,000
$16,000
$17,000
$19,000
$20,000
Guatamala
$1,079
Ecuador
$1,137
Colombia
$1,345
Peru
$2,191
Brazil
$2,525
Chile
$2,828
Venezuela
$2,972
Uruguay
$3,350
Mexico
$3,690
Argentina
$7,429



Early Development
Middle Development
Advanced Development
Sulfur
Potash
Nitrogen
Phosphate Rock
Figure 4
Fertilizers
Kg per capita
GDP per capita (US$ 1992)
$0 $2,000 $3,000 $5,000 $6,000 $7,000 $9,000 $10,000 $12,000 $13,000 $14,000 $16,000 $17,000 $19,000 $20,000
Guatamala $1,079
Ecuador $1,137
Colombia $1,345
Peru $2,191
Brazil $2,525
Chile $2,828
Venezuela $2,972
Uruguay $3,350
Mexico $3,690
Argentina $7,429

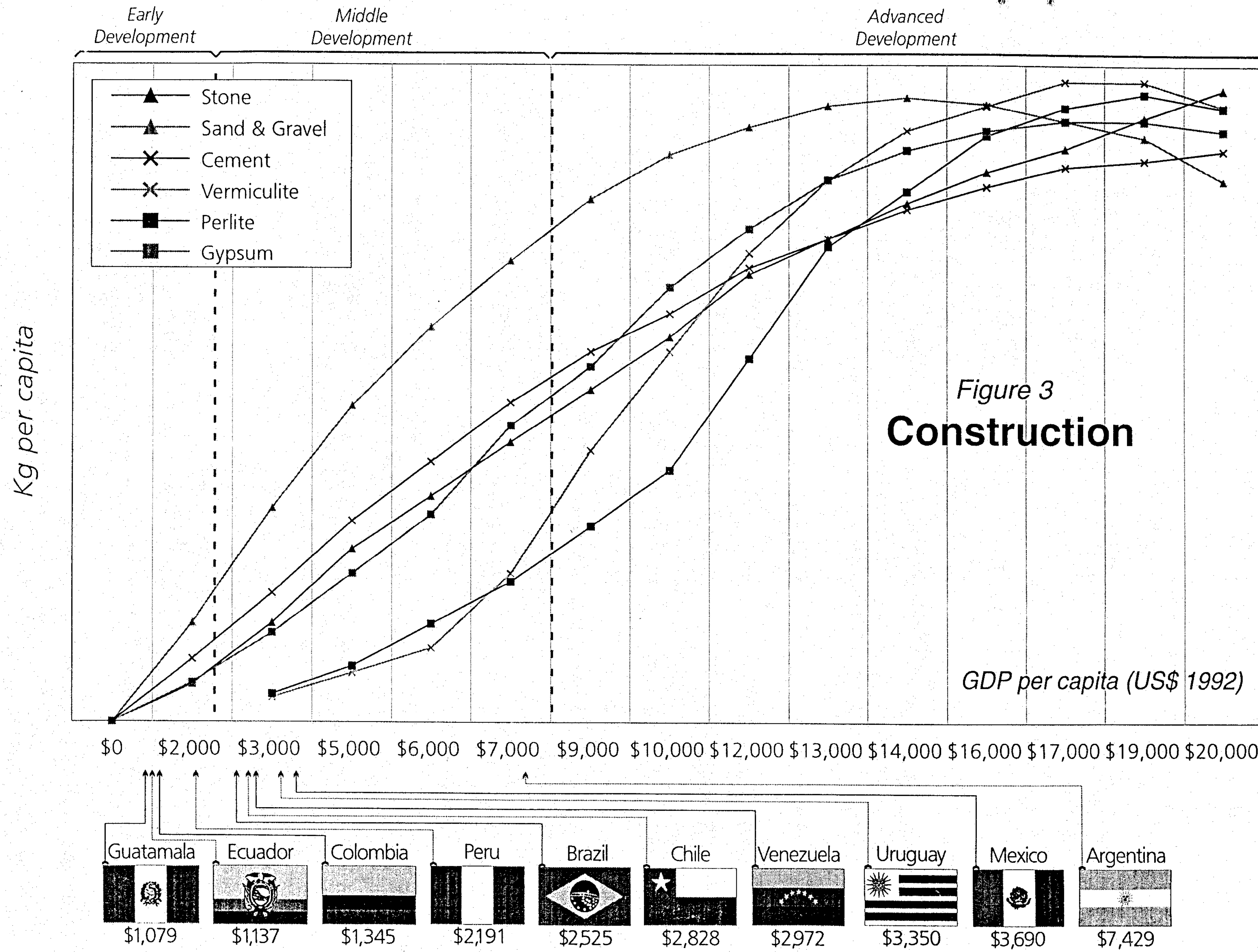


Figure 3

Construction

Industrial Mineral Opportunity for B.C. Custom Processing

by

B. Ainsworth,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

The Custom Milling of Industrial Minerals in B.C.

GOOD MORNING TO YOU ALL – I AM DELIGHTED TO HAVE THE OCCASION TO FOLLOW ON FROM PETER HARBIN AND DISCUSS SOME COMPLEMENTARY APPROACHES TO DEVELOPING INDUSTRIAL MINERALS ACTIVITY IN THE PROVINCE.

In 1989, WE CARRIED OUT A STUDY, FUNDED BY THE CANADA - BRITISH COLUMBIA MINERAL DEVELOPMENT AGREEMENT, TO EVALUATE THE CUSTOM MILLING OF INDUSTRIAL MINERALS IN THE PROVINCE. PART OF THE OBJECTIVE OF THIS STUDY WAS TO SEE IF THERE WERE WAYS IN WHICH THE GOVERNMENT MIGHT INTERVENE TO ASSIST IN THE DEVELOPMENT OF THE INDUSTRIAL MINERALS SECTOR. ANOTHER OBJECTIVE OF THE STUDY WAS TO PRESENT THE POTENTIALS SO THAT PRIVATE SECTOR INDUSTRY MIGHT BE ENCOURAGED TO START UP UNITS OF PRODUCTION.

THE MAIN CONCLUSIONS OF THE STUDY WERE THAT GOVERNMENT SHOULD NOT PARTICIPATE DIRECTLY BUT RATHER ENCOURAGE AND FACILITATE ANY PROPOSED PRIVATE PROJECT - IN OTHER WORDS, BE IN THE CHEERING SECTION. I AM PLEASED TO BE ABLE TO SAY THAT THAT RECOMMENDATION WAS ADOPTED AND SEVERAL SEGMENTS OF GOVERNMENT HAVE BEEN CHEERING LOUDLY. THE PROOF OF THIS IS IN OUR MEETING TODAY AND THE SUPPORT FOR BC'S INDUSTRIAL MINERALS GIVEN AT INTERNATIONAL TRADE SHOWS THROUGH THE COOPERATIVE ACTION OF THE DEPARTMENTS OF MINES AND TRADE AND INDUSTRY. TO THE UNINITIATED IT MIGHT SEEM UNLIKELY THAT ONE MIGHT BE AGRESSIVELY SELLING SOMETHING AS SOLID AS ROCK BUT THAT IS ONE PARTICULAR AREA OF LIVELY PARTICIPATION BY OUR GOVERNMENT FRIENDS.

THE RECOMMENDATION WAS ALSO MADE IN THE STUDY THAT A LOWER MAINLAND CUSTOM PLANT COULD BE A USEFUL PROFIT CENTER GIVEN BOTH THE POSSIBILITY OF LOCAL INDUSTRIAL MINERAL SOURCES OR LOW COST BULK IMPORTS BY SEA, AND THE SIZE OF SOME OF THE MARKETS NEARBY.

THIS ONE HAS NOT BEEN FOLLOWED UP AS FAR AS I KNOW, ALTHOUGH I AM WORKING WITH A GROUP TO PURSUE THE OPPORTUNITY AT PRESENT - SORT OF PUTTING MY MONEY WHERE MY MOUTH WAS.

WELL, SINCE THE STUDY WAS DONE THERE HAVE BEEN SOME VERY IMPORTANT STRUCTURAL CHANGES IN THE EXTERNAL AND INTERNAL FRAMEWORK WITHIN WHICH A BC BASED CUSTOM PROCESSOR WILL NOW OPERATE.

AMONGST THOSE EXTERNAL FORCES, NAFTA AND THE CHEAP CANADIAN DOLLAR COULD ENCOURAGE THE SELECTION OF A BC SITE OVER ANOTHER WEST COAST PACIFIC RIM SITE.

AMONGST THE INTERNAL FORCES IS A RELATIVELY NEW PERCEPTION IN POLITICAL CIRCLES AND BUREAUCRATIC SQUARES, THAT INDUSTRIAL MINERALS ARE ENVIRONMENTALLY HAPPIER THAN SOME OF THOSE NASTY TOXIC METALS THAT MINERS USED TO BE ALLOWED TO START MINING IN THIS PROVINCE. THIS SHOULD MAKE PERMITTING OF OF AN INDUSTRIAL MINERALS PROJECT EASIER TO FAST TRACK, ESPECIALLY IF IT IS NOT A WASTE PRODUCER AND IS DELIVERING JOBS WITH THAT VALUE ADDING CACHET. EVEN MORE RECENTLY OTTAWA KILLED THE "CROW" - REMOVED THE CROW RATE SUBSIDIES FROM GOODS MOVING BY RAIL WESTWARDS INTO BRITISH COLUMBIA FROM THE FROZEN EAST. THIS COULD SIGNIFICANTLY INCREASE SOME FREIGHT COSTS FOR MOVEMENTS IN THAT WESTERLY DIRECTION.

THESE KEY CHANGES MAKE IT WORTHWHILE REVISITING SOME OF THE IDEAS ORIGINALLY PROPOSED IN OUR STUDY AND PUTTING THOSE THAT STILL APPLY TOGETHER WITH POTENTIALS THAT HAVE DEVELOPED BECAUSE OF A CHANGING INDUSTRIAL AND HUMAN DEMOGRAPHY FOR THIS PART OF THE PACIFIC RIM.

BEFORE GOING FURTHER I WOULD LIKE TO DEFINE CUSTOM PROCESSING.

FOR OUR PURPOSES, I WOULD INCLUDE EVERYTHING FROM SIMPLE PRODUCT STORAGE, TO PACKAGING FROM BULK, SIZE REDUCTION AND CLASSIFICATION, MIXING AND BLENDING.

THE CUSTOM PROCESSOR STANDS AS A KEY LINK BETWEEN THE SUPPLIER OR THE TRADER, AND THE END USER OF THE PRODUCT. THE DEGREE OF PROCESSING MAY VARY FROM SIMPLY MAKING SURE THAT THE PRODUCT IS NOT DEGRADED OR CONTAMINATED - PROPER STORAGE - TO A TECHNICALLY SOPHISTICATED MICRONIZING OF PARTICLES WITHOUT CONTAMINATION WHICH MIGHT BE FOLLOWED BY THE PROCESS STEPS TO MAKE PRECISION ADDITIONS OF HIGH COST SURFACE TREATMENT AGENTS.

CUSTOM PROCESSING IS GENERALLY NOT CUSTOM BENEFICIATION, REMOVING PRODUCT FROM WASTE MATERIAL - ALL "WASTE" TRIES TO FIND SOME MARKET AND NOT A WASTE DUMP IN THIS PART OF THE INDUSTRIAL MINERALS DISTRIBUTARY CYCLE. A REGULAR DUMPSTER SHOULD SURFICE THE WEEKLY WASTE NEEDS OF THE PLANT.

WE WERE WONDERING HOW TO GET INTO THE BUSINESS THE STUDY EXPLORED HOW SOME OF THE EXISTING CUSTOM PROCESSORS STARTED UP.

DURING VISITS TO SEVERAL CUSTOM PROCESSORS IN EUROPE AND IN THE NORTHEAST U.S., IT QUICKLY BECAME CLEAR THAT MOST CUSTOM PROCESSORS WERE EITHER AN OUTGROWTH OF A WAREHOUSING FACILITY OR AN ADJUNCT TO A TRADING COMPANY. IN BOTH CASES, THE COMPANY WAS ASKED OR SAW THE NEED TO MODIFY THE PRODUCT TO MEET REQUIREMENTS OF THE NEXT CONSUMER IN THE DISTRIBUTARY CHAIN. THE COMPANY CAUGHT A BENEFIT FROM THE RESULTANT VALUE-ADDING.

THIS MODIFICATION MAY HAVE BEEN AS SIMPLE AS PUTTING BULK SALT INTO A BAG; A BAG SMALL ENOUGH THAT THE HOUSEKEEPER DID NOT GET A HERNIA LIFTING IT OUT OF THE TRUNK OF THE CAR TO SPRINKLE SALT ON THE DRIVEWAY IN WINTER. IT MAY HAVE BEEN AS SIMPLE AS SCREENING OUT COARSE MATERIAL FOR DELIVERY TO ONE SANDBLASTER WHILE SAVING THE FINES FOR ANOTHER. IT MAY HAVE BEEN THE CRUSHING AND GRINDING OF WOLLASTONITE IN A ROD MILL TO ACHIEVE A HIGH ASPECT RATIO FILLER OF CERTAIN SPECIFICATION AND COATING THE PARTICLES WITH SILANES.

IN GENERAL, THE SIMPLE CUSTOM PROCESSOR WAS ACTING AS AN INTERMEDIARY ONLY TO CHANGE THE NATURE OF THE PRODUCT TO SUIT THE NEXT CONSUMER. THE WAREHOUSE WAS NOT ACTIVELY PURSUING MARKETS FOR THE PRODUCT NOR BUYING PRODUCT FROM EXOTIC SOURCES. THE TRADER ALREADY WAS INVOLVED IN THE PURCHASE AND SALE OF PRODUCTS BUT NEEDED TO CARRY OUT A FEW EXTRA PROCESS STEPS TO KEEP HIS CONSUMER CONTENT.

THE EXTENT TO WHICH THE SIMPLE CUSTOM PROCESSOR BECOMES INVOLVED IN ACTUALLY PURCHASING AND MARKETING PRODUCT VARIES. IT IS RECOMMENDED BY SOME AS A WAY OF TAKING CONTROL OF THE THROUGHPUT OF MATERIAL SOMEWHAT. THIS COULD GIVE SOME STABILITY TO THE VOLUMES OF BUSINESS AND REDUCE THE UNCERTAINTIES OF CUSTOMERS DEMANDS. IT WOULD BE IMPORTANT, HOWEVER, TO AVOID THE PERCEPTION OF CONFLICT OF INTEREST THAT COULD ARISE FROM INTERVENING IN A CUSTOMER'S MARKET.

A CROSS-SECTION OF THE DIFFERENT SHAPES OF PROCESSOR COMPANIES WAS INCLUDED IN THE 1989 STUDY. EGGERDING AND CO. OF THE NETHERLANDS IS A GOOD EXAMPLE OF THE WAREHOUSER WHO GREW INTO CUSTOM PROCESSING. COLIN STEWART MINERALS OF CHESHIRE, ENGLAND, IS MORE OF A TRADER AND VENDOR OF VALUE ADDED PRODUCTS, HAVING GROWN BY AGGLOMERATION OF SEVERAL SMALLER CUSTOM PROCESSORS. JAN DE POORTER B.V. OF THE NETHERLANDS STARTED AS A TRADER IN THE 30'S AND DEVELOPED THEIR CUSTOM PROCESSING AS PART OF THE NEED TO SATISFY CUSTOMERS IN THE CERAMICS INDUSTRIES.

ONE OTHER, LESS COMMON FORM OF CUSTOM PROCESSING NOTED WAS THE OCCASIONAL PIGGY-BACK OF TOLL PROCESSING ONTO AN ESTABLISHED, LARGER INDUSTRIAL MINERALS PRODUCER. HERE, THE MAIN PRODUCT LINE MIGHT BE INTEGRATED AND SOLD ON THE BASIS OF LONG TERM CONTRACTS WITH THE FINAL CONSUMER BUT, WITHIN A DIVISION OF THE INDUSTRIAL MINERALS PRODUCER, THERE IS A SOUL IN MANAGEMENT WHO IS SUFFICIENTLY ENTRPRENEURIAL TO BE ABLE TO DEVELOP A PROFIT CENTRE THAT IS SUPPLEMENTAL TO THE PRINCIPAL BUSINESS. ONE EXAMPLE OF THIS IS THE FORDAMIN DIVISION OF ENGLISH CHINA CLAYS IN THE U.K.

IF WE CONSIDER A START-UP SITUATION FOR A CUSTOM PROCESSOR HERE IN B.C., IT IS CLEAR THAT THE COMPANY WILL PROBABLY HAVE TO SEEK AND PROBABLY PURCHASE SOURCES OF PRODUCT OR JOIN FORCES WITH A SPECIALIST WAREHOUSING GROUP THAT IS ALREADY OPERATIONAL AND SERVING THE INDUSTRIAL MINERALS SECTOR.

IF WE CONSIDER THAT START-UP SITUATION A LITTLE FURTHER, WE QUICKLY REALIZE THAT THE COMPANY WILL ALSO PROBABLY HAVE TO DEVELOP MARKETS FOR THE PRODUCTS IT HAS ACQUIRED. THE GROWTH WILL NOT BE A SIMPLE ORGANIC EXPANSION OF A WAREHOUSING TYPE OF BUSINESS BUT A FULL JUMP INTO INDUSTRIAL MINERAL MARKETING OR TRADING WITH A VALUE ADDING INTERFACE. MY GUT FEELING IS THAT, IN THE SETTING OF THE PORT OF VANCOUVER AREA, ORGANIC GROWTH MAY BE SLOWER THAN A SPRUCE TREE ABOVE THE 60TH PARALLEL.

WE RECOGNIZED THIS CRITICAL DIFFERENCE AS WE DID THE STUDY AND WE DECIDED THAT THE NEXT STEP WAS TC ESTABLISH WHAT WERE THE POTENTIAL SOURCES OF SUPPLY IN THE PROVINCE AND NEARBY FOR A CUSTOM PROCESSING PLANT. IT WAS NOT THEN, AND IS NOT NOW, OBVIOUS THAT BC HAS MANY SUITABLE SOURCES OF SUPPLY OF INDUSTRIAL MINERALS TO FEED A CUSTOM MILLING FACILITY . HOWEVER THERE IS GOOD POTENTIAL FOR DEVELOPING A PROCESSING PLANT INITIALLY BASED ON MINERAL SUPPLY THROUGH THE TRANSPORTATION LINKAGES THAT EXIST, INCLUDING BY SHIP FROM OTHER PACIFIC RIM COUNTRIES. SINCE, AS PETER HARBEN HAS SO ELOQUENTLY DESCRIBED, MARKETS DEFINE EXPLORATION, WE ALSO RECOGNIZED THAT WE HAD BETTER DEFINE WHAT WERE THE INDUSTRIAL MINERALS MARKETS WITHIN REASONABLE REACH OF SUCH A PLANT.

ALL OF THE FOREGOING LEADS TO THE SHORT CONCLUSION THAT ANY PLANT WOULD HAVE TO BE AT A LOW COST SITE AT A DEEP SEA PORT, WITH GOOD RAIL AND HIGHWAY CONNECTIONS FOR THE EFFICIENT DELIVERY INCOMING AND OUTGOING PRODUCT. THAT MAY BE AN OXYMORON WHEN WE NOTE THAT THE PORT OF VANCOUVER SITES TRADITIONALLY RUN AT ABOUT $1.00 A SQUARE FOOT FOR WATERFRONT LAND AND 10 CENTS A SQUARE FOR THE WET PARTS. A LITTLE FAST ARITHMETIC SHOWS THAT TO BE ABOUT $200-400,000 ANNUAL LEASE COST FOR A REASONABLE SIZED PIECE OF WATERFRONT - AND THAT IS BEFORE ANYTHING ELSE IS BOUGHT OR BROUGHT TO THE SITE.

THE TRANSPORTATION LINKS TO A PORT OF VANCOUVER FACILITY UP SHOWED UP AS A MAJOR DIFFERENCE BETWEEN A BC PLANT AND THE SITUATION THAT PREVAILED FOR EUROPEAN AND NORTHEASTERN US PROCESSORS. THEY CAN TYPICALLY REACH THEIR CUSTOMERS WITH A ONE DAY DELIVERY SCHEDULE. OFFSETTING THAT, ONE CAN REMEMBER THAT NORTH AMERICAN FREIGHT SYSTEMS ARE IMPRESSIVE IN THEIR ABILITY TO DELIVER GOODS IN A TIMELY FASHION.

TIMELY DELIVERY FROM THE WAREHOUSE IS SO IMPORTANT BECAUSE IT EFFECTIVELY WORKS LIKE UNPAID INVENTORY CLOSE TO THE CONSUMER. THE CONSUMER CAN MAINTAIN AN APPEARANCE OF "JUST IN TIME" INVENTORY WITH THIS ARRANGEMENT AND IN THIS MAN'S LIFE PERCEPTION HAS BECOME REALITY! IN ALL SERIOUSNESS THE WAREHOUSE FUNCTION IS AN INSURANCE FOR MORE RELIABLE DELIVERY, ESPECIALLY IF WE ARE TO CONSIDER SOURCES OF SUPPLY IN CHINA, INDIA OR THE HIGH ANDES OF SOUTH AMERICA. DELAYS IN SUPPLY FROM ACROSS THE PACIFIC CAN AMOUNT TO MONTHS ACCORDING TO SOME SADDER AND WISER CHINA BUYERS - A COUPLE OF EXTRA DAYS TRAVEL BETWEEN VANCOUVER AND SAY LOS ANGELES ON A BACKHAULING TRUCK MAY BE SEEN AS QUITE AN IMPROVEMENT.

MARKETS DEFINE THE COMMODITIES WE SHOULD CONSIDER. WITH THE BROADER SPREAD OF SOURCES OF SUPPLY THAT CAN BE DELIVERED BY THE SHIPPING LINKAGES, WE NEED TO LOOK AT WHAT SEGMENTS OF MARKET ARE BIG ENOUGH TO ENTER INTO WITHOUT MAKING TO MANY RIPPLES; ALSO WHICH ARE THE LARGER LOCAL MARKETS THAT MIGHT HAVE A MAJOR FREIGHT COST ADVANTAGE IF DELIVERED FROM THE BC PROCESSOR.

PETER HARBEN HAS ALREADY SUGGESTED SOME OF THE MARKETS THAT WE SHOULD FOCUS ON FOR OUR START-UP PLANT. FOR ME, THE PULP AND PAPER SECTOR PROBABLY OFFERS THE MOST IMPORTANT POTENTIALS. THE MARKET SIZE OF PAPER MINERALS COULD BE BIG ENOUGH TO FORM A BROAD BUILDING BLOCK FOR THE START-UP CUSTOM PROCESSING PLANT UPON WHICH OTHER SMALLER PRODUCT LINES CAN BE BUILT.

CLEARLY THIS IS A CHICKEN AND EGG SORT OF SITUATION AT PRESENT AND IS NOT WITHOUT A RISK. THERE IS STILL NOT MUCH FILLED OR COATED PAPER MADE IN BC. THE PULP INDUSTRY HAS SAID LOUD AND CLEAR SEVERAL TIMES IN RECENT YEARS THAT THEY MUST MOVE INTO VALUE-ADDED PRODUCTS IF THEY ARE GOING TO CONTINUE IN BUSINESS WITH BC's HIGH COST FIBRE. PART OF THEIR PROBLEM HAS BEEN THE HIGH COST OF KAOLIN FROM GEORGIA WHEN INCLUDING THE COST OF RAIL FREIGHT. THE FILLED PAPER THEN HAS TO BE SOLD INTO MARKETS WHERE MUCH CHEAPER KAOLIN IS AVAILABLE - AND THAT INCLUDES JAPAN, WHICH GETS ITS KAOLIN FROM GEORGIA BY SHIP.

CALCIUM CARBONATE, TALC AND SODA ASH COULD ALL BE CONSIDERED WITH KAOLIN AS PART OF THE PRODUCT LINE TO OFFER TO THE PULP AND PAPER PRODUCERS. A STRATEGY COULD BE TO SUPPLY THOSE EXISTING PAPER MINERAL CONSUMERS INCLUDING SOME OF THE NEW CALCIUM CARBONATE REQUIREMENT FOR THE PORT ALBERNI 'NEXT GENERATION' PLANT OF MACMILLAN BLOEDEL. THE AVAILABILITY OF SLURRIED MINERALS FOR DIRECT APPLICATION IN THE PAPER MILL IS POSSIBLY A SERVICE THAT WOULD ENCOURAGE SOME OF THE PULP PLANTS TO LOOK AT EXPANDING THEIR PAPERMAKING CAPABILITIES.

CRITICAL IN THE CHOICE OF THE MINERALS WITH WHICH TO START THE CUSTOM PROCESSING PLANT IS THE MINERAL OR GROUP OF MINERALS THAT WILL BE BIG ENOUGH BUSINESS TO CARRY THE OPERATION WITH A REASONABLY SHORT PAY-BACK PERIOD FOR CAPITAL INSTALLATIONS. THE PAPER MINERALS MAY BE LESS ATTRACTIVE THAN BENTONITE FROM HAT CREEK OR ZEOLITES FROM CACHE CREEK. AFTER THE PAY-BACK, THERE IS A POSSIBILITY OF GOING FORWARD WITH A MORE ORGANIC TYPE GROWTH - HOPEFULLY MORE LIKE THE WEEDS IN MY FERTILIZED GARDEN THAN THAT SPRUCE TREE NORTH OF '60.

JUST BRIEFLY, TO PUT CONTEXT TO THE SIZE OF THE BUSINESS THAT WOULD BE POSSIBLE FROM THESE SORTS OF BEGINNINGS, WE COULD REASONABLY AIM FOR CASHFLOWS STARTING AT SOMETHING OVER $1 MILLION WITH POTENTIAL TO GROW TO SEVERAL MILLIONS. IF THE SPIN OFF IS ALSO TO KEEP JOBS IN THE BC PULP AND PAPER INDUSTRY, WE WILL HAVE HELPED BUILD FUTURE MARKETS FOR INDUSTRIAL MINERALS.

THANK YOU

Industrial Kaolin and Market Growth on the Pacific Rim

by

C. C. Harvey
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Industrial Kaolin Resources in the Pacific Northwest and Central Canada

Colin C. Harvey

Department of Geological Sciences, Indiana University, Bloomington, IN 47405

Abstract

The very large paper industry in the Pacific Northwest is a potentially large market for industrial clays. Current trends within the paper industry towards higher quality newsprint, filled and coated papers offers an incentive for exploration in the region since the current supply of kaolin is from Georgia in the southeastern US. This long distance attracts freight rates which commonly exceed $100/mt.

The regional kaolin resources require very expensive processing technologies to meet the required specifications and it is doubtful that any large development of the local resources can be supported at the present time.

Competition from high quality regional resources of carbonates is another factor weighing against the development of local kaolin resources while there is a potential threat from shipments of Asian kaolin in the early part of the 21st century.

1. Introduction

Industrial kaolins are used in a wide range of industrial processes. They are amongst the world's largest tonnage of processed industrial minerals and can command prices as high as US$600 per ton.

The largest industrial user of kaolins on the world scene is the paper industry. In British Columbia, the paper industry is a very significant contributor to the commercial strength of the Province of British Columbia although currently little clay is used. With the current trend towards the increasing use of mineral fillers, it is essential to determine whether or not commercially viable kaolin resources are present in the region.

The paper industry utilizes large tonnages of a wide range of raw materials for both the chemical processing of pulp and the manufacture of filled and coated paper and board. British Columbia produces about 35% of Canada's pulp and paper products. Until the early 1990's the industry was commodity driven, providing relatively low value-added products of market pulp and newsprint to the North American and world markets (Temanex, 1994).

Note: The currency used in the study is US$ with tonnages in metric (2204 lb) tons.

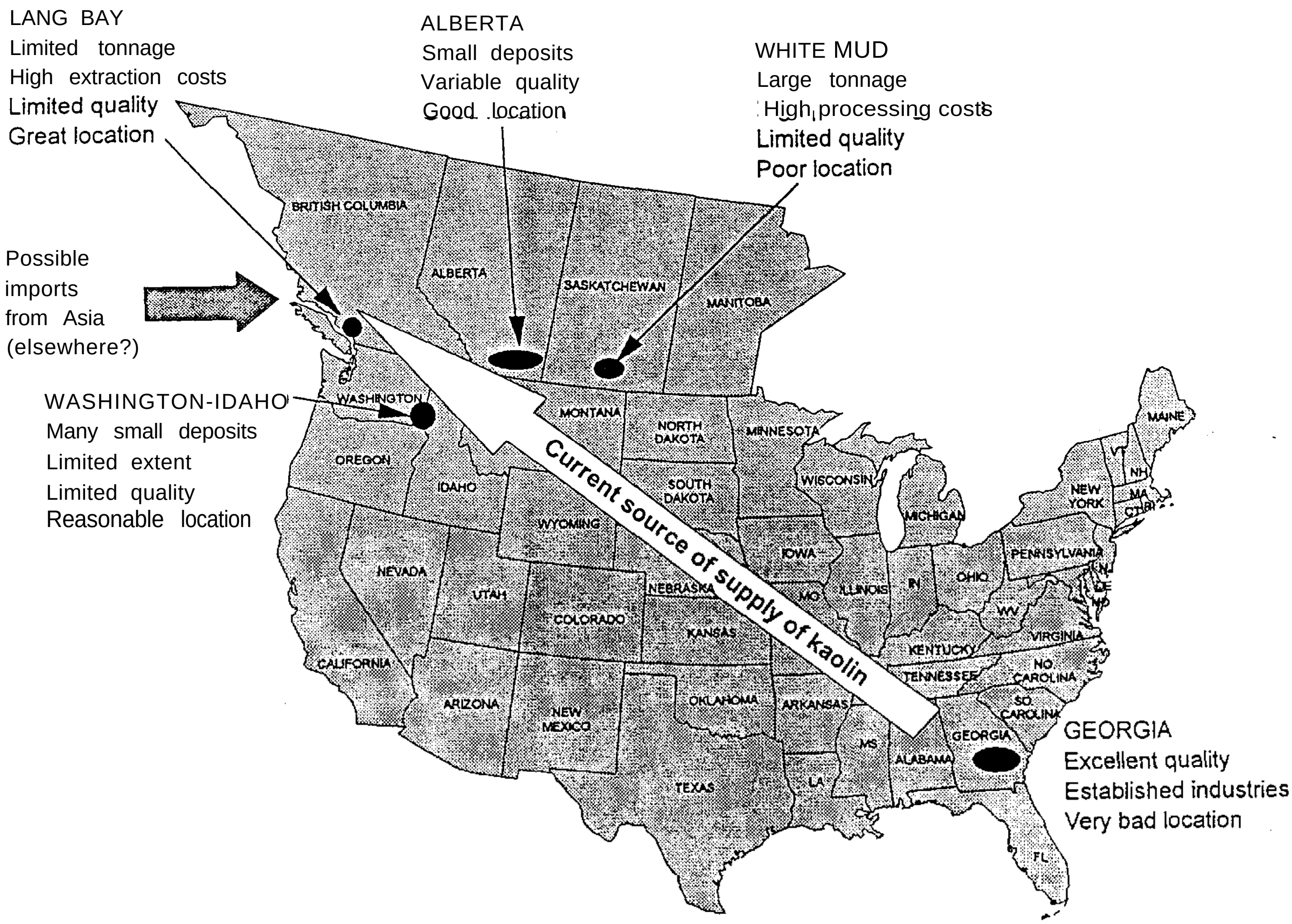


Figure 1 - Regional distribution patterns and options for kaolin supply to the Pacific Northwest

3. Market trends

Over the past five years, a rapid increase in the utilization of both GCC and PCC for fillers and coating in the paper industry has occurred. This increase is reflected in Figures 2 and 3 which illustrate the projected growth in the use of filler materials in the North American paper industry in the period from 1989 to 1994 (Figure 2) and the proportions of kaolin and carbonate used east and west of the Rockies (Figure 3). Virtually all the growth has been in the uses of PCC and GCC. The calcium carbonate used in the North American paper industry is in the form of either GCC or PCC. The former is usually used as a coating pigment and the latter as a filler. Consumption of both of these mineral forms is rapidly increasing as paper makers switch to alkaline or neutral paper processes. Some of the first paper makers to switch to the new techniques were producers of woodfree papers in both the coated and uncoated market sectors.

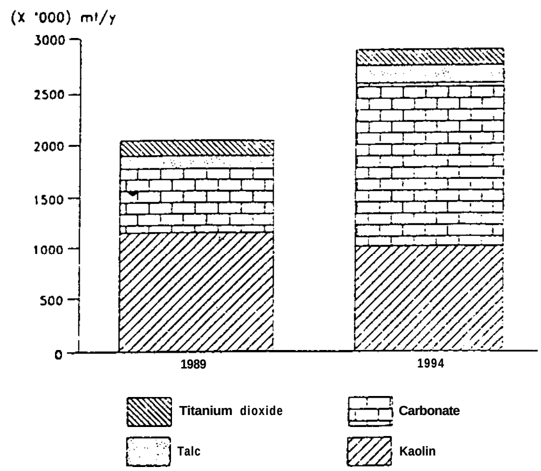


Figure 2 - Growth trends in pigment usage in the paper industry projected for the period 1989-1994 (Temanex, 1993)

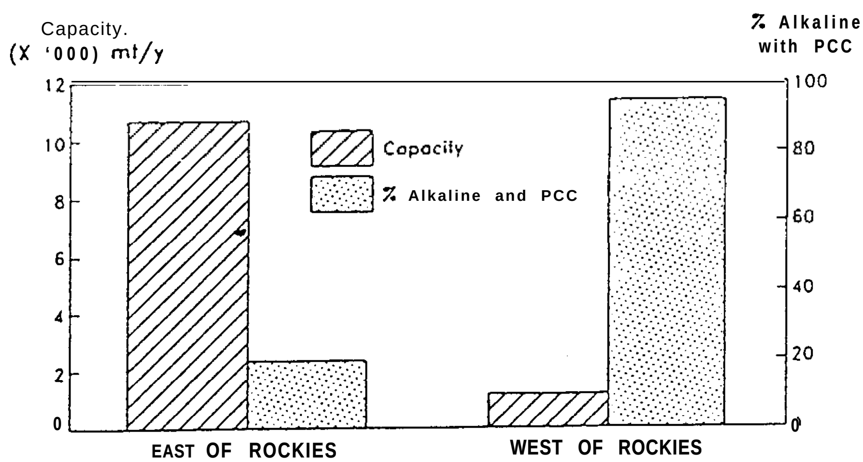


Figure 3 - Trends in pigment usage in the paper industry in North America (west of the Rockies) (Temanex, 1993)

4. Kaolin resources in the region

Despite these trends towards the use of carbonates over the past decades, considerable effort has been directed towards the location and evaluation of regional kaolin resources. Detailed work has been carried out on the primary and secondary kaolins of Idaho-Washington (Hosterman et al., 1960; Pruett and Murray, 1993), the primary kaolins of Lang Bay, British Columbia (Harvey and Farris, 1992) and the secondary kaolins of the White Mud Formation in southern Saskatchewan (Pruett and Murray, 1991).

A series of primary and secondary kaolin deposits associated with weathering and perhaps some hydrothermal alteration of the Idaho batholith are located in Latah County, Idaho. These deposits have been exploited for many years as refractory clays. Unsuccessful attempts have been made to establish a filler clay operation for use in paper and other industries but current activities are confined to refractory applications. A locality map of the area is shown in Figure 4, while a section through the deposits is illustrated in Figure 5.

The primary kaolins are weathering profiles on granodiorite rocks while several sedimentary kaolin deposits downstream from the primary clays are interbedded with basalts of the Columbia River Basalts (Keller and Ponder, 1959). The natural brightness of the clays are typically in the low 70's (GE scale) and with bleaching many can reach the low 80's (GE scale). However the size of the individual deposits is small and there are insufficient proven tonnages of 'good quality reserves to justify commercial development for supply to the paper industry.

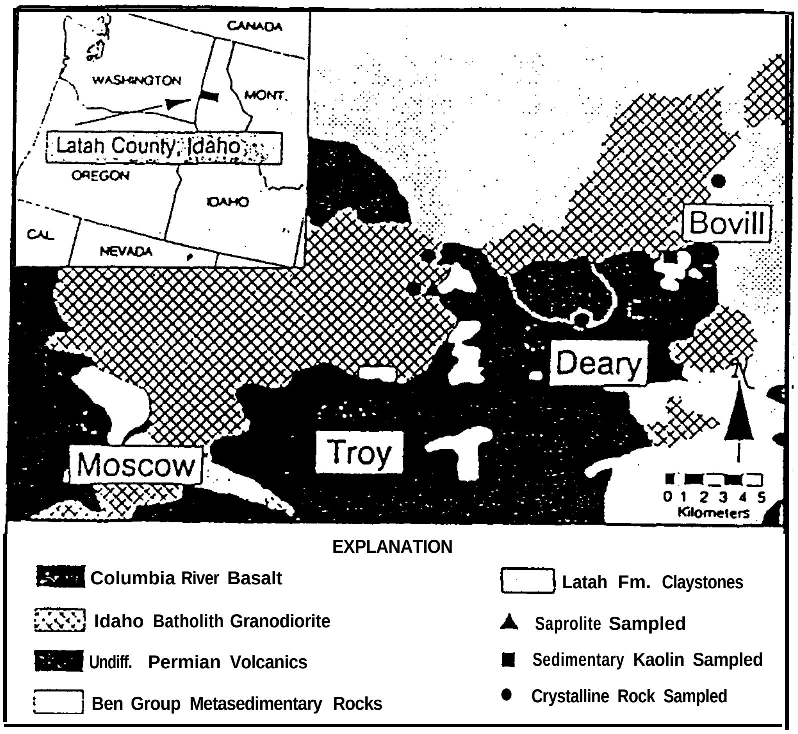


Figure 4 - Location of kaolin resources in Latah County, Idaho (modified from Hosterman, et al., 1960)

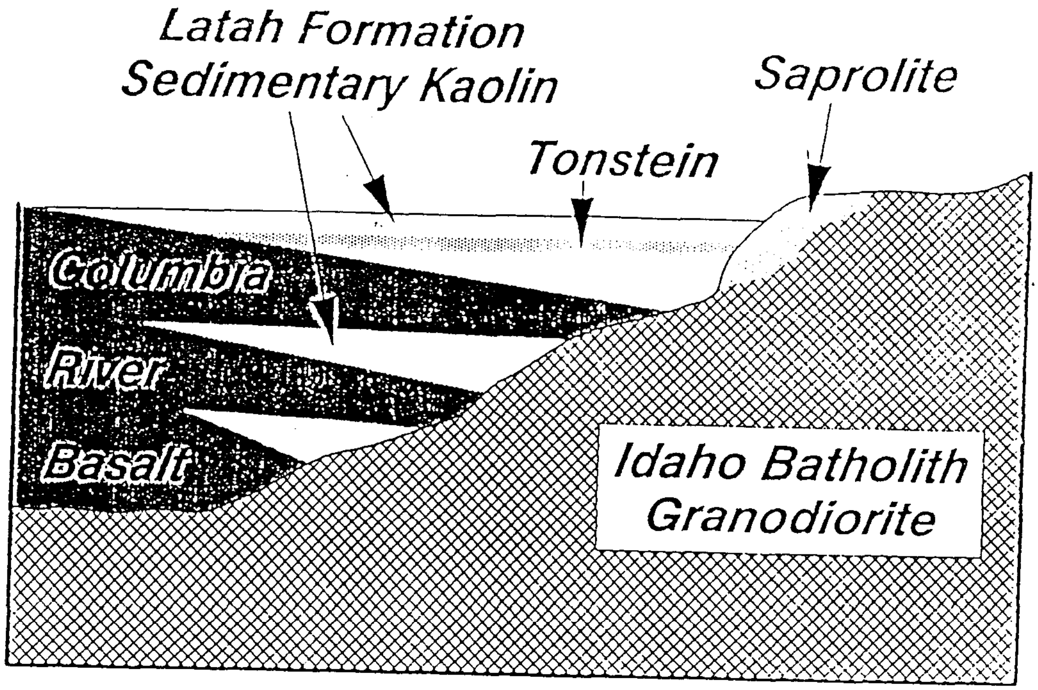


Figure 5 - **Cross-section of kaolin resources in Latah County, Idaho (modified from Ponder and Keller, 1959)**

At Lang Bay, approximately 80 km north of Vancouver, a small primary kaolin resource (approximately 6 Mmt of crude ore) is located close to tidewater 8 km south of Powell River township (Figure 6). The resource is formed from low temperature hydrothermal alteration and weathering of a granodiorite rock of the Coastal Plutonic Complex (Harvey and Farris, 1992). The natural brightness of the kaolin varies between 60 and 70% (GE scale). The resource is located beneath 20 to 30 m of glacial till and alternatives of opencast and underground mining have been investigated. The crystallinity of the kaolin is low and this fact in combination with low brightness classifies this material as a wood fiber replacement or at best, a low quality filler clay.

The location of the resource is excellent for the supply of kaolin filler clays to the adjacent paper mills but the quality of kaolin and the high overburden ratio in combination with the limited size of the resource has weighed against its commercial development.

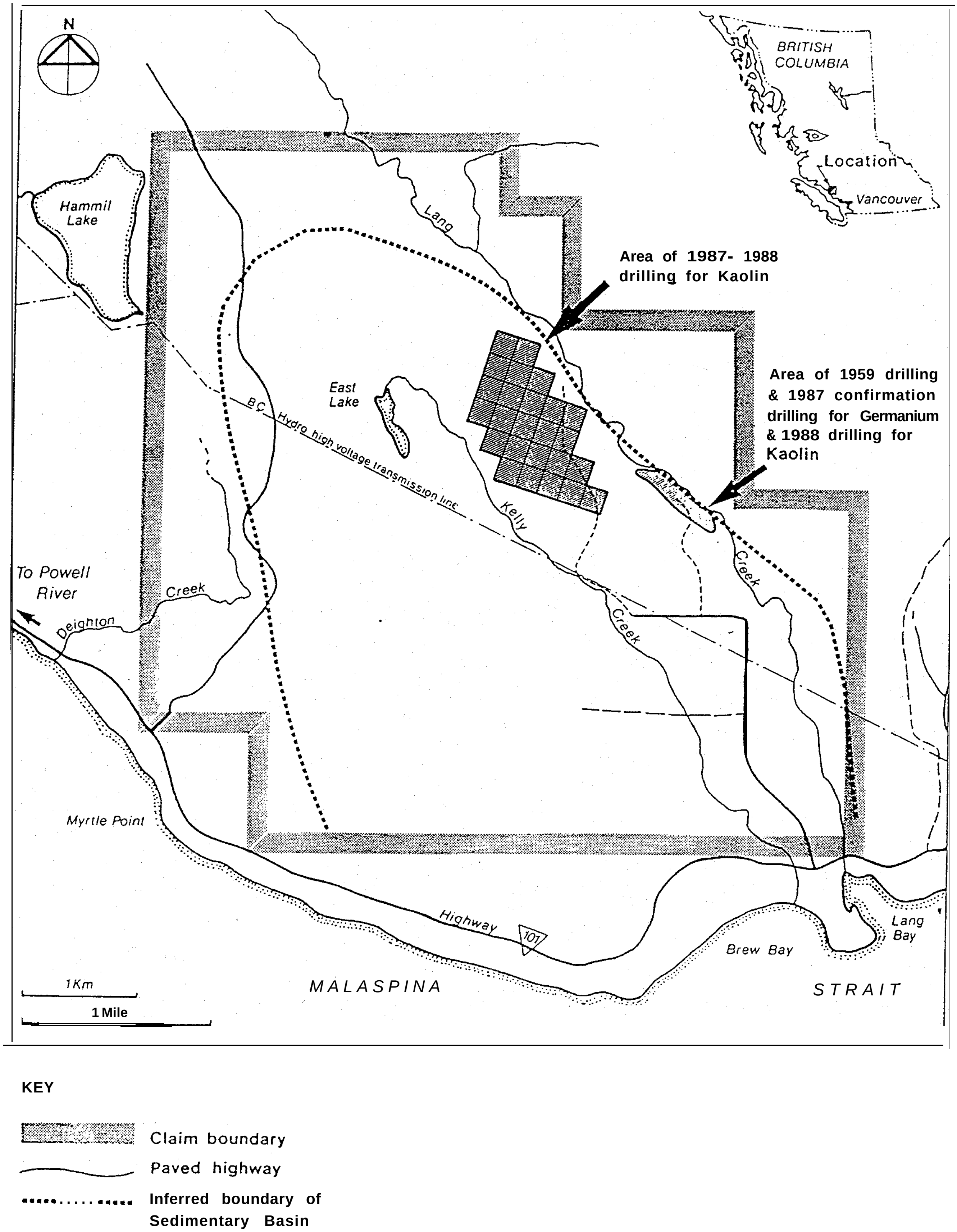


Figure 6 - Location of the Lang Bay kaolin resource in British Columbia

In southern Saskatchewan and southeastern Alberta (Figure 7), large exposures of white clays of the Whitemud Formation have been known for many years (Byers, 1969). The natural brightness of the clays is generally in the mid 70's (Pruett and Murray, 1991). In the 1980's considerable effort was expended by Ekaton Industries to prove the technical and commercial viability of these clays to supply the paper industry in both Canada and the midwestem United States. The clays are composed of a mixture of kaolin, illite and quartz. The kaolin is of relatively low crystallinity and was considered to have limited potential as a coating clay (Pruett and Murray, 1991). The deposits are located relatively distant from both the east and west coasts of Canada and freight factors are therefore not advantageous. Ekaton applied a wide range of enhanced upgrading techniques to meet the quality specifications for filler and calcined kaolin but the complex technology requirements were a strong disincentive to commercial investment.

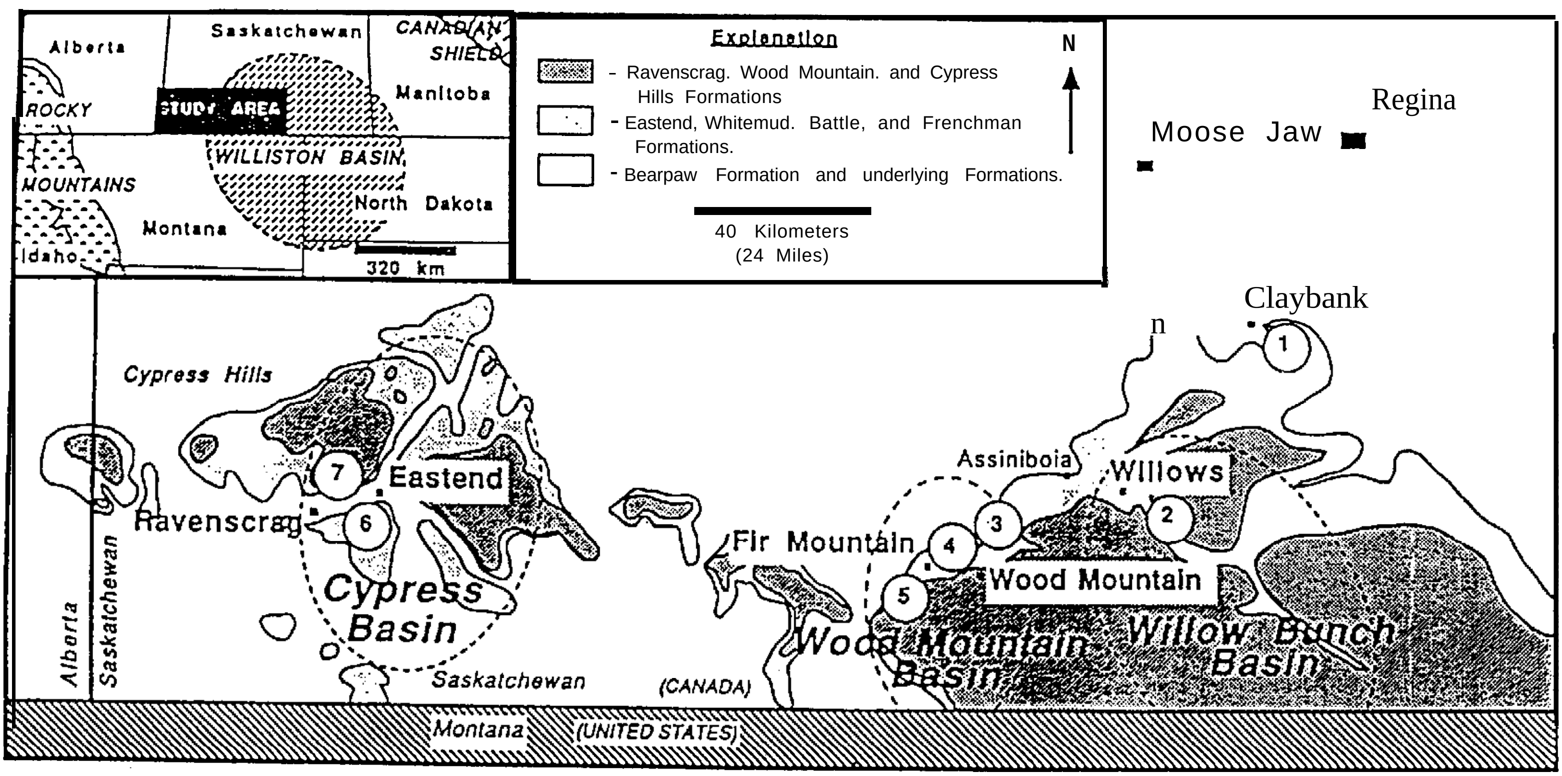


Figure 7 - Location of the Whitemud kaolin deposit in southern Saskatchewan and southeastern Alberta (Whitaker and Pearson, 1972)

Table 1 - Summary table of economic potential of western North American resources of kaolin for paper clays

Province or State	Location	Developer	Comment
British Columbia	Lang Bay	Lang Bay Resources	Great location, limited tonnage, high overburden ratio, quality limited to filler clay
Idaho	Latah County	Simplot, A.P. Green and others	Reasonable location, large tonnages spread between many deposits, quality variable
Saskatchewan and Alberta	Wood Mountain and southeastern Alberta	Ekaton	Poor location, large tonnages, complex processing requirements

In summary, it is unfortunate that none of these deposits are of sufficient quality to be classified as potential coating clays using conventional economically-proven processing technologies. Although the studies on these deposits in most cases have shown that it is technically feasible to upgrade the raw materials to current commercial specifications, the costs involved in implementing such complex processes have tended to make investment decisions too risky to justify entering a highly competitive market (i.e. local high quality carbonates versus local (or distant) low grade kaolins requiring high capital, high operating cost operations).

Note on conventional economically-proven technology: Over the past thirty years the kaolin industries in Georgia and Europe have introduced several revolutionary breakthroughs in processing technology which have enabled marginal raw materials to be upgraded significantly. It is beyond the scope of this paper to go into this in detail although several papers have been written on the subject (Murray, 1991; Harvey, 1995).

5. Potential for Asian kaolins

The current developments of kaolin processing operations in Asia frequently benefit from low mining costs and low labor costs. A summary of present delivered costs into Japan are detailed in Table 2. For example, shipments of Indonesia tiller clay in 1994 were delivered CIF to Japan for $135/mt. Providing that sufficiently low freight costs can be obtained it is conceivable that processed Asian kaolins could competitively enter the filler or coating clay markets of the Pacific Northwest.

It should be noted that over the past ten years tonnages of over 1 Mmt/y of cement and clinker have sometimes been imported into California and Washington from Japan and other Asian countries (Harvey, 1996). Such shipments have attracted very attractive freight rates because of the imbalance in bulk freight movements across the Pacific (tonnages heavily weighed in favor of movements east to west meaning potentially lower cost backhaul freight rates from west to east).

Although such movements in kaolin from Asia have yet to become a reality, the potential for such developments cannot be ignored.

Table 2 - Import statistics for kaolin in Japan

	1992			1993			1994		
	Tons	Value	Cost /mt	Tons	Value	Cost /mt	Tons	Value	Cost /mt
USA	76 1,447	186,223	245	799,181	188,947	236	841,114	202,148	240
Australia	94,275	14,536	154	115,021	17,870	155	118,010	18,669	158
Brazil	88,906	17,001	191	82,634	16,086	195	99,149	19,923	201
Indonesia	62,452	8,729	140	66,086	9,320	141	83,035	11,247	135
China	57,523	5,190	90	46,193	4,477	97	44,579	5,559	125
Korea	35,897	3,238	90	28,540	2,805	98	25,508	2,434	95
UK	21,072	5,285	251	26,024	5,795	223	31,959	7,482	234
Malaysia	16,197	2,626	162	12,834	2,000	156	16,717	2,659	159
New Zealand	11,660	5,552	476	9,440	4,866	515	9,039	5,475	606
Others	3,794	471	124	3,667	495	135	14,659	3,362	229
Total	1,153,223	248,851	216	1,189,611	252,661	212	1,283,769	278,958	217

References

Byers, P.N. (1969) Mineralogy and origin of the upper Eastend and Whitemud formations of south-central and southwestern Saskatchewan and southeastern Alberta: Can. J. Earth Sci., 6, pp. 317-334.

Harvey, C.C. and Farris, L.F. (1991) The Lang Bay Kaolin Resource, British Columbia: Proc. of the 27th Forum on the Geology of Industrial Minerals. Alberta Geological Survey Information Series, pp. 93-98.

Harvey, C.C. (1995) Kaolin Resources of the United States and their Industrial Utilization: Proc. of the 1993 UN. Workshop for Industrial Minerals Development in Asia and the Pacific, Vol. 8, pp. 252-265,

Harvey, C.C. (1996) Carbonate resources of British Columbia and potential for new markets (published in this volume).

Hosterman, J.W., Scheid, V.E., Allen, V.T. and Sohn, I.G. (1960) Investigations of some clay deposits in parts of Washington and Idaho: U.S. Geol. Survey Bull. 1091, 39.

Murray, H.H. (1991) Overview - clay mineral applications: Applied Clay Science, 5, pp. 379-395.

Ponder, H. and Keller, W.D. (1959) Geology, mineralogy and genesis of selected fireclays from Latah County, Idaho. Clays and Clay Minerals, 8, pp. 44-62.

Pruett, R.J. and Murray (1991) Clay mineralogy, alteration history and economic geology of the Whitemud Formation, Southern Saskatchewan, Canada: Clays and Clay Minerals, 39, pp. 586-596.

Pruett, R.J. and Murray, H.H. (1993) The mineralogical and geochemical controls that source rocks impose on sedimentary kaolins: in Kaolin Genesis and Utilization, Murray, H.H., Bundy,W.M., and Harvey, C.C., eds. The Clay Minerals Society, Boulder, Colorado, pp. 149-170.

Temanex Consulting Inc. (1994) Industrial minerals opportunities in pulp and Paper in British Columbia to the year 2003. British Columbia Geological Survey Branch Open File Report 1994-23, 70p.

Whitaker, S.H. and Pearson, D.E. (1972) Geological Map of Saskatchewan. Saskatchewan Dept. Min. Res. and Sask. Res. Counc. (1:1,267,000).

Challenges for the Pacific Northwest Cement Manufacturer

by

E. Cardey,
President,
I.M.P.A.C.T. Minerals Inc.

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

RAW MATERIAL CHALLENGES

TO THE

PACIFIC NORTHWEST CEMENT

MANUFACTURER

I.M.P.A.C.T. MINERALS INC.

- ***What is cement and clinker?***
- ***Industrials minerals used to produce cement***
- ***Current and historical sources of supply***
- ***Raw material challenges***
- ***Substitution opportunities***

CEMENT

- ***a finely ground mixture of:***
  - ***95% clinker***
  - ***5% gypsum***

CLINKER

- ***a mineralogical mix of calcium silicates obtained by partial fusion of raw materials containing:***
  - ***lime***
  - ***silica***
  - ***alumina***
  - ***iron***

CLINKER mineralogical composition

C_3S	50 - 60%
C_2S	73 - 23%
C_3A	5 - 8 %
C_4AF	8 - 12%

CLINKER chemical composition

CaO	66%
SiO_2	22.5%
Al_2O_3	4.5%
Fe_2O_3	3.0%
MgO	1.0%
K_2O	0.2 - 0.5%
Na_2O	0.1 - 0.4%

TYPICAL RAW MATERIALS

- ***limestone*** - CaO
- ***sand*** - SiO_2, Al_2O_3 alkalis
- ***slag*** - Fe_2O_3
- ***shale/clay*** - Al_2O_3, SiO_2, Fe_2O_3, CaO, alkalis

REGULATORY RESTRICTIONS

$Na_2O + 0.658\ K_2O < 0.60\ \%$

$MgO < 5.0\ \%$

PROCESS RESTRICTIONS

Alkalis

MgO

Sulphur

Chlorine

HISTORICAL RAW MATERIALS

LIMESTONE

Texada Island	**-**	***Vananda, Blubber Bay***
Vancouver Island	**-**	***Cobble Hill***

ALUMINA

Vancouver Island	**-**	***Cobble Hill, Nanaimo, Ladysmith***
Texada Island	**-**	***Vananda***
Fraser Valley	**-**	***Matsqui***

SILICA

Vancouver Island	**-**	***Cobble Hill***
Squamish area	**-**	***Brittania***
B. C. Interior	**-**	***Oliver***
U.S.A.	**-**	***Wenatchee***

IRON

B.C.	**-**	***Vancouver***
USA	**-**	***Tacoma***

GYPSUM

Kootneys
Falkland
Mexico
Spain

CURRENT RAW MATERIALS

LIMESTONE
- ***Texada Island***

ALUMINA
- ***Sumas***

SILICA
- ***Sumas***
- ***Washington***
- ***Fraser River***

IRON
- ***Anyox, B.C.***

GYPSUM
- ***Mexico***
- ***Falkland***

TYPICAL QUANTITIES

- ***For 1,000,000 tonnes of cement***

  require approximately

  - ***1,220,OOO tonnes - limestone***
  - ***235,000 tonnes - alumina***
  - ***60,000 tonnes - silica***
  - ***50,000 tonnes - iron***
  - ***50,000 tonnes - gypsum***

RAW MATERIAL CHALLENGES

- ***raw materials should be on tide water***
- ***long term availability of low alkali silica***
- ***long term availability of low alkali alumina***
- ***long term availability of local gypsum***
- ***alternate man-made and waste materials***

SUBSTITUTION OPPORTUNITIES

- ***low alkali alumina***
- ***low alkali silica***
- ***alternate materials***
  - ***wollastonite***
  - ***foundry sand***
  - ***sand blasting material***
  - ***gypsum from de-papered drywall***
  - ***petroleum contaminated soils***
  - ***steel belted tires***
  - ***low sulfur fuels***
  - ***diatomaceous earth - brewery waste***

B.C. Dimension Stone in 1995

by

Z. D. Hora,
Industrial Minerals Specialist,
B. C. Geological Survey

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

B.C. DIMENSION STONE IN 1995

BY Z.D. HORA

One hundred years ago, British Columbia had a flourishing dimension stone industry. Rapid urban growth in the western part of North America required permanent structures for banks, courthouses, legislative buildings, post offices and businesses. Quarried stone was the principle building material of choice; and production centres on the coast, in the Okanagan and the Kootenays provided a variety of dimension stone for both local and export markets. B.C. marble was used as far away as Winnipeg and Salt Lake City, sandstone went to San Francisco, and granite was used in Oregon, Hawaii, and Australia. With economic depression and new construction technology, stone production in B.C. gradually decreased and the last dimension stone quarries shut down during the 1950s. The recent increased worldwide popularity of stone for facing of high-rises, counters, wall and floor tile and other decorative purposes resulted in a gradual comeback for B.C.'s stone industry. Still small by world standards, British Columbia, in 1996, has three stone processing plants which not only supply the local market, but also export to foreign consumers. A major portion of the stone processed by these three plants is quarried from seven locations in the southwestern part of the province. While the historical production of B.C. stone included granite, marble and sandstone with minor volumes of slate, the present producers concentrate on a variety of types of granite, some marble, and two types of flagstone - quartzite and mica schist.

A wide range of intrusive rocks are produced under the generic name of "granite". Substantial tonnages are quarried for splitface ashlar products, as well as in blocks to be processed into slabs, tiles and cladding sheets. Fine and medium grained grey varieties of quartz monzonite, diorite and granodiorite are currently utilized for facing and masonry purposes by several companies and are marketed under names such as "Tsitika Grey", "Fox Island Grey", "Arctic White", "Glacier White", "Garibaldi Gold", Garibaldi Grey" and "Cascade Coral". These are established market varieties and the quarry sites are located on Vancouver Island; near Squamish; at the mouth of the Jervis Inlet; and near Beaverdell in the B.C. Interior. The stone is quarried by Garibaldi Granite Inc., Quadra Stone Company Ltd., Tsitika Stone Industries, and Granite Island Quarries. Four of the granite varieties - the "Glacier White", "Garibaldi Gold", "Garibaldi Grey", and "Fox Island Grey" are also used for custom work as polished slabs for counter tops in kitchens, bathrooms, etc.

Fine to coarse grained varieties of granite, mbnzonite and granodiorite are also produced in B.C., usually in approximately 15-tonne blocks, and are processed into polished tile by Margranite Industry Ltd. in Surrey, B.C. Pink varieties include two from the Skagit Valley - "Robson Rose" and "Valley Rose", and

“Cascade Coral” from Beaverdell. White granodiorite “Whistler White” comes from Elaho River near Squamish. Greenish to greenish-beige fine and medium grained “Aqua Mist”, “Alpine Summer”, “Whitewater” and “White water Classico” are quarried near Boston Bar east of the Fraser Canyon and all of the above stone is becoming very popular both in B.C. and abroad. Several other stone types are not yet commercially developed, but have very good market potential. Dark blue-grey “Majestic Blue” from Knight Inlet, and dark grey-almost black “Sable Black” from Princess Royal Island, black “Pedro Black” from Grand Forks and “Raven Black” from Harrison lake, mottled beige “Pacific Pearl” from Kelowna and pink “Pacific Rose” from McNulty Creek near Summerland are some examples.

On Vancouver Island, Matrix Marble Corp. processes two types of local marble into custom made products. Fine-grained black with white veining is called “Carmanah Black” and coarse crystalline white is marketed as “West Coast White”.

British Columbia is also a well established producer of flagstone. The Salmo area has been, for decades, a source of quartzite slabs with the Kootenay Stone Centre as the main producer. Mica schist is also a decades old product of the Revelstoke Flagstone Quarries in Revelstoke.

As a source of ornamental stone, B.C. has been the primary producer of nephrite jade and rhodonite for designers, sculptors and jewelers internationally. Jade West Resources Ltd. is marketing blocks, tiles, cut-to-size pieces and slabs to its customers worldwide in both rough and polished form.

This overview covers only the highlights of current dimension stone activity in British Columbia. There is a considerable degree of additional ongoing exploration and development activity and new discoveries are made every year

B.C.‘s vast, favourable geology, largely unexplored for dimension stone, provides unlimited scope for prospectors, producers and serious developers. With an excellent network of secondary and tertiary roads for access, one of the world’s largest and most efficient coastal barging systems, and several modern deep-sea port facilities, B.C. is well equipped to produce and deliver stone and stone products to anywhere in the world. Further, recent legislative changes have significantly streamlined the quarry land tenure acquisition process on Crown Land. Under Bill 13, dimension stone in B.C. is covered by mineral definition, which simplifies the development and start-up of quarry operations and reduces the time required to get the deposit to the production stage.

Market Development and Business Growth Strategy for Light Weight Zeolite Concrete

by

L.E.W. Hogg,
President,
Polar Powders and Technology Inc.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

MARKET DEVELOPMENT STRATEGY FOR LIGHTWEIGHT ZEOLITE CONCRETE

PREPARED FOR

FOCUS ON BRITISH COLUMBIA INDUSTRIAL MINERALS
VANCOUVER, BRITISH COLUMBIA

OCTOBER 19, 1995

By

LuVerne E.W. Hogg

TABLE OF CONTENTS

INTRODUCTION

Polar Powders & Technologies Inc. (PPT) acknowledges a financial contribution by the Canada-Alberta Partnership on Minerals through the Alberta Department of Energy and the National Research Council (NRC). The research and development work was conducted by the Institute for Research and Construction (IRC) of the NRC.

Lightweight zeolite concrete (LZC) is a new product developed by technologies resulting from research and development. There is an increased demand by society, for new materials to replace traditional building materials. These demands are a result of society's changing values and recognition that our natural resources are finite. The development of lightweight zeolite concrete is a response to this growing demand for new materials and sustainable exploitation of our natural resources.

The research and development program resulted in a new technology, for which a U.S. patent was granted in October 1995. I will not deal with details of the processes or methodologies except to state that the LZC formulations are, for the most part, 80% natural zeolite,' which are subsequently cured in a conventional manner. The resulting material has the following desirable characteristics.

1. The material can be cast and is dimensionally accurate as well as machineable, which facilitates reduced construction time and costs.
2. The material can be made with compressive strengths in a range of 5-30 MPa, which meets a broad spectrum of needs in the construction industry.
3. The dry density can be made in the range of 500-1500 kg/m^3 (lightweight).
4. Excellent thermal properties and acoustical properties.
5. Fire resistant, impervious to rot and insects.
6. Flexibility, which allows for production of various size blocks, panels and reinforced members for walls, floors and roofs.
7. Good to excellent engineering properties of density,. pore structure, permeability, efflorescence, specific heat, thermal conductivity and elastic modulus.
8. Good to exceptional durabilities which are sulphate resistant, acid resistant, carbonation resistant and frost resistant.

THE OPPORTUNITY

Changing Traditions

The building industry is changing. Today's generation of builders is increasingly more sophisticated and relies heavily on cost benefit analysis of completed construction systems. These builders are more likely to change to new materials and techniques if they provide greater in place value over traditional systems.

Wood products are the traditional dimensional material for building purposes. Wood products use, as a depleting natural resource, has resulted in dramatically increased costs; a trend which is unlikely to change.

The consistent increases in energy costs, have created a requirement for energy conservation in new construction.

The above factors have created an opportunity for LZC to become an effective alternative to traditional systems by focusing on the production of high quality, value added materials for market niches.

THE CHALLENGE

Successful introduction of LZC will have to overcome the inhibiting factors of:

1. A facility for the production of LZC in commercial quantities.
2. Acquiring the necessary construction and inspection code approvals.
3. The consumer must be educated on the advantages of LZC systems and request its use. The consumer of today is more demanding, more sophisticated and smarter than ever about their options. They want better value and they have the muscle to insist on it.
4. Whereas building tradition is changing, the industry is highly fragmented with decision makers from architects, builders, developers, contractors, construction managers, unions and suppliers, all of whom must be educated to the opportunities of utilizing LZC.
5. LZC must meet the consumers' demands by satisfying the underlying requirement for a cost effective system.

THE STRATEGY

The strategy is to establish initial market share by concentrating on niche market products. This introduction stage commits all the key functions of research, development, engineering and production to the establishment of early adopters of LZC in the niche markets.

LZC is a differential product. A differential product is a product which can replace other products in the marketplace. In this instance LZC can replace both concrete and wood products. The potential customers must be shown a sufficient differential advantage to motivate the shift to LZC.

The strategy for LZC introduction, utilizing the differential advantage, will be adjusted into a developing strategy for the growth stage of LZC, beyond the niche markets. The strategy will continue to adjust and change as LZC reaches a maturity stage. it is important to recognize that the strategy must be flexible, adapting to the acceptance time for a differential product.

LZC is a high technology product. One of the key strategic implications is to be first in the marketplace and to be fast. Efficiency and economic production are important.

THE TACTICS

The tactic for the development of LZC is to overcome the challenges to fulfil the strategy.

PPT's tactic to overcome the challenge of initial production of commercial product is to have LZC produced under-license by a pre-cast concrete manufacturer with the required curing equipment. This method will allow PPT to achieve initial commercial production without the initial high capital cost of constructing a plant.

PPT will be able to begin acquiring the necessary construction and inspection code approvals for LZC. Priorities will be established for codes and approvals in the niche markets subsequently leading to additional approvals. Emphasis will be placed on utilization of LZC outside of urban areas to take advantage of faster approvals in the rural and remote industrial and agricultural sites.

The consumer, in the identified niche markets, can be provided with demonstration products from licensed production. All of the engineering properties and durabilities will be elucidated for the potential consumers, as well as the key function of costing. Architects, builders, developers, contractors and suppliers will be introduced to LZC and provided with details on utilization and construction techniques.

It is necessary to note the critical importance of marketing at this stage in the development of LZC. Up to the point of commercial production of LZC from a licensee, all of the financial resources have been allocated to. the research and engineering development of LZC. A preponderance of resources must be devoted to the marketing of the product in order to survive the introductory stage, otherwise, the product will fail. Sufficient resources for new product introduction is a must and planning must allocate sufficient financial resources for this.

The introduction of LZC systems is predicated on meeting consumer demands for a cost effective system. Initial production of LZC is planned at pre-cast concrete plants under license. In order to maintain low cost production, variables such as raw material costs for zeolite can be moderated by the location of the ore-cast plant and supply contracts for zeolite. Any zeolite raw material can be adapted with the technology to produce LZC.

A large scale plant dedicated to the production of LZC systems will cost several million dollars. The risk to the capital is too great to consider until market acceptance of the LZC has been demonstrated.

THE MARKETING

LZC is a differential product. Aggressive marketing of LZC products is acute to the success of the product and project. Significant missionary work introducing LZC to the consumer is going to be necessary. The LZC marketing plan allocates significant resources in money and personnel to achieve the goal of sustainable production.

The initial focus of the marketing effort will be to the niche markets with general market introductions of LZC made to potential customers. This initial introduction will be used to involve the potential customers in the development of LZC. The potential customers can provide valuable linkages in the development strategies. The object is to not only respond to the potential customers' expressed needs but to anticipate and supply their future needs.

LZC as a differential product requires elucidation of its advantages from a technical and engineering basis. Technical data sheets, physical demonstrations and price lists will be provided to potential consumers, as they form the cornerstones of the decision to purchase. No sales efforts can proceed until the two key questions can be answered and they are "How much will it cost?" and "When can you deliver?".

Product awareness is the result of an effective marketing program. The methods of creating awareness must produce an image for the consumer that the product is an alternative that they need. Acquiring the answer to that need provides satisfaction to the consumer: For example, if they live beside an airport and don't like noise, LZC acoustical panels will mitigate the noise.

The engineering properties and durabilities of LZC will be presented to the consumers as solutions to their needs for lightweight, strength, high R factors, sound attenuation, fire proof, dimensionally accurate, machineable building materials. A campaign of product awareness will utilize the format of trade shows and conferences. Technical papers will be published in trade journals.

The above methods are a normal approach to industrial marketing. Marketing of LZC must go beyond the conventional approach and create markets. The product has a very broad scope of uses which can be utilized in a myriad of new and replacement applications. In order to promote the LZC into these areas it is necessary to involve active participation by individuals in developing applications for LZC.

A more esoteric product awareness program is aimed at artists. LZC is machineable, it can be cut with a saw, drilled, etc. The plan is to sponsor a sculptors' competition with cash prizes for the winners. The competition will be adjudicated by the art colleges. Along the same lines, we plan to hold a design competition with cash awards for designers and architects for innovative and creative uses of LZC.

I have deliberately used the word “cash prizes” to emphasize the critical point that new or alternative product introduction requires a substantial investment in time and money in order to succeed.

The mass marketing media techniques of newspapers, television and radio will not be employed, except for special features i.e. who won the cash and why. The marketing plan for LZC targets specific consumers with specific messages and tailored products and promotion.

In the final analysis, regardless of any course of action, whether that be the adaption of the science and technology, public opinion or market research and development, only results matter.

Economics of Various Industrial Minerals in B.C. for the Pulp and Paper Industry

by

B.A. Slim,

President,

MineStart Managment Inc.

presented at

Focus on British Columbia

Industrial Minerals

October 19, 1995

Vancouver, Canada

ECONOMICS OF VARIOUS INDUSTRIAL MINERALS IN B.C. FOR THE PULP AND PAPER INDUSTRY

Bryan A. Slim

MineStart Management Inc, 1763 Scott Road, North Vancouver, B.C. V7J 3J4
Telephone: +1604 986-7014, Fax: +1604 986-7017

1 INTRODUCTION

All white industrial minerals have the potential to be used either as a filler or coater in the pulp and paper industry. Their potential lies in meeting the *Economic Foundation* - Figure 3 - which requires that the mineral or supply characteristics must be in balance with the demand requirements.

The accompanying figures were developed for slide presentation and are half tone prints from the slides

2 MARKET STATUS AND MILL NEEDS

Of initial importance is determining if the market is supply or demand driven. - Figure 4 From the producers view-point the supply is looking for the market to sell into for a profit whereas the paper mill is looking for a demand which will be of economic benefit to the mill. We believe that there is a regional demand looking for an economic supply of minerals filler and coater.

The terminology of marketing and sales must be understood. *Selling* is supplying what you have and for which there is a ready buyer. However, *marketing* is determining what the buyer needs and ensuring that the production matches this demand - as per Figure 5. This implies, correctly, that the onus is on the potential supplier to investigate the market. For many of the white industrial minerals the emphasis will have to be on the marketing when the mineral company is wishing to sell a mineral which is new to the paper mill.

There are an estimated 119 pulp and paper mills in the west coast region comprising Alaska, British Columbia, Alberta, Washington, Oregon and California - Figure 6. The product outputs range from newsprint to some printing and writing grades, to liner board, building papers and market pulp. However, the paper mills are constrained by a similar range of problems as shown in Figure 7. The emphasis should be seen as on the lack of a regional supplier of a good filler and coater.

The high freight charges for the traditional kaolin supply from the south-east USA eliminates the economic benefits stressed in Figure 4. This restricts the region to the lower selling priced unfilled or uncoated newsprint, limited directory grades or market pulp - Figure 7.

3 Role of Industrial Minerals in Paper Mills

Typically unfilled or uncoated paper has a rough surface and low opaqueness. To improve this paper for printing and writing demands white industrial minerals are needed to either fill or coat the surface - Figure 8. The mineral can also substitute for some of the pulp which offers a further saving for paper manufacture. Figure 9 presents the alternatives for mitigating the Westcoast mill needs named in Figure 7.

In Figure 10 we describe some of the typical loadings - percentage of mineral used - in various paper grades.

4 Which Industrial Minerals

Clearly with the fundamental requirements established, including the application for the paper, it is then possible to describe which minerals are suitable. Figure I I presents a summary of the more common minerals and some of their typical specifications.

Selection of a minerals is dependent on the mill operating system, ultimate market for the paper and the delivered selling price. This can be summarized as "...capable of delivering an economic benefit".

5 Mine Feasibility

We turn now to the economics of the mine-site. In Figure 12 we give a nominal flowchart setting out the critical stages of investigations for economic feasibility. Specific to this paper is the need to understand the beneficiation testing which allows for the initial description of possible market type products by providing characterization - a reflection back to the *economic foundation* presented in Figure 3. By matching the mineral characteristics to the preliminary market opportunity analysis the preferred products can be established and this in turn allows for estimating the possible demand tonnages and revenues and costs. Where and when profits are indicated then possible reserves can be estimated for the various products.

This stage is followed by a trial market entry which, when it leads to a sales contract, allows the reserves to be classified as *proven and probable.*

6 Some Competitive Forces

Competitive forces are an inevitable part of the marketing and selling. In Figure 13 we present some of the more typical forces of three categories.

The *entry barriers* are totally controllable by the mining company and rest on the previous section of this paper. *Other industry substitutes* require an adequate understanding of other mineral fillers, and their economic benefits, which could be offered to the mills.

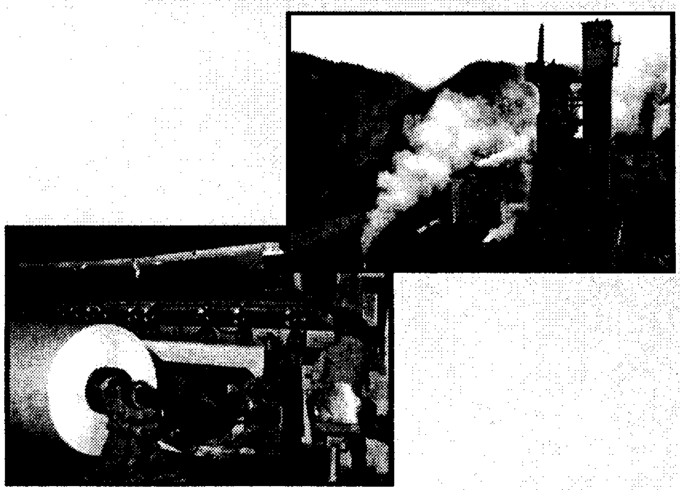
Buyer power leverage is the seller losing control, in this case to the paper or pulp mill. This which must not be allowed to happen and the components listed here identify some areas in which the seller can lose control.

7 Conclusions and Initial Demand Estimate

The initial demand shown here for 100 000 to 200 000 t/a is for the existing 1995 potential. If a mining company can demonstrate that it can *deliver the second load* then it is possible to contemplate the market demand could increase to 700 000 to 800 000 t/a as some paper mills could switch to printing and writing production lines.

> The ... *second load* apart from the economics is the overall key. In summary it means that there has been sufficient property investigations coupled with beneficiation trials that all shipments will be consistent with the first load and meet the buyers requirements.

Economics of various industrial minerals in B.C. for the pulp and paper industry



Bryan A. Slim

MineStart Management Inc
North Vancouver

Highlights

- economic foundation
- market status & mill needs
- role of industrial minerals in paper mills
- which industrial minerals
- mine feasibility
- competitive forces
- conclusions and the demand estimate

Economic Foundation

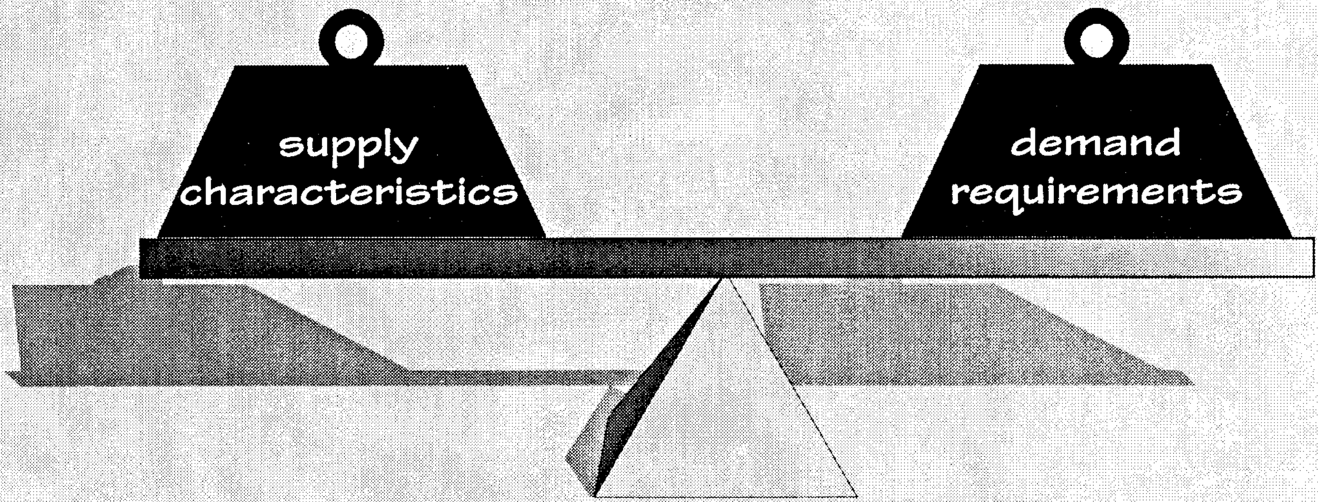


Figure 3

Industrial Minerals and Bill 13

by

D. Lieutard, Director,
R. Conte, Assistant Director,
Mineral Titles,
B. C. Ministry of Energy, Mines
and Petroleum Resources

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

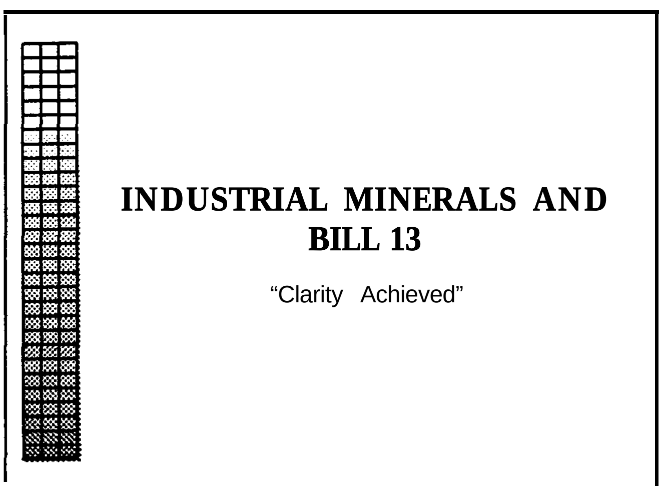
Speaker: Denis Lieutard, **Director of Mineral Titles Branch and Chief Gold Commissioner**

Denis was appointed Director in 1990, prior to that he was Deputy Director of the Branch for 7 years. During the 9 years previous to this, Denis, was a Mineral Titles Inspector working in Northern B.C. for 9 years. He holds a Bachelor of Science Degree in Geography and a Diploma in Public Administration from the University of Victoria.

INDUSTRIAL MINERALS AND BILL 13
"Clarity Achieved "

Slide Left and Right

INDUSTRIAL MINERALS AND BILL 13 'CLARITY ACHIEVED'



Thank You. I am very pleased to have the opportunity to present this short paper on industrial Minerals and Bill 13.

Bill 13 - is the Mineral Tenure Amendment Act which was passed by Legislature this summer.

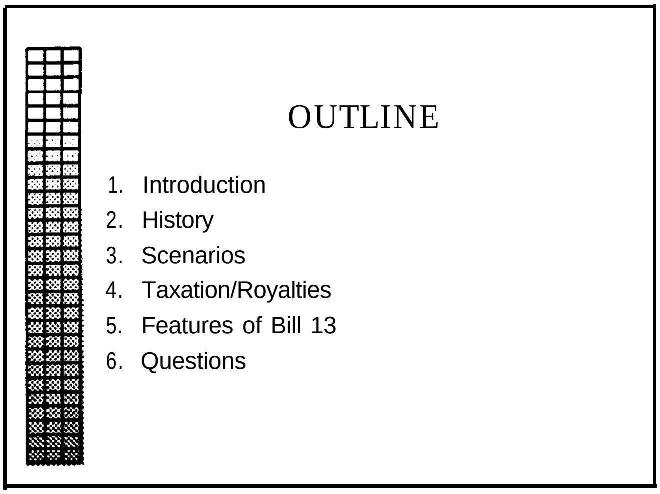
The implementation date for the Act is not set, but it will likely be in the coming months.

I've subtitled the paper, "Clarity Achieved" because I believe clarity as to the ownership of industrial minerals has been finally achieved after 30 years of trying.

History may ultimately prove us right or wrong, but for now, let's see if you agree with me at the end of this talk!

Slide Left

Outline



Here is the Outline of my presentation:

1. Introduction

2. History

A review of history often helps us understand a problem more clearly

3. Scenarios

These Scenarios will help you to know what to expect when Bill 13 is proclaimed

4. Taxation/Royalties

This will be a quick indication of what tax or royalty scheme you will be subject to.

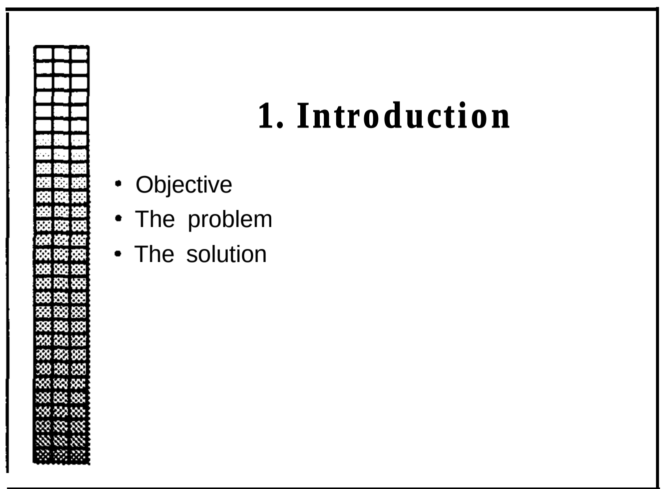
5. Features of Bill 13

We will look at some of the feature of Bill 13 designed to help in industrial minerals sector.

6. Questions

I will try and leave some time for questions.

Slide Right



1. Introduction

- ***Objective***

The objective of my presentation is to provide you with sufficient information to help you determine:

1. how to assess your industrial mineral tenure situation or

2. how to best acquire clear title to industrial mineral

- ***The problem***

There must be a clear definition of the rights granted in order for Government to issue clear title to a land lot or clear title to a sub-surface mineral claim, The definition of mineral and the corresponding definition of Land must be very clear, concise and stable in the Statutes.

The definition must not be subject to various interpretations and thus come into question after tenure is granted. It must not change when circumstances, such as end use or the production volumes change.

In reality the definition of mineral has changed several times in the past 100 years.

These changes related mainly to the inclusion or exclusion of construction materials and industrial minerals.

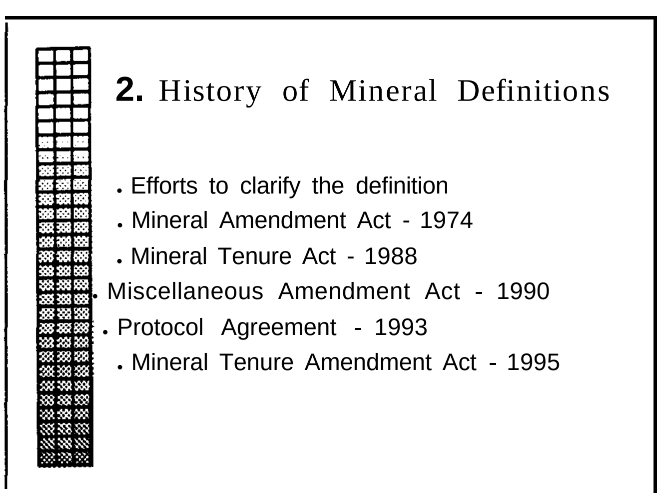
Some definitions relied upon the end use of the rock to determine if the rock was a mineral or a land tenure.

This condition has caused considerable uncertainty for the past 30 years.

. The solution

The solution of course lies in providing a clear definition, which allows perspective tenure holders to explore and develop industrial minerals. The challenge is making the appropriate changes to the legislation and implementing the changes successfully

Slide Right



2. History of Mineral Definitions

I'd like to spend a few minutes demonstrating the changes in the definition of mineral over time. As I mentioned earlier, a great deal can be learned from examining the history of change. (something about not repeating mistakes!)

- ***Efforts to clarify the definition***

In the past 10 years there have been several attempts to improve the definition of mineral

- ***Mineral Amendment Act - 1974***

A number industrial minerals were transferred to the Mineral Act but the system was never implemented and thus repealed in 1977

- ***Mineral Tenure Act - 1988***

The Mineral Tenure Act you will recall consolidated the Mining Placer Act and Mineral Act and simplified, streamlined and deregulated a number of things.

Unfortunately the new definition of mineral was not as clear as it could have been.

- ***Miscellaneous Amendment Act - 1990***

Here we attempted to correct the 1988 wording of the definition of mineral, but we could not reach a consensus with BCLands on how to implement this section. It was never implemented

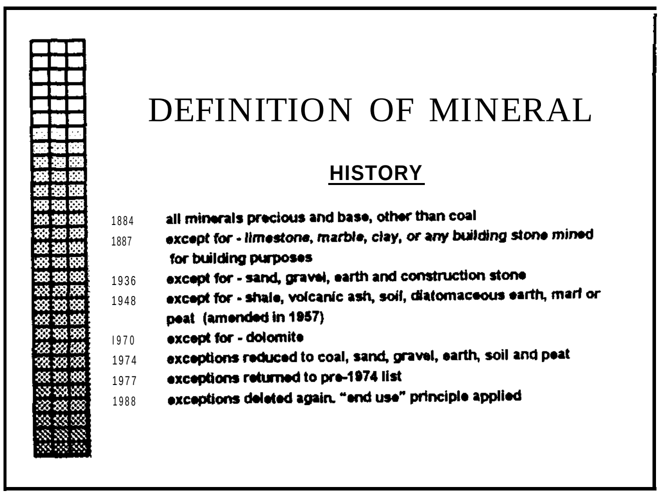
- ***Protocol Agreement - 1993***

As an interim step, an agreement was forged between Ministry of Energy, Mines and Petroleum Resources and BC Lands. This agreement set out the rules for dual tenure and guided both administrations in the issuance of tenures.

. *Mineral Tenure Amendment Act - 1995*

This Act will simply ensure that dimension stone products are included in the definition of mineral and that rock used for construction purposes is clearly excluded. More on this later.

<u>**Slide Right**</u>



<u>**DEFINITION OF MINERAL - HISTORY**</u>

Here is a summary of the definition of mineral in the Mineral Act over the past 111 years.

***1884* - all minerals precious and base, other than coal**

Very simple and straight forward, worked fine in the 1880's

1897 - except for - limestone, marble, clay or any building stone mined for building purposes

This is where material typically used for construction purposes was excluded from the definition and administered by BCLANDS

1936 - except for - sand, gravel, earth and construction stone

Here again, more construction and land tenure type materials are excluded.

1948 - except for - shale, volcanic ash, soil. diatomaceous earth, marl or peat (amended in 1957)

The 1948 Mineral Act was a long standing, but it too underwent changes in 1957 that removed certain material. This meant that shale could not be staked, even if it contained minerals.

1970 - except for - dolomite

Here is a last minute exclusion.

The trend reversed in the mid 1970s and industrial mineral products were returned to the definition of mineral

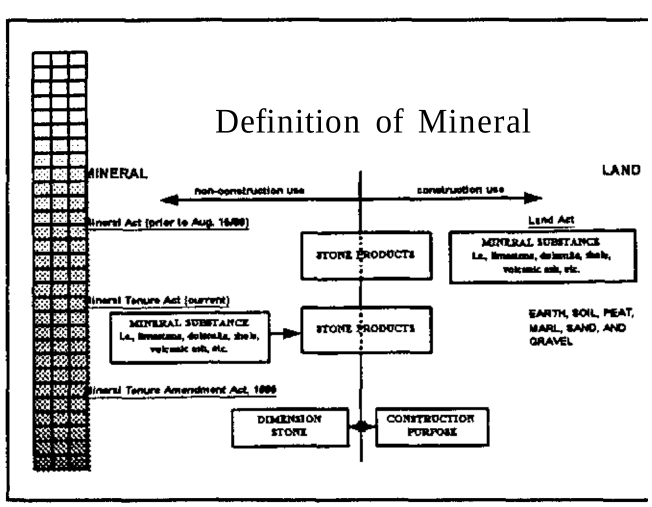
1974 - exceptions reduced to coal, sand, gravel, soil, and peat

This meant that limestone, shale, marble, dolomite and other materials were returned to the definition. Unfortunately this amendments was never activated and repealed in 1977.

1988 - exceptions deleted again "end use of stone products" principle applied

The next slide will give you a better appreciation of what happened in 1988.

<u>Slide Right</u>



Definition of Mineral

This slide is not as complex as it looks.

The world is divided into the Land Act and Mineral Act

Prior to 1988 the definition of mineral did not include what we collectively call MINERAL SUBSTANCES. That is limestone, shale, dolomite, marble, diatomaceous earth, volcanic rock etc.

The **stone products** box signifies:

- when you are on the land side - material used for construction purposes;

  such as roads, dams, berms levies, construction stone, tiles etc.

- when you are on the mineral side - material used for industrial purposes;

  such as ceramics, glass making, abrasives, refractory minerals, cement etc.

In 1988 the MINERAL SUBSTANCES were transferred to the definition of mineral. Notice that Stone products box did not change.

In reality we complicated the matter, in 1988 because before, limestone, shale, dolomite were clearly excluded from the definition of mineral. Now they became part of the stone products puzzle.

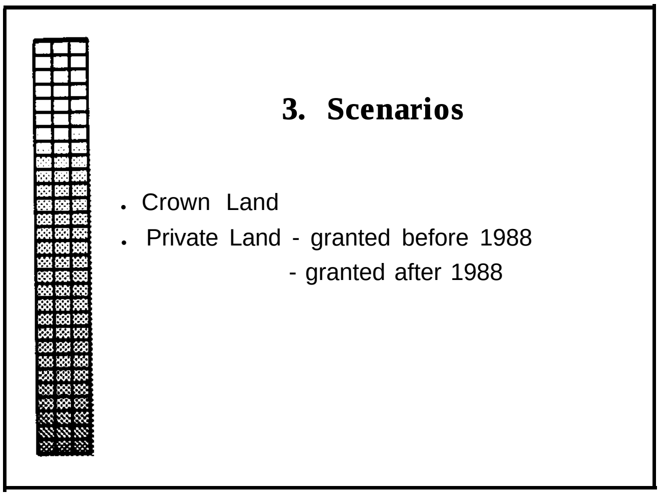
On the bottom of the slide is the Mineral Tenure Amendment Act - Bill 13

You will see that the Stone Product box has now been split into two distinct portions:

Dimension stone
Construction Purpose

More details on this definition later

Slide Right



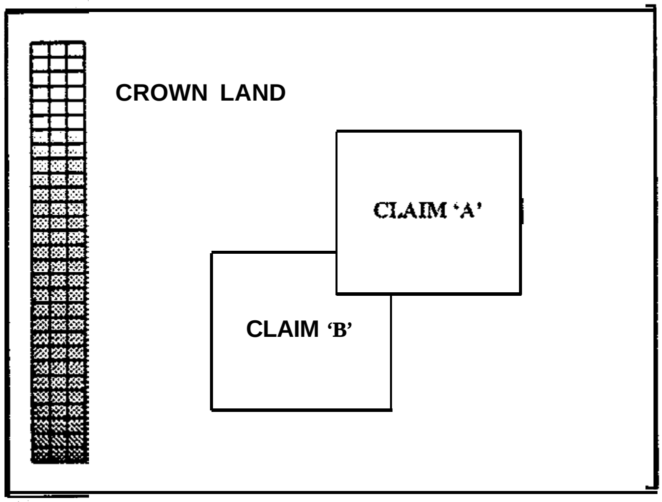
3. *Scenarios*

The following two slides illustrates the three basic scenarios you should expect when Bill 13 is brought into force related to.

- ***Crown Land***
- ***Private Land - granted before 1988***
- ***Private land - granted after 1988***

First the Crown land

Slide Right

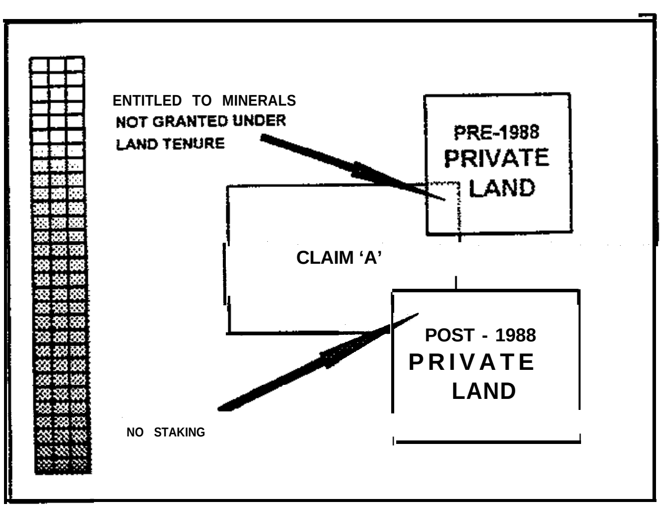


Crown Land

Mineral rights will continue to be determined by priority of claim location. Each claim will receive the benefit of the new definition for all areas of the claim not covered by private land or by a prior located mineral claim

Now the Claim staked over Private Land granted before 1988

Slide Right



Private Land - pre 1988

A Private Land owner may confirm mineral rights granted. by examining the granting indenture.

A land owners may also asked the court to rule on whether a substance such as limestone is held by the Land owner

The claim holder is entitled to all minerals as defined prior to 1988.

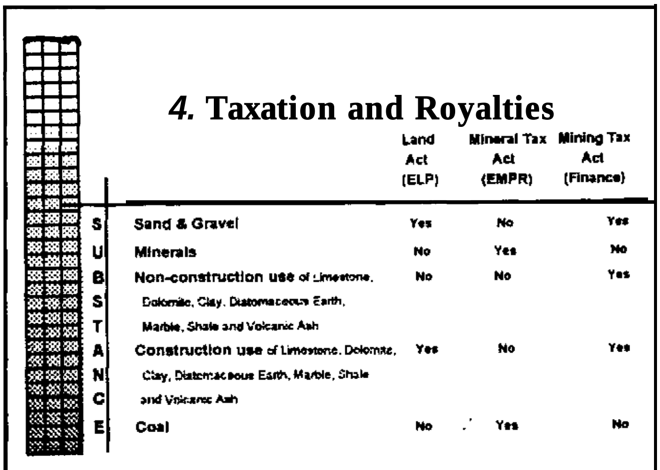
That means that limestone, dolomite, shale, marble etc. is likely to be excluded for the mineral rights acquired.

- ***Private Land - post 1988***

Few Private land lots have been issued since 1988.
Because of potential problems of mineral ownership, all lots issued after 1988 are not available for staking.

You can only stake on Land granted after 1988 when
the Minister of Mines,
the Minister responsible for Crown Lands and
the Land owner agree and
the appropriate Regulation has been passed.

<u>Slide Right</u>



4. Taxation and Royalties

SUBSTANCE	Land Act (ELP)	Mineral Tax Act (EMPR)	Mining Tax Act (Finance)
Sand & Gravel	Yes	No	Yes
Minerals	No	Yes	No
Non-construction use of Limestone, Dolomite, Clay, Diatomaceous Earth, Marble, Shale and Volcanic Ash	No	No	Yes
Construction use of Limestone, Dolomite, Clay, Diatomaceous Earth, Marble, Shale and Volcanic Ash	Yes	No	Yes
Coal	No	Yes	No

4. Taxation and Royalties

The right side indicates the various substances:

Sand & gravel

Minerals

Non - Construction Use **of limestone, dolomite, clay, diatomaceous earth, marble, shale and volcanic ash**

Construction Use **of limestone, dolomite, clay, diatomaceous earth, marble, shale and volcanic ash**

Coal

The construction material such as sand and gravel are subject to Land Act royalties

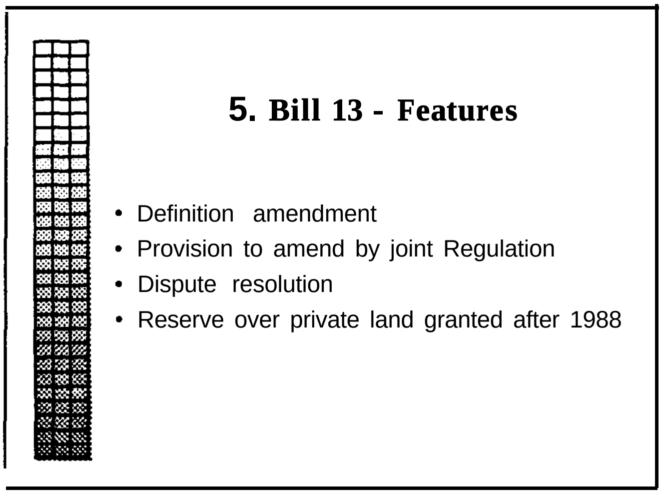
Minerals are covered by the Mineral Tax Act, Administered by the Ministry of Energy Mines and Petroleum Resources - which is an after period cost tax on profit

Non Construction - is taxed under the Mining Tax Act administered by the Ministry of Finance and Corporate Affairs - here to this is an after period cost profit based tax.

Construction Use - As you can see there are two potential tax acts to apply. There is agreement between the Land Act and Mining Tax Act that no duplicate taxes will be taken. The Land Act is a royalty and rent, whereas the Mining Tax is an after profit tax.

Coal is covered under Mining Tax administered by EMPR.

Slide Right



5. *Bill 13 - Features*

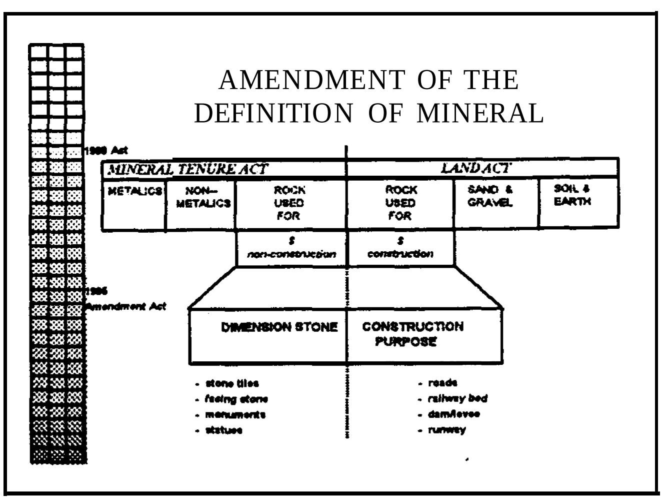
Here are a few of the features of Bill 13 which may affect industrial minerals

- Definition amendment

As indicated earlier, the moment Bill 13 comes into force, all existing claims and leases and all future claims and lease will enjoy the clarification of the definition of mineral.

The next slide illustrates this change.

Slide Right



AMENDMENT OF THE DEFINITION OF MINERAL

Here too the world is split between the Land Act and the Mineral Tenure Act.

Included in the Mineral Tenure Act side prior to Bill 13 are:

- metallic - gold, silver copper etc.
- non metallic - barite, fluorite, gypsum, jade etc.
- Rock used for non-construction - feldspar, phosphate, silica etc.

Included on the Land Act side are:

- Soils and earth
- Sand and Gravel
- Rock used for construction purposes - tiles, dimension stone, facings, fireplace stone

The 1995 Amendment Act - Bill 13 splits the rock used for non construction and construction and defines them as:

Dimension Stone:

means a rock or stone product that is cut or split on 2 or more sides, and includes, without limitation, tiles, facing stone, crushed rock, that is reconstituted into building stone, headstones, monuments, statues, ornamental furnishings and other similar components, but does not include crushed rock, cut or split rock that is used for construction purposes.

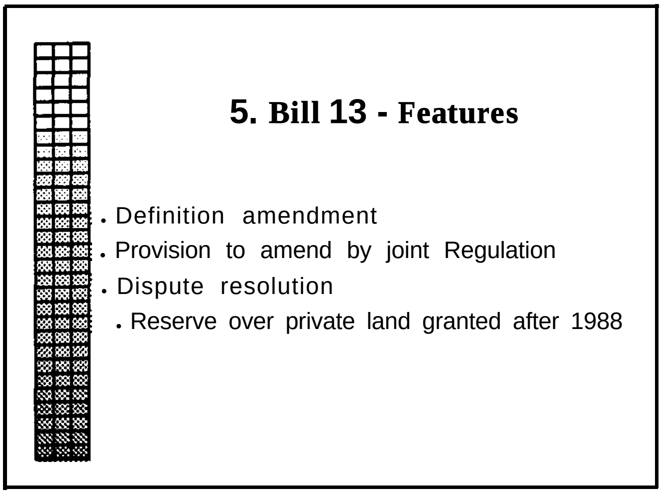
Construction Purpose:

includes without limitation:

(a) the building or maintenance of a road, railway bed, runway, berm, dam, impoundment, breakwater, dike, levee, foundation, rock wall and other similar thing and

(b) the providing of fill and riprap.

Slide Right



5 Bill 13 - Features

Here are few more features I'd like to describe

. ***Provision to amend by joint regulations***

The definition of mineral has a provision that allows the Minister of Mines and the Minister Responsible for Crown Lands to issue a joint regulations which clarifies the definition of mineral

This provision got a rough ride in the legislature, because of the mistaken belief that this power could be used to take existing mineral rights away without compensation.

. Dispute resolution

Bill 13 amends section 10 of the Mineral Tenure Act, which allows disputing parties to resolve conflicts between land tenure and mineral tenure.

The decision reached by the CGC may be appealed to the Supreme court.

- ***Reserve* over *private land granted after 1988***

I mentioned before that this provision was necessary to protect land owner rights issued between 1988 and 1995.

This provision was insisted upon by BC Lands as a protection of the surface rights owner.

The impact is small and there is a provision in the Act to lift the reserve where the three provisions are met.

IN REVIEW:

1. THE NEW DEFINITION OF MINERAL WILL BE IMPLEMENTED SHORTLY

2. THE CHANGE WILL ALLOW ALL MINERAL CLAIM HOLDERS TO ACQUIRE THE RIGHTS TO DIMENSION STONE.

3. TAXATION REMAINS ESSENTIALLY UNCHANGED, EXCEPT THE RELIEF FROM NOT HAVING TO HOLD DUAL TENURES

4. THE ACT HAS A NUMBER BUILT IN CORRECTION FEATURES AND DISPUTE RESOLUTION PROVISIONS HAVE BEEN ENHANCED.

SLIDE RIGHT AND LEFT

QUESTIONS?

6. Questions

Clayburn Industries Ltd.

by

D. Harris,
President,
Clayburn Industries Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

Abstract

Clayburn Industries Ltd.

Clayburn Industries Ltd. of Abbotsford, B.C. has continuously mined clays and shales on Sumas Mountain since 1905. This source of materials found just to the east of Abbotsford has been used to produce brick, both for the cladding of buildings and for high temperature applications since the inception of the company. Today, the company is focused upon the production of refractory materials, both brick and monolithics. The locally available clays and shales are the predominate source of materials for such production.

A description of the shales, clays and host formation will be given along with slides showing the deposit and its workings. A brief description of the markets that are served and why these materials are applicable to the various applications will be given.

Resources, Applications and Market Trends of Calcium Carbonates in the Northern Pacific Rim

by

C. C Harvey,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Carbonate Resources of British Columbia and Potential for New Markets

Colin C. Harvey
Department of Geological Sciences, Indiana University, Bloomington, IN 47405

Abstract

British Columbia is endowed with very large carbonate resources which are utilized in a wide range of applications. This study reviews the tonnages and market applications for their utilization on the west coast of North America and presents an overview of production and markets in selected Pacific Rim countries.

A potential export market is considered to exist in Japan, South Korea and Taiwan for high brightness calcium carbonate suitable for making ground calcium carbonate (GCC). This product is used as a tiller, coating pigment and extender. In these countries the supply shortage has been caused by the inability of Japanese producers to selectively mine sufficient high quality material to supply these markets. The market requires high brightness/high whiteness calcium carbonate chips which can be bulk shipped for final processing close to the end user. The delivered price to Japan of these marble or limestone chips is reported to be US$50 to $60/mt.

A growth market for GCC also exists on the west coast of North America. The largely coastal markets are currently supplied from large established resources in British Columbia, Washington State and south-central California. Additional resources have been defined on the Ketchikan Peninsula in southwest Alaska, which are of uncertain commercial value because of their isolation and the limited size of the Alaskan market.

1. Introduction

This study reviews the carbonate resources in British Columbia which are exported to Washington Oregon and Alaska. Data also is presented on California, Mexico and current export and delivered prices for the various grades and specifications of limestone in the Pacific Rim. The depth of coverage in specific countries has been governed by the consideration of whether or not a British Columbia product might realistically compete to fill current demand or shortages in any particular application or country. The study area has included the western United States, Mexico and western Canada, and briefly reviews current activities in Asia and Japan. The study also includes a review of freight rates and commodity prices.

Note: Throughout this paper all values are in US% and all tonnages are metric tons.

2. British Columbia

2.1. Resources

The location of British Columbia's resources is shown in Figure 1. Although limestones are scattered throughout the southern half of British Columbia, the dominant resources are focussed on Texada Island in the southwest comer.

2.2. Demand, supply and uses

British Columbia's production of limestone and dolomite from 1986 to 1991 is detailed in Table 1. This table also includes export tonnages to western U.S. markets. Production figures for 1992 are not yet available but they are reported to be very close to 1991 production (Pilon and Associates, 1993).

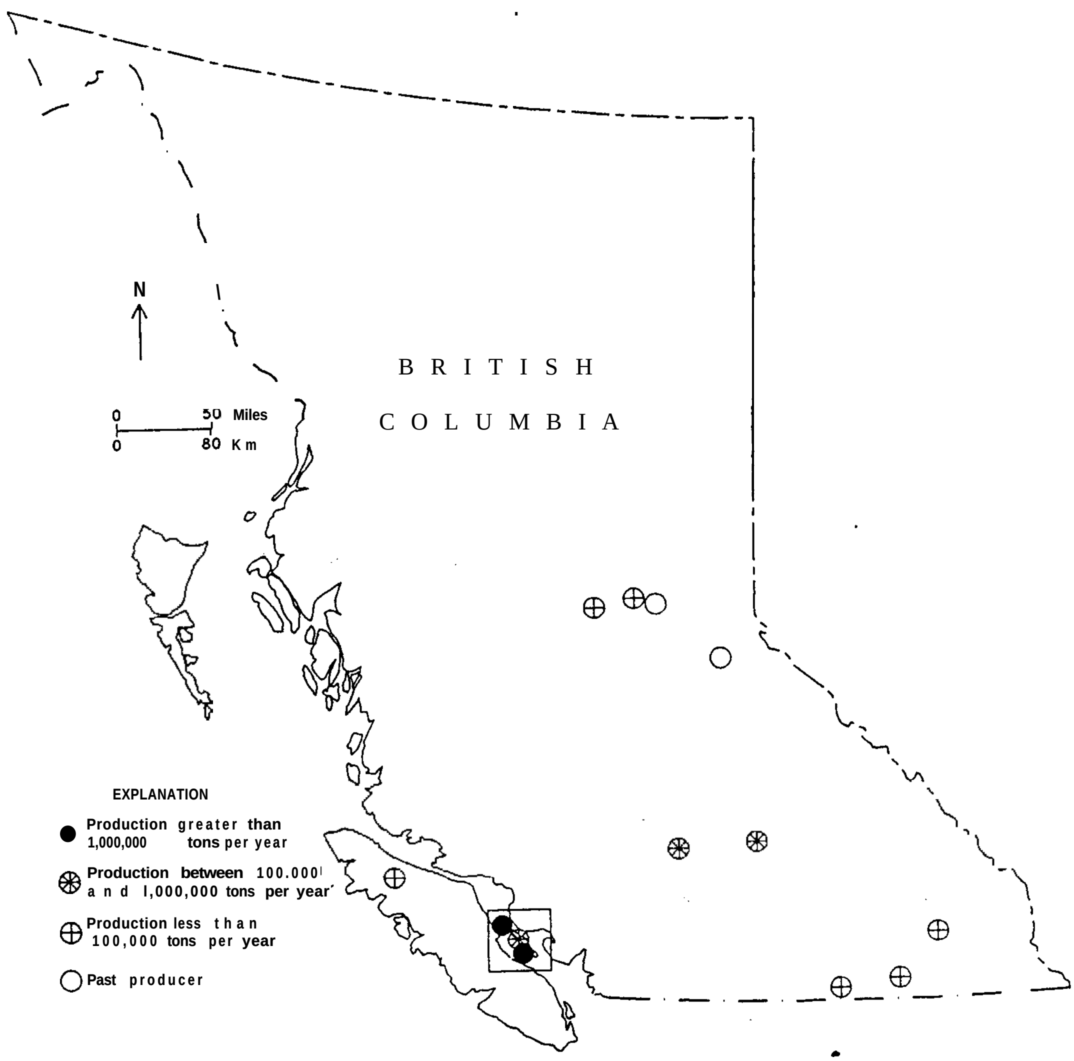


Figure 1 - Locality map of British Columbia limestone producers (Bleek, Sherar and Gulick, 1993)

Table 1 - Limestone and dolomite consumption in British Columbia (1986-1991)

(Thousands of metric tons)

Use	1988	1989	1990	**1991**
Cement Manufacture				
Domestic	1,510.0	1,615.0	1,623.0	NA
Export	575.0	805.0	867.0	NA
Lime Manufacture				
Domestic	157.0	162.0	167.0	NA
Export	339.0	236.0	236.0	NA
Pulp and Paper	102.0	87.0	92.0	NA
Agriculture	8.3	8.1	14.4	NA
Fillers (Whiting]	38.5	54.3	53.5	NA
Stucco Dash	24.1	9.7	10.7	NA
Crushed Rock	300.0	368.0	438.0	NA
Other Uses	140.0	490.0	332.0	NA
Domestic	NA	NA	NA	NA
Export	NA	NA	NA	NA
Total	3,193.9	3,835.l	3,833.6	3,781.0

Source: Canadian Government statistics
NA = Domestic/foreign breakdown not available due to a change in policy regarding industry confidentiality; combined tonnage listed with "Other Uses."

Between 1986 and 1989 the total production of limestone in British Columbia showed an increase of almost 25%. From 1989 until 1990 there was no growth, while in 1991 there was a drop in tonnage of approximately 2%. The major cause of this decrease in production has been the downturn in the economy of western Canada. Throughout the period 1986 to 1991 exports to Washington and Oregon have shown a significant growth (see below).

2.3. GCC

IMASCO (International Marble & Stone Co.) has operating quarries on Vancouver Island and at Sirdar, B.C. White limestones are produced for filler. Total production is close to 50,000 mt/y.

2.4. PCC

As far is known there, are no PCC plants currently operational in British Columbia although at least three are operating in Washington.

2.5. Potential for backhaul shipments to Asian markets

The shipment of bulk commodities in the Pacific Rim is traditionally a one-way traffic from the west coasts of Mexico, the U.S. and Canada to the nations in the Orient. The traffic in the other direction is dominated by finished goods which are almost exclusively moved in ocean containers which are carried on specialized vessels. Such container carriers are high cost, specialized vessels which would suffer substantial damage to their specialized fittings if they should carry heavy (dense) bulk material such as crushed limestone.

The carriers which will consider crushed limestone or limestone chips as freight are so-called bulk carriers, including vessels known as ore carriers or OBOs (ore-bulk-oil carriers). There are a few cargoes, including cement and alumina, which move into the Pacific Northwest and California from the Orient and Oceania on bulk carriers. Cement and alumina volumes have dropped in the past few years because of the increased value of the Japanese yen and the downward trend in aluminum pricing due to the flood of inexpensive material from China.

We are aware that the Pacific Northwest has an active logging trade to Asian countries but this offers no opportunity for backloads.

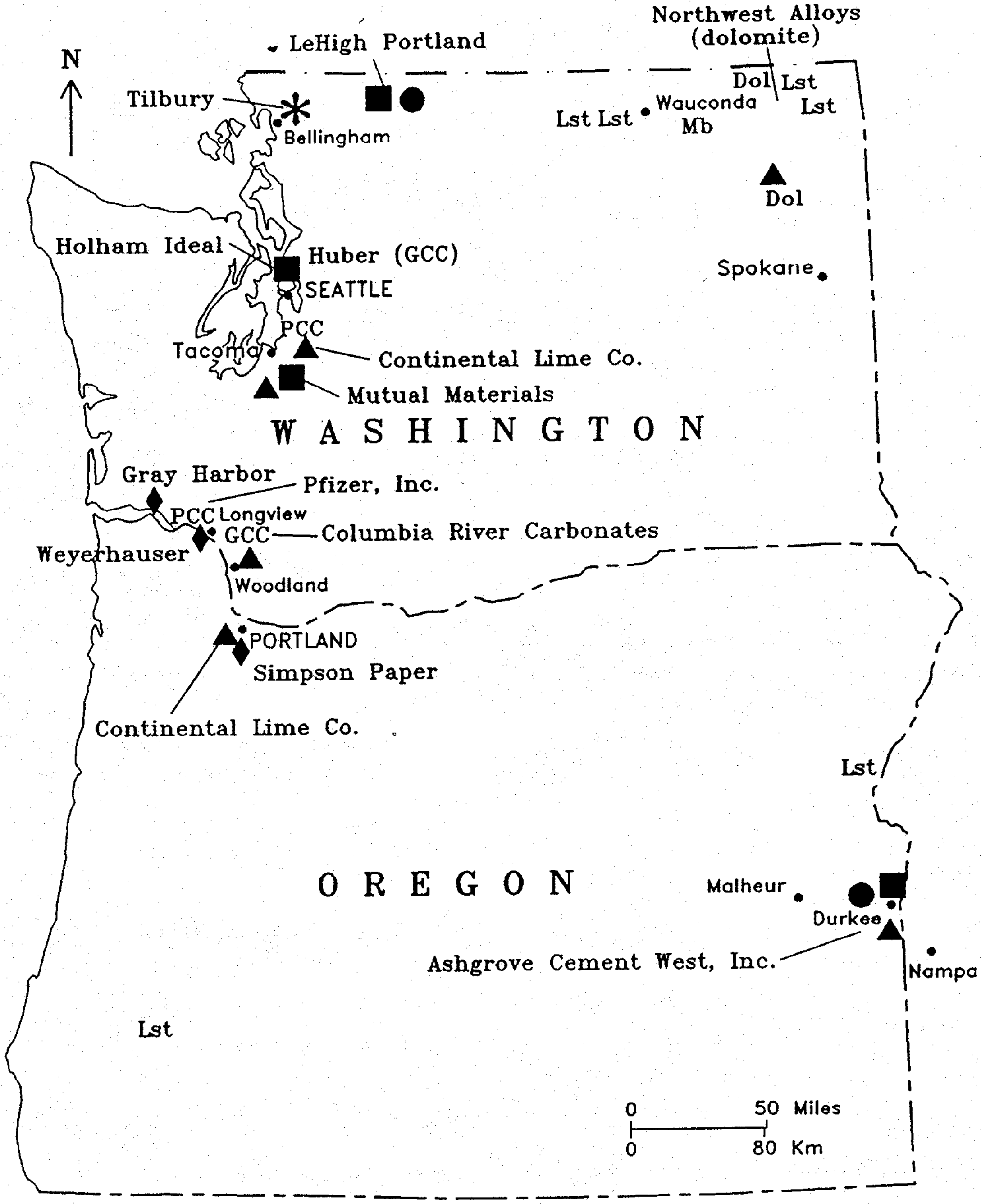
3. Washington-Oregon

3.1. Resources

Limestone is mined in both Washington and Oregon. In Washington, the availability of the high quality limestones from Texada Island, B.C., has constrained the development of local limestone resources to those located in the northeast portion of the state. The major exploited limestone deposits in Oregon are in Durkee County. A locality map of Washington and Oregon is shown in Figure 2.

3.2. Demand, supply and uses

The Washington and Oregon markets for limestone and lime are very closely related and have similar market activities, with the exception of magnesium production in Washington. They are both well serviced by inland waterways which provide access to much of the region. Virtually the whole spectrum of limestone products and processing is undertaken in these two states. These products range from agricultural lime through cement and lime production to various chemical applications to GCC and PCC and the utilization of local dolomite for magnesium refining (O’Driscoll, 1989).



KEY TO CARBONATE RESOURCES AND PROCESSING

Dol – Dolomite
GCC – Ground calcium carbonate
▲ – Lime
● – Limestone crushing and/or grinding plant
PCC – Precipitated calcium carbonate
Mb – Marble
♦ – Paper manufacturing/mill
✱ – Clinker grinding
■ – Cement manufacturing
Lst – Limestone resources

Figure 2 - Locality map of Washington and Oregon (O'Driscoll, 1989)

Statistics of domestic production of cement and lime within Washington and Oregon are not available because of single producer confidentiality. However overall production in 1991 was reported to be 13% less than in 1990 (Minarik, 1991). Cement production in Oregon was estimated to be 226,000 mt with a value of $18.7 million or $82.63/mt (Minarik, 1991). Statistics prior to 1990 are not available because of single supplier confidentiality status.

Shipments of Canadian limestone for lime manufacture and cement in 1990 were reported to be just over 1.1 Mmt (1.2 Mt). Imports of hydraulic cement and clinker in the four year period 1988-1991 are given in Table 2. This shows a growth in imports of 26% in the four year period from 1987 to 1990 but no growth in 1991. The CIF value of these shipments calculate to CIF prices (1991) of $53.34/mt from Canada and $40.60/mt from Japan.

The Continental Lime Company is strongly established in Washington and imports significant tonnages of crushed high-calcium limestone from British Columbia. This limestone is barged from Texada Island to feed lime kilns in Tacoma, Washington, and a 310 mt/d plant (340 t/d) plant in Portland, Oregon. Waste CO, from the lime kilns is utilized in Continental's PCC plant which is also located on the site in Tacoma. The PCC is utilized as a high quality filler in the paper and paint industries. These PCC plants are located adjacent to the paper mills and are termed "satellite plants".

Lime production in Oregon in 1987 increased by 17% over the 1986 production levels, 87% of this increase being quicklime. The market areas for this production are the steel, chemical, and paper markets. In southern Oregon, limestone is mined in Durkee by Ashgrove Cement West Inc. and is supplied to lime plants in Malheur, Oregon, and Nampa and Twin Falls, Idaho. These lime plants are owned by Amalgamated Sugar Co. and their output is almost exclusively used in the sugar beet industry. Lime sold or used in Washington and Oregon increased from 357,000 mt (393,000 t) in 1989 to 365,000 mt (406,000 t) in 1990. In 1991 lime production dropped by 30% which was at least in part due to a decrease in magnesium production.

Table 2 - Imports of hydraulic cement and clinker to Seattle

(Thousand metric tons and thousand dollars)

From	1988 Quantity	1988 Value CIF	1989 Quantity	1989 Value CIF	1990 Quantity	1990 Value CIF	1991 Quantity	1991 Value CIF
Canada	516	22,026	501	21,405	454	21,723,	646	35,104
Japan	215	7,787	225	9,267	258	10,596	22	893
Spain	0	0	0	0	52	2,521	0	0
Others	0	0	0	0	46	2,331	141	1,186
Total	731	29,813	726	30,672	810	37,171	809	37,183

Source: USBM Statistics.

Cement

Large tonnages of limestone are used in cement manufacture. In 1987, Washington produced 1 Mmt of cement. The reliance on limestone and clinker imports from Texada Island in British Columbia has increased in recent years.. The Durkee limestone resources in southern Oregon provide material for Oregon's and Idaho's only cement operator, Ashgrove Cement West, Inc. Reserves of the high-calcium limestone at Durkee are estimated to be 40 Mmt (O'Driscoll, 1989). The sugar beet industry dominates the agricultural uses of lime while limestone is also used for agricultural purposes in both Washington and Oregon.

GCC

GCC is used primarily in the paper industry with smaller tonnages used in paint and plastics. A 22,500 mt/y operation near Seattle (J.M. Huber) produces a dry ground product; pigment grades are produced by Columbia River Carbonates which in 1986 started production from a 90,000 mt/y plant located near Woodland, Washington. The plant uses wet processing to produce finely ground calcium carbonate in a slurry form. Over 50% of this material is supplied to the west coast paper industry for use as a coating pigment, and the balance goes into plastics and paint. The raw material for this plant comes from a lenticular pod of calcitic marble near Wauconda in Okanogan County in northern Washington. The deposit has an average composition of 98% $CaCO_3$, 1% $MgCO_3$, and 1% of acid insolubles (O'Driscoll, 1989). Processed brightness values exceed 96% (against a smoked MgO standard) (Bleeck, Sherar and Gulick, 1993).

GCC is used as in coatings in the Pacific Northwest (i.e. Oregon, Washington and British Columbia). They can contain up to 25-30% by weight of GCC with some PCC possible as a filler in the base sheet. The total GCC tonnage is therefore estimated to be 60,000 to 75,000 mt/y (Temanex, 1993). These coated papers are within the woodfree sector, the term woodfree referring to the fact that only chemical pulp and no mechanically ground pulp is used in the manufacturing process.

Note: These market estimates are considered to be within 10% of the actual (Temanex, 1993).

PCC

PCC is used as both a filler and coating pigment in the paper industry. The total annual production of uncoated woodfree grades in the last two years in the Pacific Northwest is estimated to be 1.2 Mmt/y. The pigment loading for this production (almost entirely PCC) averages about 15-20%. The estimated PCC usage is 180 to 240,000 mt/y (Temanex, 1993).

Several PCC production units are located in Washington state to service the filler market in the Pacific Northwest. They are located in Longview in southwest Washington and in Tacoma. The raw material for both operations is Texada Island limestone. This limestone is calcined at Longview and then processed to convert recovered carbon dioxide, lime, and water into Pfizer's specialty pigment, Albacar HO. The operation at Longview supplies filler to the adjacent Weyerhauser Paper Company for use in coated and uncoated paper.

4. Alaska

4.1. Resources

Exploration and sampling performed by the U.S. Bureau of Mines on Prince of Wales, Dall, Kosciusko, and Heceta Islands revealed several localities containing high-calcium and ultra-high calcium limestones (Maas et al., 1991, 1992). In addition to these highly pure limestones, marble with brightness approaching 94.5% against MgO standards were also found. Large resources of high purity material are inferred at El Capitan, Calder, Port Alice, Edna Bay, View Cove, Breezy Bay and Cleva Bay. The economic potential of these resources has yet to be determined.

4.2. Demand, supply and uses

The domestic limestone industry in Alaska consists of the mining and grinding of aggregates and agricultural limestone. Portland cement was formerly produced in Anchorage by Alaska Basic Industries Ltd. from domestic clinker supplied by Anchorage Sand and Gravel Company in Cook Inlet. Discussions with Anchorage Sand and Gravel Company revealed that they no longer grind the clinker and prefer instead to import the finished cement. There is no recorded Alaskan production of lime and small tonnages are imported from Canada or shipped from Seattle. Imports of hydraulic cement in 1990 were 131,000 mt. Hydraulic cement is a general term used to cover all grades of cement. This was made up of 62,000 mt from domestic sources (Seattle) and 69,000 mt imported from Canada and Japan. In 1991 the imported tonnage was 61,000 mt while data on domestic shipments are not yet available. Imports of lime from Canada totalled 450 mt in 1992. Domestic limestone was mined and used for aggregate and agricultural purposes. Data are not available for 1992.

With the growth in population, the demand for aggregates and cement for highways and construction will continue to increase. The use of lime for water treatment and agricultural lime is also predicted to grow at a steady rate. The mining industry in Alaska is a significant growth market which will require lime and/or limestone as process reagents, for pH control, for cyanide destruction and for waste water treatment. No accurate figures of projected market growth for lime and limestone are possible since the rate of development will be controlled by such factors as international metal prices, quality and quantity of resources and regulatory requirements,

4.3. Potential for-future development of an Alaskan limestone industry

The small local market of several hundred thousand tons for cement and lime weighs heavily against the development of any Alaska based processing operations. To achieve the benefits of large scale production typical of lime and cement plants being installed around the world, the size of a large lime plant is 500,000 mt/y while a large cement operation would be at least several million tons per year.

5. California

5.1. Resources

Limestone resources are exploited throughout California. Ultra-high calcium carbonate production is focussed in the Lucerne Valley in Southern California.

5.2. Demand, supply and uses

California consumed nearly 20 Mmt of limestone in 1992. The state is ranked number 1 in the U.S. in both clinker and cement grinding capacity. Not all of this tonnage is produced locally; a significant tonnage is imported from several countries and from Nevada and Texas. Current domestic production of lime and cement in California is summarized in Table 3 along with tonnages obtained from adjacent states The economic recession in California over the past two years has significantly reduced the demand for limestone products.

Ultra-high calcium carbonate production is focused in the Lucerne Valley in Southern California where 1.35 Mmt of limestone and calcite marble are mined (Brown, 1994). The major producers are Pluess-Staufer Inc., Pfizer Inc., and Riverside Cement. Of this tonnage, more than 300,000 mt/y is GCC. Reserves are extensive, and these industries have been established for many years, so much of their infrastructure and capital costs have been amortized.

Cement

California's hydraulic cement production in 1992 was 7.9 Mmt with a value of $522 million. This equates to an average price of $66.09/mt. California also imports significant tonnages of cement and clinker. Imports for hydraulic cement and clinker during 1988-1991 are listed in Table 4. In 1991, a total of 1.43 Mmt was imported at a CIF value of $32.60/mt to $60.40/mt. The lowest imported price was $32.60/mt from Spain.

Table 3 - Californian cement and limestone production (1989-1992)

(Thousand of metric tons and thousands of dollars)

	1989	1990	1991*	1992*
California Tonnages				
Lime	358	313	318	278
Cement	9,928	9,614	8,294	7,893
Value				
Cement	NA	NA	548,000	522,120
Other States				
Lime	197	267	NA	NA
Cement	323	926	NA	NA

Source: USBM Data. *Preliminary data from CA Division of Mines and Geology. NA=Not Available

Table 4 - Californian imports of hydraulic cement and clinker

(Thousands of metric tons and thousands of dollars)

Entry Port and Source	1988 Quantity	1988 Value	1989 Quantity	1989 Value	1990 Quantity	1990 Value	1991 Quantity	1991 Value
Los <u>Angeles</u>								
Japan	1,050	37,847	1,453	50,115	1,076	40,751	-	-
Korea	461	13,878	122	5,052	-	-	-	-
Spain	21	974	194	8,650	92	4,033	33	1,083
Mexico	-	-	-	-	338	13,544	510	22,739
Greece	-	-	-	-	-	-	134	6,946
France	-	-	-	-	-	-	171	7,877
Others	312	7,597	193	8,200	175	8,241	95	4,449
<u>San Diego</u>								
Columbia	=	-	-	-	19	924	140	7,615
Mexico	600	23,595	569	22,685	444	16,840	102	4,132
Japan	23	909	-	-	-	-	-	-
Others	-	4	-	-	-	-	-	-
San <u>Francisco</u>								
Columbia	-	-	-	-	-	-	160	9,670
Japan	36	1,605	145	5,732	136	6,003	-	-
S. Korea	-	-	70	2,388	79	2,949	-	-
Mexico	249	7,78 1	263	8,173	138	5,439	-	--
Others	7	7	49	12	72	1,908	88	4,651
Total for California	2,759	94,197	3,058	lll,oo	2,569	100,632	1,433	69,162

Source: USBM Data (-) Indicates no tonnage or less than 500 mt.

The supply of cement was formerly dominated by Japan but because of the strengthening of the Japanese yen against many currencies Japan has now all but withdrawn from the western US market. Its place has been taken by Mexico and, more recently by Columbia, France and Greece. No detailed explanation was obtained regarding why such countries as Spain, Greece and France have been able to enter the Californian market. Possible explanations are:

- the hydraulic cement category includes all categories of cement. It is possible that specialized grades of cement were imported.

- production from very large plants in these countries means minimum production costs due to benefits of large scale production. In combination with low freight rates, this enables them to deliver to California at a CIF price competitive with local production.

The patterns of overseas supply have also been affected by anti-dumping legislation imposed by the U.S. on certain foreign importers including Japan. Imports of quicklime, slaked lime, and hydraulic lime are tariff free from countries with most-favored-nation (MFN) status. Non MFN countries have tariffs of 0.2 cents per kg (about $2.40/mt) for quicklime and hydraulic lime and 0.3 cent per kg for slaked lime. Since 1989, Mexican lime has been assessed a countervailing duty of 1.21% because the Mexican government has been involved in ownership of these exporting companies and some government cost subsidies were involved. These duties are now under review as a result of the North American Free Trade Agreement (NAFTA). Imports of cement and clinker are tariff free for nations with MFN status.

The average price of domestically produced cement in the U.S. in 1991 was $66.15/mt. The price differential between the imported and domestic price is considered to be balanced by internal freight costs and certain captive markets for cement in which production costs are typically somewhat higher.

6. Mexico

6. I. Resources

Mexico has very large resources of dolomite and high-calcium limestone. Twenty-one Mexican states are known to produce high-calcium limestone and/or high-magnesium limestone. Deposits of high quality carbonates suitable for GCC production are located near Guadalajara and in San Juan Del Rio (Queretaro Province).

6.2. Demand, supply, and uses

Annual production of limestone is 30 Mmt/y of which the majority is used in the construction industry (Griffiths, 1988). Market growth is about 4% per year.

Large tonnages of cement are exported to Texas and other Gulf States but the most relevant export shipments are those to California. Future supplies to Californian may however be affected by:

- anti-dumping legislation brought against Mexican cement shipments in 1990.

- competition from other suppliers.

- the drop in the Californian domestic market (particularly in southern California).

Mexico exploits high quality carbonates from resources near Guadalajara which are ground locally in a 25,000 t/y facility owned jointly by Technica Minerals and Pluess-Staufer. For the highest quality paper markets some U.S. carbonates are imported. Pluess-Staufer/Omya has recently announced its intention to establish a GCC grinding facility in San Juan Del Rio (Queretaro Province) in central Mexico. This plant is projected to be operational by late 1994 and will use local raw materials. The finely ground GCC will supply the local paper, paint, plastics and other filler markets.

The establishment of NAFTA will provide encouragement for the exploration and development of Mexico‘s carbonate resources. The California market is a logical target for such developments. At the present time we have no knowledge of any coastally located GCC quality carbonates which might be competitive in the California market.

7.0 Japan

7.1 Resources

Limestone is probably the best known and most abundant industrial mineral in Japan. It is widely distributed throughout the islands of Japan and estimated reserves approach 58,000 Mmt (Saito, 1982). Production in 1990 was 198 Mmt predominantly for the local market, but some quantity was exported to Pacific Rim countries including Australia.

7.2. Demand, supply, and uses

Limestone

A summary of limestone production and its uses in Japan during the three year period 1989-1991 is given in Table 5. The category of “Fillers” refers to the use of limestone as low grade fillers in asphalt, animal feed, acid neutralization, and fertilizers. The category of “Others” includes both low grade and higher grade GCC and PCC fillers.

Table 5 - Iimestone production and consumption in Japan

(Thousands of metric tons)

	1989	1990	1991 (Jan-Nov)
Production	190,860	198,199	206,684
<u>End Use</u>			
Cement	87,562 44.9%	93,130 45.6%	99,486 47.1%
Aggregate	56,237 28.9%	58,739 28.8%	60,383 28.8%
Iron/Stee1	21,982 11.3%	22,375 11.0%	21,928 10.4%
Lime	11,612 5.9%	11,734 5.8%	11,670 5.5%
Soda glass	1,935 1.0%	1,846 0.9%	1,804 0.8%
Fillers	6,659 3.4%	6,720 3.3%	6,605 3.1%
Others	8,821 4.6%	9,420 4.6%	9,510 4.5%
Total	194,808	203,964	211,386

Source: O’Driscoll (1992)

It may appear unusual that Japan, traditionally a dominant importer of raw materiaIs, should actually be an exporter of limestone. This situation arises because of the following factors:

- Japan has extensive resources of high quality limestone suitable for cement manufacture.

- by importing such large tonnages of other raw materials from around the world, Japan has a significant freight imbalance in terms of outward cargos from Japan. For this reason, Japan is able to export high grade limestone to Australia and cement and clinker to the west coast of the U.S. at very low freight rates.

Figures 3 and 4 are based on the compilation of data in this report. Figure 3 summarizes the major shipping movements of cement and clinker within the Pacific Rim in 1990 with the focus being on shipments from Japan. Figure 4 summarizes the situation for 1991.

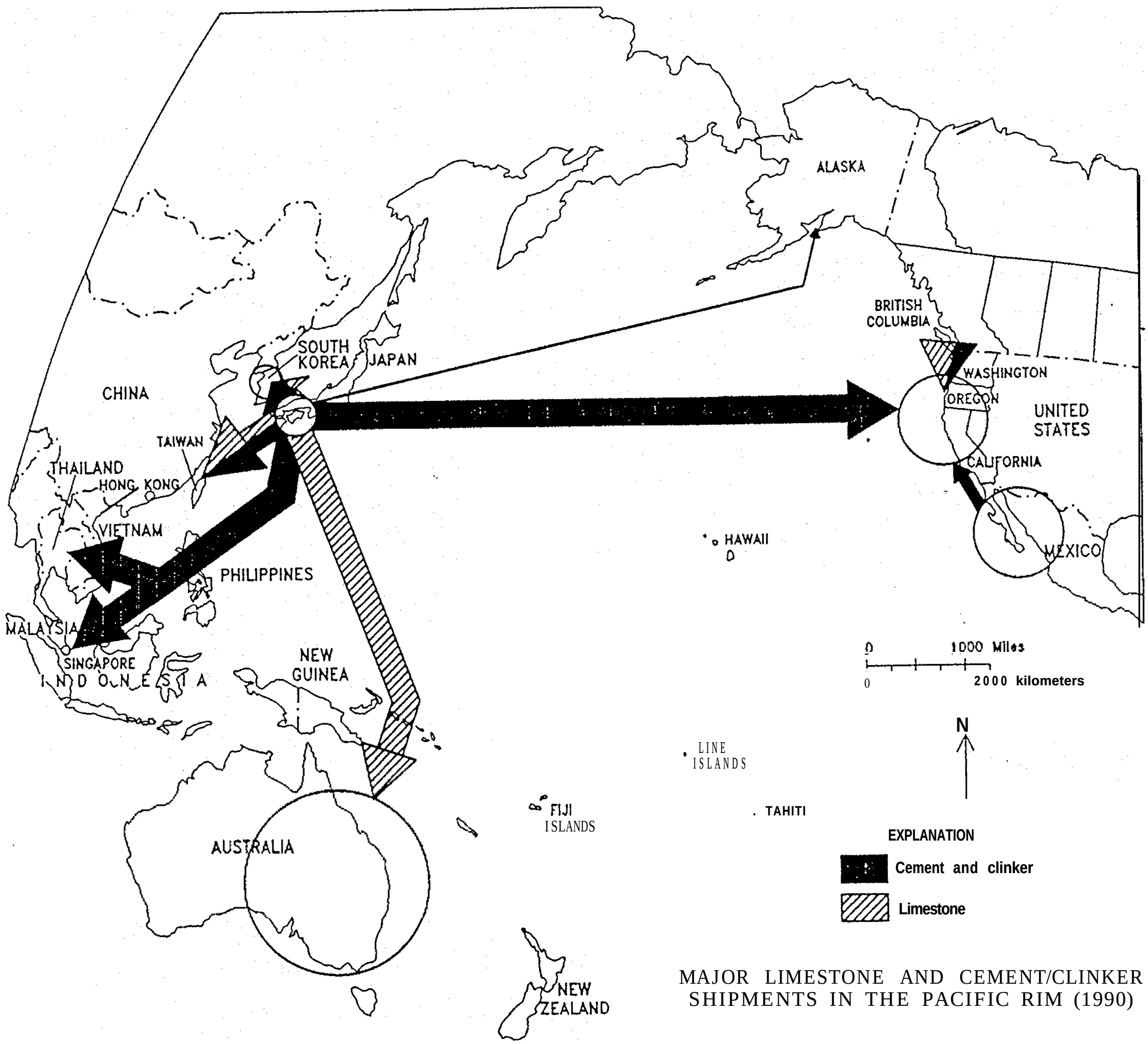


Figure 3- Major shipments of limestone, clinker and cement in the Pacific Rim in 1990

Table 6 - Specification of Japanese export chemical grade limestone

Component	%
CaO	55.40
MgO	0.25
Al_2O_3	0.04
Fe_2O_3	0.03
SiO_2	0.15
P	0.004

Note: Product of the Nittetsu Mining Company Ltd., Torigatayama Quarry, S. Shikoku which produced 14.7 Mmt in 1991.

Within Table 5 the column headed "Others" includes ground calcium carbonate (GCC) used in high value filler markets such as paint, paper, plastics, and rubber. Although this category also includes other end uses, its total demand has tripled from 3.3 Mmt in 1987 to 9.4 Mmt in 1990 to over 10 Mmt in 1991 (O'Driscoll, 1992). This growth includes many low cost applications within the construction and process industries, but there has also been a significant increase in consumption of the more finely ground, higher quality carbonate fillers. The coarser particle sized GCC products are dry ground to 100% finer than 44µm while the highest quality GCC is subsequently wet ground to much finer sizes. Japanese imports of high brightness limestone are shown in Table 7.

Table 7 - Japanese imports of high brightness limestone

(Metric tons and thousands of dollars)

Source	1989 Tons	1989 Value	1990 Tons	1990 Value	1991 Tons	1991 Value	1992 Tons	1992 Value
France	794	166	799	199	1,080	245	960	230
Malaysia	-	-	-	-	-	-	22,687	1,382
Philippines	5,041	51	-	-	2	6	-	-
Taiwan			40	4	3,170	160	3,307	214
Others	104	21	59	139	86	36	173	127
Total	5,939	238	898	342	4,338	447	27,127	1,953

Source: Japanese government statistics.

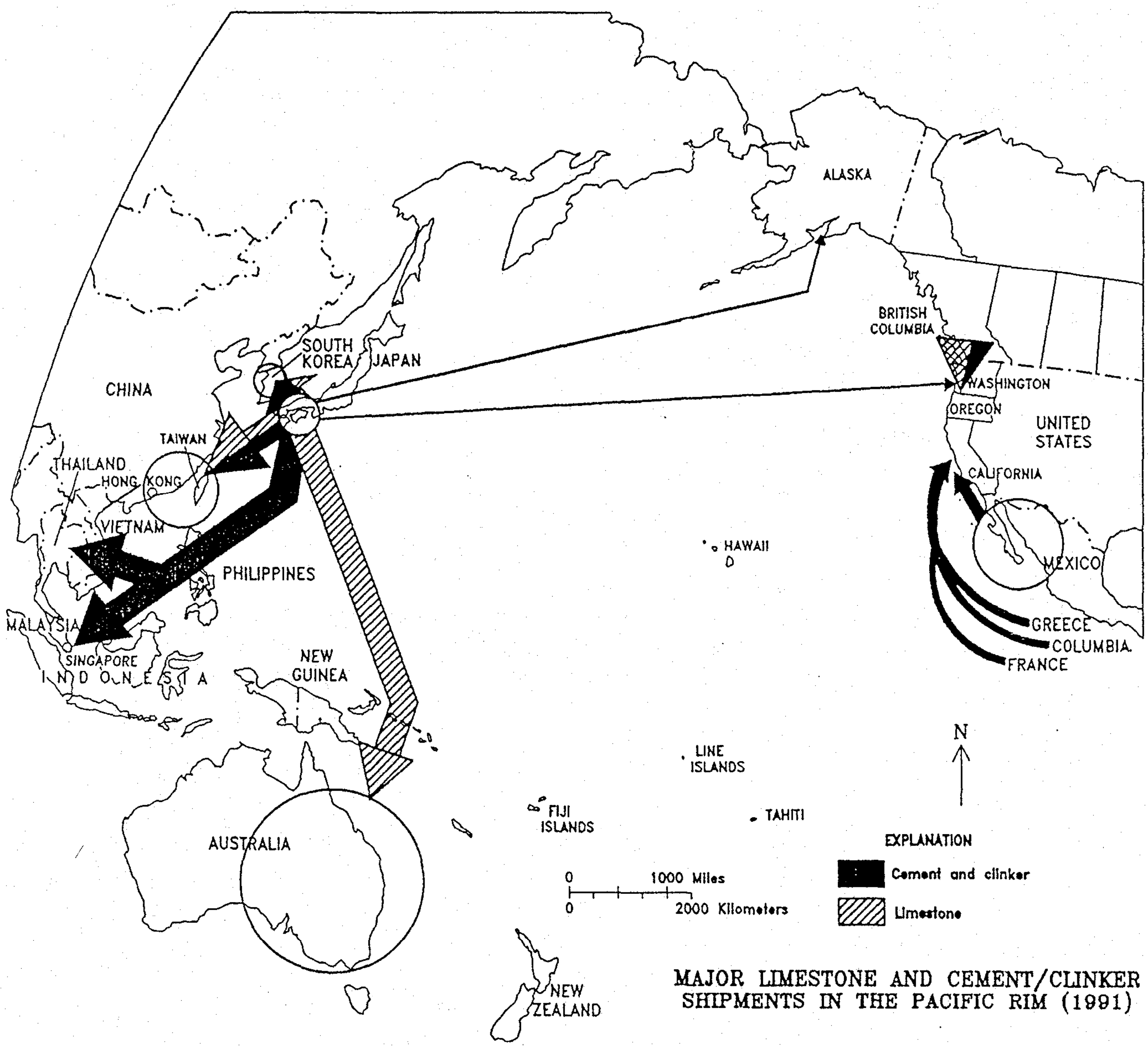


Figure 4 - Major shipments of limestone, clinker and cement in the Pacific Rim in 1991

In Japan, mining and processing has been cut back recently due to the recession in domestic industry and the consequent decrease in demand from both the steel and construction industry. Very little limestone has been imported to Japan in the past, and no markets for imported construction grade material are anticipated.

An analysis of a typical chemical grade limestone currently being exported to Australia is reproduced in Table 6. This specification exceeds the requirements for ultra-high calcium carbonate of 97% $CaCO_3$ (53.2% CaO).

Specialty carbonate pigments

There are specialty carbonate pigments which are highly refined pigments coated with various organic compounds or activated colloidal carbonates which are used in high quality rubber, high strength plastics, inks and paints. These pigments are predominantly PCC based but very finely ground GCC also may be used in some of these pigments. Exports are dominated by shipments to Korea and the U.S. for the rubber and automotive plastics markets. The current trend is for Japanese industry to invest and manufacture in other countries. When they manufacture overseas, the Japanese typically specify the same raw materials as used in Japan. In 1992 Japan exported over 70,000 mt of these specialty products to over 40 countries.

8. Asian market potential for GCC

There is a growing market for high brightness limestone for the production of fine particle size GCC in Japan, Korea, Taiwan and the U.S. (Parallax Inc., 1993; Temanex, 1993). The largest market is in paper but a growing market also exists in paint, plastics and other extender pigment and filler applications. At present a shortfall exists in this market in Japan, Taiwan and Korea (Figure 5) which is estimated to be between 175,000 and 250,000 mt/y. This market will increase because of the continued growth of the paper, paint and plastics industries in Asia. This growth cannot readily be identified from statistical data because GCC is not a specific item within import or export classification schedules. Estimates are therefore based on direct experience of marketing specialists servicing the region. The growth in GCC usage in the paper industry is due to several factors which include:

- the present trend toward alkaline paper making rather than acid processes. Alkaline processes permit the use of carbonates rather than kaolins as fillers, coating pigments or extenders.

- the growth in demand for high quality coated papers.

- the recognition that high brightness GCC has superior physical and optical performance over PCC and kaolin in certain applications.

Potential market tonnages are summarized in Table 8.

Table 8 - Usage and potential markets for GCC in Japan, S. Korea and Taiwan

(Metric tons)

Location	Estimated tonnage Used	Estimate of market tonnage undersupplied in 1993	Estimated Value CIF $/mt
Japan	1,200,000	135,000 to 180,000	50 to 60
Korea	250,000+	30,000 to 50,000	50 to 60
Taiwan	100,000+	10,000 to 20,000	50 to 60

Source: (Parallax, Inc., 1993)

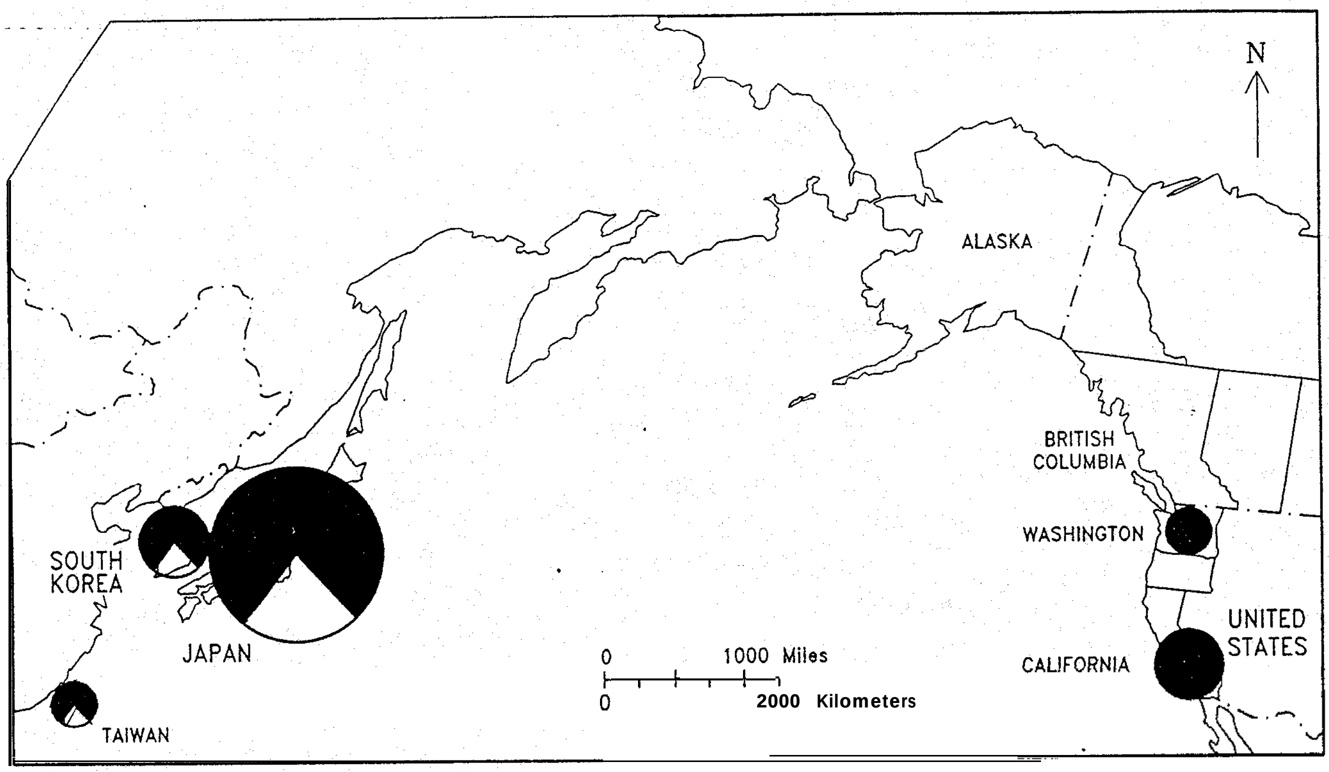


Figure 5 - Location and size of major GCC markets in the Pacific Rim

Note: Area of circle indicates relative market size. Proportion of undersupplied market is indicated by the open segment of circle. Market tonnages are detailed in the text.

The paper industry is projected to have the strongest growth potential where GCC will be used in conjunction with kaolin to improve both brightness and viscosity characteristics. The growth in GCC usage in the plastics and paint markets is due to the increasing production tonnages of these products particularly .in Asian markets.

If limestone/marble chips of suitable quality were to be supplied to Asia from the Pacific Northwest the projected delivered price (CIF Japan) is US$50 to $60/mt. The chip size is dependent on the hardness and resistance of the material. Softer materials tend to be shipped as larger lumps with up to a 15 cm diameter, while more resistant materials such as marble may be as fine as 2.5 cm diameter. If tonnages are sufficiently large to justify bulk shipments of 20,000 mt the FOB price is estimated to be within a range of $30.00/mt and $47.00/mt. This wide range in price reflects the $10 range in delivered CIF price and the volatility in bulk freight estimates which range from $13/mt to $20/mt .

9. Western U.S. markets

In the western U.S. the highly competitive GCC market is supplied by existing resources and no shortfall was identified . The market for GCC in Washington and California is projected to increase with the paper industry, having the strongest growth potential followed by paint and plastics. While the GCC resources in Washington and California are inland, in British Columbia they are located near deep water. This could offer a considerable freight advantage since the paper markets are predominantly coastal. Inland rail freight costs from the Washington GCC resources (in Okanagan County) to the Columbia River Carbonates plant in Woodland (approximately 300 km) are confidential to the operator. They are however conservatively estimated to be no less than $15/mt. In California, the coastal markets for CCC also are supplied by the inland resources of the Lucerne Valley in Southern California. The distance from these resources is approximately 160 km to Los Angeles and 640 km to San Francisco.

Although no comparative data has been obtained on the relative qualities of the high brightness marbles (in British Columbia, at Wauconda, Washington and the Lucerne Valley, California), the potential for supplying GCC chips to coastal situations in Washington or California justifies further study.

10. Prices by specific product and geographic area

10.1. Limestone

In British Columbia (Pilon and Associates, 1993), the 1993 prices for Texada Island limestones are:

Cement grade limestone:	$2.60/mt ($2.34/t)
High-calcium limestone:	$3.60/mt ($3.24/t)

Local prices of limestone are highly competitive with low profit margins (Pilon and Associates, 1993). Small quantities of white limestone sell for $7.93/mt.

10.2. Lime production costs and prices ,

Lime prices within the United States have remained very static for many years. The average selling price for lime moved from $55.22 in 1987 to $57.0/mt in 1991.

The average cement prices for general use and for all grades are presented in Table 9. In British Columbia statistical data are not available because the production is by few companies and the data are confidential.

Table 9 - Domestic cement prices in the U.S. aud British Columbia

	1988 $/mt	1989 $/mt	1990 $/mt	1991 $/mt
Alaska	54.28	59.57	68.86	58.25
British Columbia	C	C	C	C
Washington	54.29	C	C	C
Oregon	C	C	C	C
California (north)	63.68	65.04	67.40	65.57
California (south)	63.51	64.76	65.95	65.16
Portland cement	53.50	52.82	53.56	54.41
Hydraulic cement	54.40	54.76	55.32	55.79

Source: USBM Data
C = Data confidential because of limited number of producers.
* = Alaskan estimate is based on an average CIF price for imports

Table 10 - Imports of hydraulic cement and clinker to North American west coast (1991)

Region	Imports Mmt	Major Suppliers	Value CIF $/mt
Alaska	0.08	Japan, Canada	$51.70 $183.00
Washington & Oregon	0.81	Canada Japan	$54.34 $40.59
		Average Price	$45.96
California	2.57	France Mexico	$46.06 $45.59
		Average Price	$48.26*

Source: USBM Data
* This average exceeds the average price of the two major suppliers because of small imports of higher priced cement from other countries.

10.3. *Trends in clinker and cement prices in A sian countries of the Pacific Rim*

The trends in clinker and cement prices in Asian countries of the Pacific Rim have been assessed from five years of statistics from Japan and Taiwan. There has been a progressive increase in value for these commodities on an FOB port price as illustrated in Figure 6.

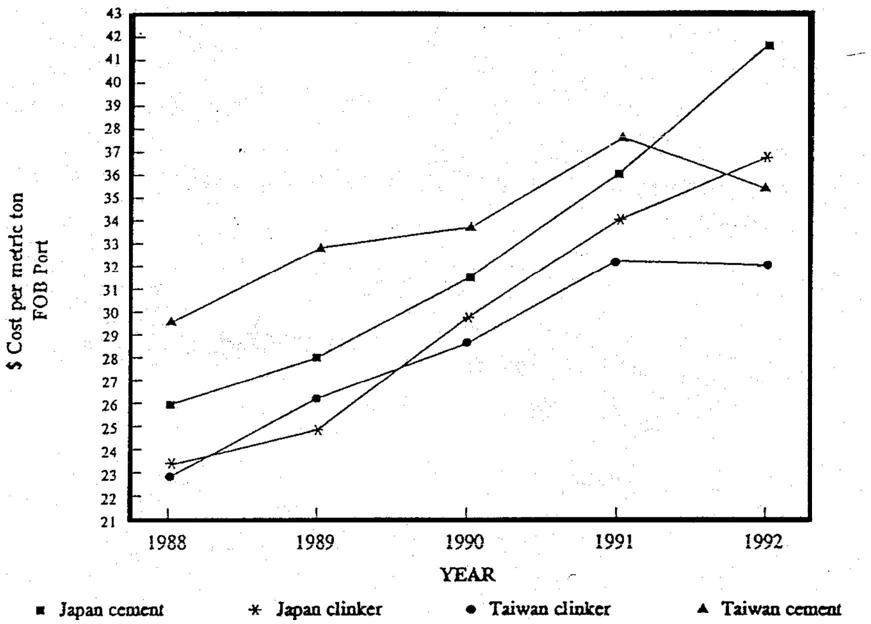


Figure 6 - Trends in FOB port prices for clinker and cement for Japan and Taiwan

10.4. Prices for marble or limestone chips

In California and Washington the resources of limestone and marble for the production of GCC are held by the processing companies and their cost data are confidential. In Asia, the CIF value for high grade ore suitable for GCC processing is $5O/mt to $60/mt (Parallax, Inc., 1993).

10.5. Prices for GCC products

After fine grinding, the prices range from $150 to $230/mt depending on the level of processing, and whether the materials are supplied in slurry, bulk or bagged. Pricing varies greatly depending upon the final application. The prices of GCC vary according to grade, contract type/size, and transport costs. For a large consumer with on site PCC and some CCC requirement, the price is on the order of $150 to $160/mt. Because of the highly competitive nature of the industry it is reported that base prices have not moved since 1987.

In Asia the pricing for high grade ore suitable for GCC processing is approximately $50/mt to $60/mt (Parallax, Inc., 1993). After fine grinding, the prices are around $150 to $250/mt depending on the level of material processing. Limited markets exist for decorative marble tile and block in the building industry. Pricing varies greatly depending upon the final application.

IO. 6. Specialty carbonate pigments

These carbonate pigments are highly refined pigments coated with various organic compounds or activated colloidal carbonates which are used in high quality rubber, high strength plastics, inks and paints. They are predominantly PCC based and may sell for over $400/mt on an FOB plant basis. Although such refined products are considered to be beyond the objectives of this study, the high prices illustrate the complexities to which carbonate processing may extend.

11. Shipping costs

Barge transportation is a logical option for transportation to a number of markets, particularly those delivery points that are located on the U.S. west coast. Barges of 5,000 mt (5,500 t) capacity are typically used to transport Texada Island limestones along the coast (Transmode Consultants Inc., 1990). The barge size is constrained by the depths in the inland waterways and the size of docking facilities. A quotation was obtained in May 1993 from the Rivertow Company in Vancouver for destinations from Texada Island. The costs to Vancouver, Seattle and Portland are presented in Table 11. For Californian ports the costs would be higher.

Table 11 - Barge Costs from Texada Island to Pacific Northwest ports

Destination	Freight Cost $/mt	Freight Cost $/t
Vancouver	2.40	2.16
Seattle	4.80	4.32
Portland	10.80	9.72

Source: Pilon and Associates (1993)

Estimates of 1993 freight rates from the Pacific Northwest to Asian Markets are detailed in Table 12.

Table 12 - Freight costs from Pacific Northwest to Asian markets

Vessel Size	Ocean freight estimate May 1993	Ocean freight estimate November 1993
60,000 to 70,000 mt capacity	$14 to $1 5/mt	$8 to $9/mt
25,000 to 30,000 mt capacity	$16 to $20/mt	$13 to $14/mt

Source: Transmode Consultants (1993)

12. Conclusions

12.1. Limestone, cement and clinker

In British Columbia, Washington and Oregon the Texada Island resources will continue to dominate the market for lime, clinker and cement in the foreseeable future. Their resource base is reported to be strong in all grades of limestone, while their production costs and distribution costs are low. The markets for cement and lime are currently either static or depressed. The cement industry is reportedly undergoing hard times, while lime prices have progressively decreased over the past 10 years:

Trends in CIF prices in Seattle and California are summarized in Table 13. There has been a significant increase in the CIF price since 1990. However, this has been caused by a higher proportion of cement rather than clinker within this category and the imposition of dumping duties on some imports.

Table 13 - Trends in imported hydraulic cement and clinker prices to U.S west coast ports

	1988 CIF/mt	1989 CIF/mt	1990 CIF/mt	1991 CIF/mt
Seattle	$40.78	$42.25	$45.89	$45.96
California	$36.77	$36.30	$39.16	$48.26

Source: USBM Data

With the recent establishment of NAFTA and the very large productive capacity in the Mexican cement industry, Mexico is poised to take a major role in the supply of cement to the Southwestern U.S.

12.2. GCC

In the Pacific Northwest the demand for GCC will continue to increase with the focus of the growth being the paper industry. No information has been obtained on the resources held by IMASCO in British Columbia. Resources of the high brightness Wauconda marbles in northern Washington held by Columbia River Carbonates are reported to be 20 Mmt (22 Mt) (O'Driscoll, 1989).

These resources are inland while the paper markets are predominantly coastal. Inland rail freight costs from the resources (in Okanagan County) to the Columbia River Carbonates plant in Woodland (approximately 300 km (200 miles)) are confidential to the operator but they are conservatively estimated to be not less than $l5/mt ($13.57/t). In California the coastal markets for GCC also are supplied by the inland resources of the Lucerne Valley in Southern California. The distance to Los Angeles is approximately 160 km (100 miles) while to San Francisco it is 640 km (400 miles). Although no comparative data has been compiled on the relative qualities of the Alaskan high brightness marbles versus the Wauconda marble and the Californian high brightness limestones, the potential for supplying GCC chips to coastal plants in Washington or California may justify further study.

12.3. Asia

The Asian area is a region of both tremendous market growth and resource development in industrial minerals. Japan, Korea and Taiwan have dominated the growth for many years; more recently, Thailand, Indonesia, the Philippines, Malaysia and other nations have shown very rapid rates of development. With the normalization of China's diplomatic relations with many countries, Chinese industrial mineral resources are now beginning to influence the patterns of supply in Asian markets. Japan has made significant investments in limestone resource development in China in the past two years, with several large cement plants under construction in southeast China. Mitsubishi Materials Corp. is investigating a 900,000 mt/y cement plant in Yantai Province, while Nippon Cement is considering a 7.3 Mmt/y plant near Nanjing.

Acknowledgements

Some of the statistical data for this study was compiled for the U.S. Bureau of Mines Alaska by the author. The U.S. Bureau of Mines generously consented to the inclusion of these data in this presentation.

References

Bleeck, J. A., R. L. Sherar, and C. W. Gulick. The Geology of Papermaking. Washington Geology, v. 21, No. 3, 1993, pp. 3-8.

British Columbia Ministry of Energy, Mines and Petroleum Resources. Mineral Market Update, v. 5, No.1, 1993, 31pp.

Brown, H. J. Geology, Genesis and Mining of High Brightness, High Purity Limestone Deposits at Pluess-Staufer (California) Inc. Lucerne Valley Operation. AIME Preprint No. 94-13, 1994, 11 pp.

Griffths, J. Mexico's Industrial Minerals Meeting Manana's Challenge. Industrial Minerals, No. 250, 1988, pp 19-41.

Maas, K. M., Private communication, 1993; available on request from K. M. Maas, BuMines AFOC-Juneau, AK.

Maas, K. M., J. C. Still, A. H. Clough, and L. K. Oliver. Mineral Investigations in the Ketchikan Mining District, Alaska, 1990: Southern Prince of Wales Island and Vicinity. U.S. Bureau of Mines OFR 33-91, 1991, 138 pp., and 12 plates.

Maas, K. M., J. C. Still, and P. E. Bittenbender. Mineral Investigations in the Ketchikan Mining District, Alaska, 1991: Prince of Wales Island and Vicinity. U.S. Bureau of Mines OFR 81-92, 1992, 69 pp.

Minarik, R. J. The Mineral Industry of Oregon. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 429-439.

Minarik, R. J., T. K. Bundtzen, R. C. Swainbank, J. E. Wood, and A. H. Clough. The Mineral Industry of Alaska. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 59-70.

Minarik, R. J., R. E. Derkey, and C. W. Gulick. The Mineral Industry of Washington. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 543-553.

O'Driscoll, M. U.S. Pacific Northwest - An Outpost of Industrial Mineral Wealth. Industrial Minerals, No. 259, 1989, pp. 19-55.

_____ Fine Carbonate Fillers - PCC Breaks Ground in Paper. Industrial Minerals, No. 276, 1990, pp. 21-34.

_____ Industrial Minerals in Japan - Bowing to Recession Reality. Industrial Minerals, No. 295, 1992, pp. 19-45.

_____ South Korea's Minerals Industry - Imports Prove Seoul-Destroying. Industrial Minerals, No. 312, 1993, pp. 19-37.

Parallax Inc. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Pilon and Associates. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Saito, H. Limestone and Argillaceous Resources for Cement and Lime Production in Japan. AIME Preprint No. 82-371, 1982, 5 pp.

Stitt, P.H. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Stokowski, S., Jr., A. Shapiro, and A. Pincomb. Industrial Minerals for Lime Neutralization. Industrial Minerals, No. 302, 1992, pp. 67-73.

Temanex. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Tepordei, V. Crushed Stone. Ch. in BuMines Minerals Yearbook, v. I, 1991, pp. 1469-1511.

Transmode Consultants Inc. Transportation Costs for Industrial Minerals in B.C. A Report Prepared for the Province of B.C. under the Canada-British Columbia Mineral Development Agreement 1990, 50 pp.

Update on Perlite

by

D. F Gunning, Consultant
B. C. Trade Development Corporation

presented at
Focus on British Columbia Industrial Minerals
October 19, 1995
Vancouver, Canada

UPDATE ON PERLITE

Donald F. Gunning, P.Eng.
October, 1995

INTRODUCTION

The industrial mineral "Perlite" is a hydrated rhyolitic volcanic glass that typically contains between two and five percent of chemically combined water, which permits the production of an expanded cellular material of extremely low bulk density when the ore is heated to its softening temperature in the range of 900-11000 C.

Raw perlite can in fact be expanded to up to twenty times its volume, creating a unique mineral product that finds application in many horticultural, construction and manufacturing sectors.

There is virtually no demand for raw perlite, other than for expansion. Since most expanders require a relatively tightly sized product, the mining and processing of the ore can generate significant quantities (up to 30%) of unmarketable fines, increasing the net cost of production. This problem is mitigated with less friable ores. Of course, product mix is also an important factor.

One other very significant customer requirement is the need to keep the sized ore completely dry prior to expansion. This necessitates close control of post-processing storage and transportation methods and facilities.

TRADE

Worldwide demand for perlite is modest by most industrial mineral standards, totaling less than 2.0 million tonnes per year, and has changed very little over the past ten years or so.

The production of perlite in the U.S. was relatively stagnant from 1989 to 1993 ranging between 515 and 575,000 tonnes per year. This increased to 610,000 tonnes in 1994, according to the U.S. Bureau of Mines. Apparent consumption is slightly higher at 660,000 tonnes, with imports of raw ore on the east coast, largely from Greece, exceeding exports of western ore, mainly to Canada.

Prior to the '80's, only one small attempt at commercial operation is recorded. It was undertaken by Western Gypsum Products of Winnipeg very briefly in 1953 at the Francois Lake deposit near Burns Lake in central B.C.

As noted earlier, Canada now imports 100% of its perlite requirements from Greece and the U.S.

Currently, a Quebec company - Canada Perlite Inc. - is attempting to develop a mine and processing facility at a perlite deposit on the Gaspe Peninsula, and efforts are being made to re-open the Frenier deposit in B.C., to supply raw ore to well-established expanders in Alberta, B.C. and the Pacific Northwest states.

UNITED STATES DEVELOPMENTS

The perlite mine at Malad City in southern Idaho, owned by the Oglebay Norton Company of Cleveland, Ohio, once a major supplier of raw ore to expanders in Alberta, B.C. and the Pacific Northwest states, remains closed; it has been rumoured to be for sale since its shutdown in 1991.

Atlas Perlite Inc. of Denver, Colorado, is actively proceeding with the development of its vast deposit at Tucker Hill in southern Oregon. A plant site has been purchased in nearby Lakeview, extensive product testing has been carried out, and an environmental impact statement completed and distributed for public input. On receipt of permits, the company plans to construct the required facilities during early 1996, with an initial capacity of 50,000 tonnes per year. Atlas could have a substantial impact on perlite trading patterns in the Pacific Northwest, given their favourable location and shipping costs compared to New Mexico producers. Atlas claims that their ore is less friable than most, and that the energy required for expansion is significantly less than for many other U.S. ores.

MAJOR U.S. PRODUCERS

As noted earlier, mines in New Mexico account for 80% of U.S. perlite production. The balance comes from Arizona, California, Colorado, Nevada and at one time, Idaho. The New Mexico operations are located at Socorro, Grants, and No Agua Peaks near the Colorado border as shown in this overhead by Chamberlin and Barker. The No Agua resource is said to be the largest perlite deposit in the world. It hosts two of the State's largest mines, one owned by Harborlite (previous Celite and Johns Manville); the other by Dicaperl (a subsidiary of Grefco, previously General Refractories). Dicaperl also mines a deposit near Socorro, and U.S. Gypsum has a small operation in Grants, in west-central New Mexico.

All of the mines are open-pit, extracting by simple ripping and scraping; only a minor amount of drilling and blasting is required. Dicaperl's processing plant for its No Agua perlite is located on railhead in Antonito, Colorado, 25 miles north of the mine. It produces up to 200,000 short tons per year of sized crude perlite, over one-quarter of total U.S. output. Over 90% is shipped to expanders; 7% is expanded on-site.

The Harborlite mine is adjacent to Dicaperl's. Their ore is also trucked to Antonito for sizing and rail shipment. Output is comparable to Dicaperl's.

Dicaperl's Socorro mine has a similarly large capacity. It is estimated that 1995 sales will exceed 200,000 short tons; 98% of shipments are by rail.

The U.S. Gypsum operation at Grants is very small by comparison, with an annual throughput of less than 10,000 tonnes.

PRICING TRENDS

Wallace Bolen of the U.S. Bureau of Mines, and Peter Harben in the I.M. Handybook, report selling prices for 1989 through 1993 ranging from $29 to $31 U.S. per metric tonne, f.o.b. mine or plant. It would appear that major long-term contract customers have been successful in preventing any meaningful price escalation over the five-year period.

From discussion with other sources, however, it is learned that lower volume consumers are paying considerably more for sized raw ore, in the neighbourhood of $50 U.S. per short ton, f.o.b. mine or plant, in truckload quantities. While this increment of $20 or more is large, it is perhaps not atypical for industrial minerals commodities generally, where suppliers compete very aggressively for the high volume business they consider essential to sustain their desired operating rates.

Suffice it to say that pricing obviously varies from source to source, and also from any one producer as a function of grade, volume and competitive environment.

APPLICATIONS

The uses for expanded perlite are numerous and varied. In terms of overall U.S. consumption, Harbin shows almost 60% of all output going into formed products such as acoustic ceiling tile, pipe insulation and roof insulation board. Filter aids account for about 112% and horticultural uses 9%.

Regional markets can reflect quite different weightings. With no formed product plants in Western Canada, almost 100% of uncoated expanded perlite sales are directed at horticultural end-users.

In recent years, perlite has lost much of its beverage filter aid market share to diatomaceous earth. Further, there is little or no demand in the Pacific Northwest for perlite in lightweight concrete, either poured or pumped.

A very significant application for expanded perlite in North America is in coated microsphere form for use in lightweight joint cement. The minus 100 mesh, silicone-coated, low-density perlite particles repel water, retaining their cellular voids and dramatically reducing the weight of the applied coating. The microsphere product can cost as much as $1,000 Cdn per metric tonne, delivered to Vancouver. The total B.C., Alberta and Washington market is about 2,700 tonnes. There are only about three producers of this specialty value-added product in North America, all in the midwest and southwest states.

BRITISH COLUMBIA RESOURCES

The B.C. Geological Survey Branch lists 18 perlite occurrences in the Province in its MINFILE database compilation, some of which are located near tidewater but without road access. The interior deposits are generally readily accessible by logging road or better.

This overhead by White shows the location of several of these deposits -namely those with some commercial history or positive exploration and test data.

These showings were all investigated by Gary White of the B.C. Geological Survey Branch in 1989. The results were published in "B.C. Geological Fieldwork - 1989, Paper 1990-1, pp. 481-487". A year later, CANMET tested the expansion properties of the ores studied by White and published their findings in B.C. Geological Fieldwork - 1990, which can be summarized as follows:

1. Total weight loss during expansion:
   Frenier, near Clinton 3.6%
   Uncha Lake near Burns Lake 3.2%
   Francois Lake near Burns Lake 3.0%
   Port Clements Blackwater Creek 4.3%,
   Port Clements Gold Creek 7.9%

2. Softening temperatures ranged from 12401 to 1290'C
3. They confirmed White's conclusion that all of these perlite ores are expandable, stating that the Gold Creek ore had the best potential as a filler. Expanded bulk densities ranged from 16 to 58 lb, per cu. ft., Frenier having the lowest. All four samples had a raw density of about 150 lb. per cu. ft.

As noted earlier, the Francois Lake deposit was mined briefly in 1953, but no published property or product data is available.

The Queen Charlotte Island deposits near Port Clements remain relatively unexplored, but showed positive test results at CANMET, and are favourably located close to tidewater, with the potential for low cost barge or ship transport to processing facilities at or near expanded product market centres.

FRENIER DEPOSIT

There is a great deal of information available about the Frenier perlite deposit, about 80 km. north of Lillooet and 60 km west of Clinton, on the Chilcotin Plateau, on the west side of the Fraser River, some 4,000 ft above sea level, as shown on this overhead. It is well described in the GSB MINFILE and the B.C. Geological Fieldwork Reports of 1988 and 1989. Mining was carried out on the property by Aurun Mines Ltd. from 1983 through 1987**,** a total of 6,500 metric tonnes being removed and shipped by truck to Aurun's expansion plant in Vancouver where a variety of expanded products were produced and successfully marketed throughout B.C., particularly in the horticultural sector.

The Frenier ore analysis is similar to others, containing on a dry basis:

- 77% silica
- 12% alumina
- 5% potassium oxide
- 2% sodium oxide
- 1 % iron oxide

The Aurun reported PH of 8.3 is slightly higher than normal.

In addition to the high level of customer acceptance of Aurun's expanded Frenier products - they quickly dominated the B.C. market -its credibility was further enhanced by research done by Giles and Poling at U.B.C. wherein they determined optimum parameters for the manufacture of commercial filter aids grades of expanded perlite at Aurun, concluding that competitive products could readily be produced.

CONCLUSIONS

Markets for expanded perlite in Western Canada and the Pacific Northwest states are relatively stable and within industry sectors exhibiting better-than-average mid-term growth prospects.

There is a strong demand for raw perlite within the region, well over 30,000 metric tonnes per year. A substantial portion of the total, however, is vested in one northwest Oregon consumer.

At least one B.C. perlite deposit is of proven commercial quality and several others appear to have good potential.

Coated perlite microspheres represent a substantial dollar volume of business in the region - in excess of $2.5 million per year.

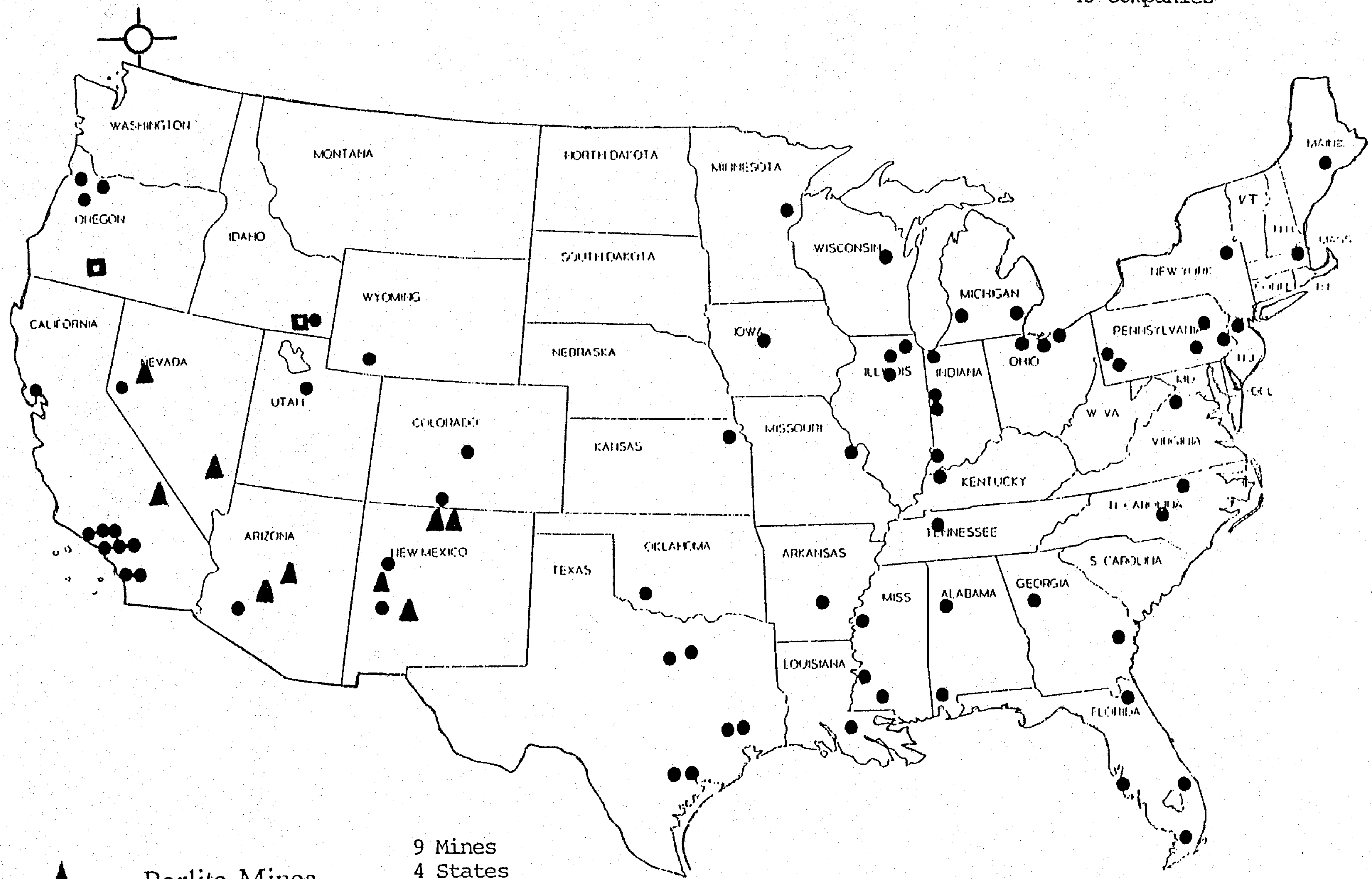
And now, in the time remaining, I would like to show some slides of the Frenier mine and the Aurun plant in Surrey, for which I am indebted to Bill Kure of Calgary, owner of the property.

/mcidgO17

1.

● Perlite Expansion Plants

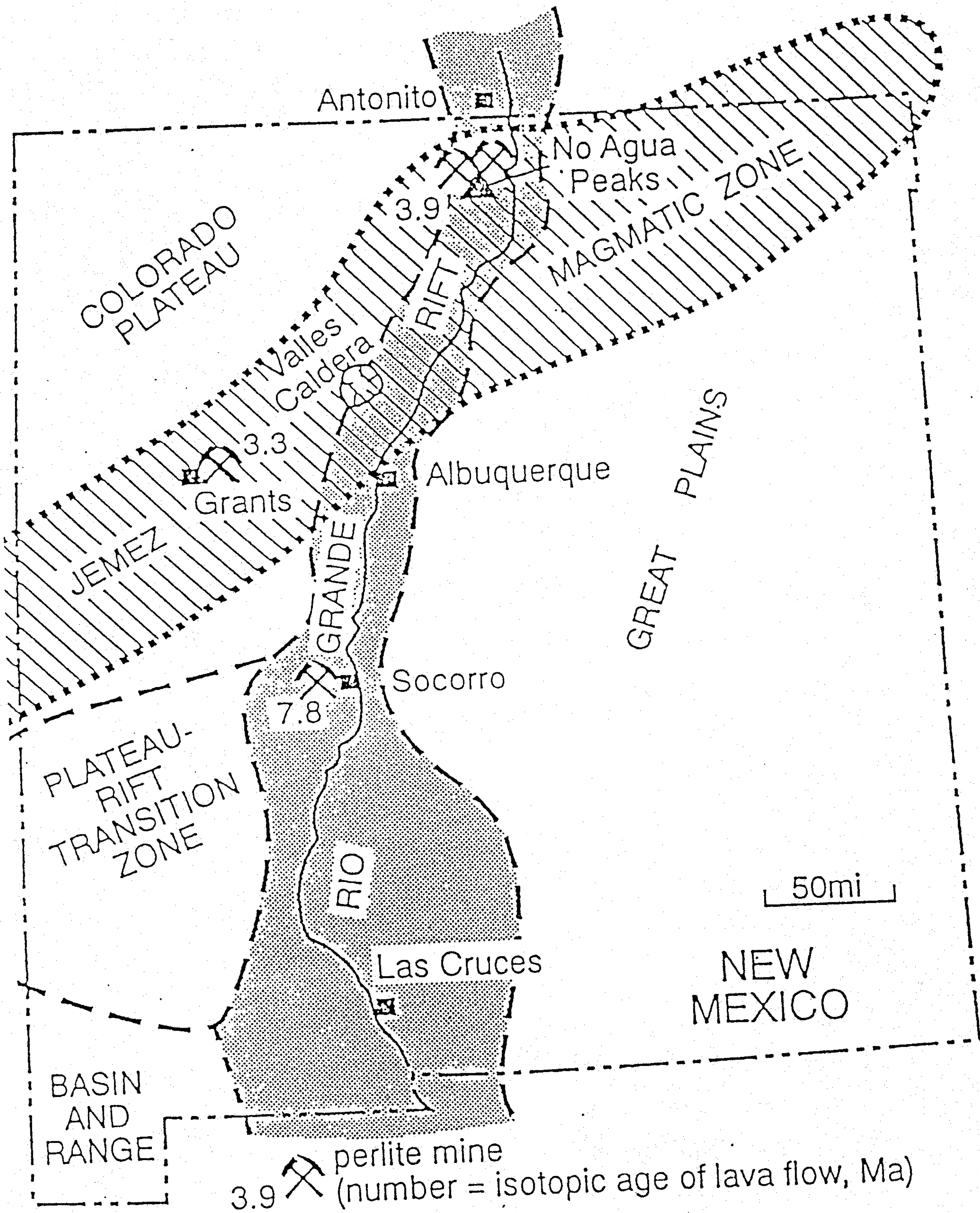
71 Plants
34 States
45 Companies



▲ Perlite Mines

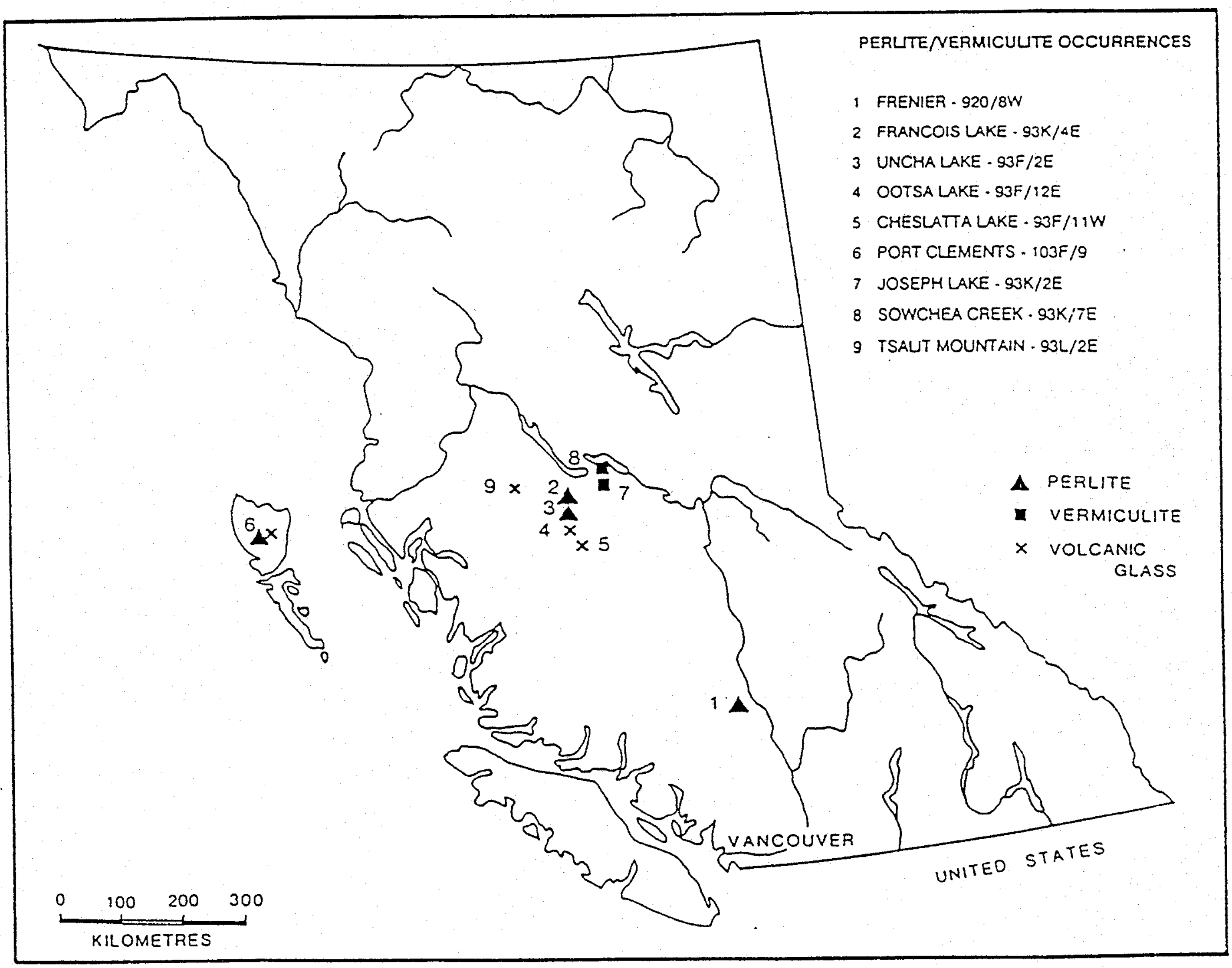
9 Mines
4 States
6 Companies

2.


Antonito
No Agua
Peaks
3.9
MAGMATIC ZONE
COLORADO
PLATEAU
RIFT
Valles
Caldera
3.3
Grants
Albuquerque
GREAT
PLAINS
JEMEZ
GRANDE
Socorro
7.8
PLATEAU-
RIFT
TRANSITION
ZONE
RIO
50mi
Las Cruces
NEW
MEXICO
BASIN
AND
RANGE
perlite mine
3.9 (number = isotopic age of lava flow, Ma)

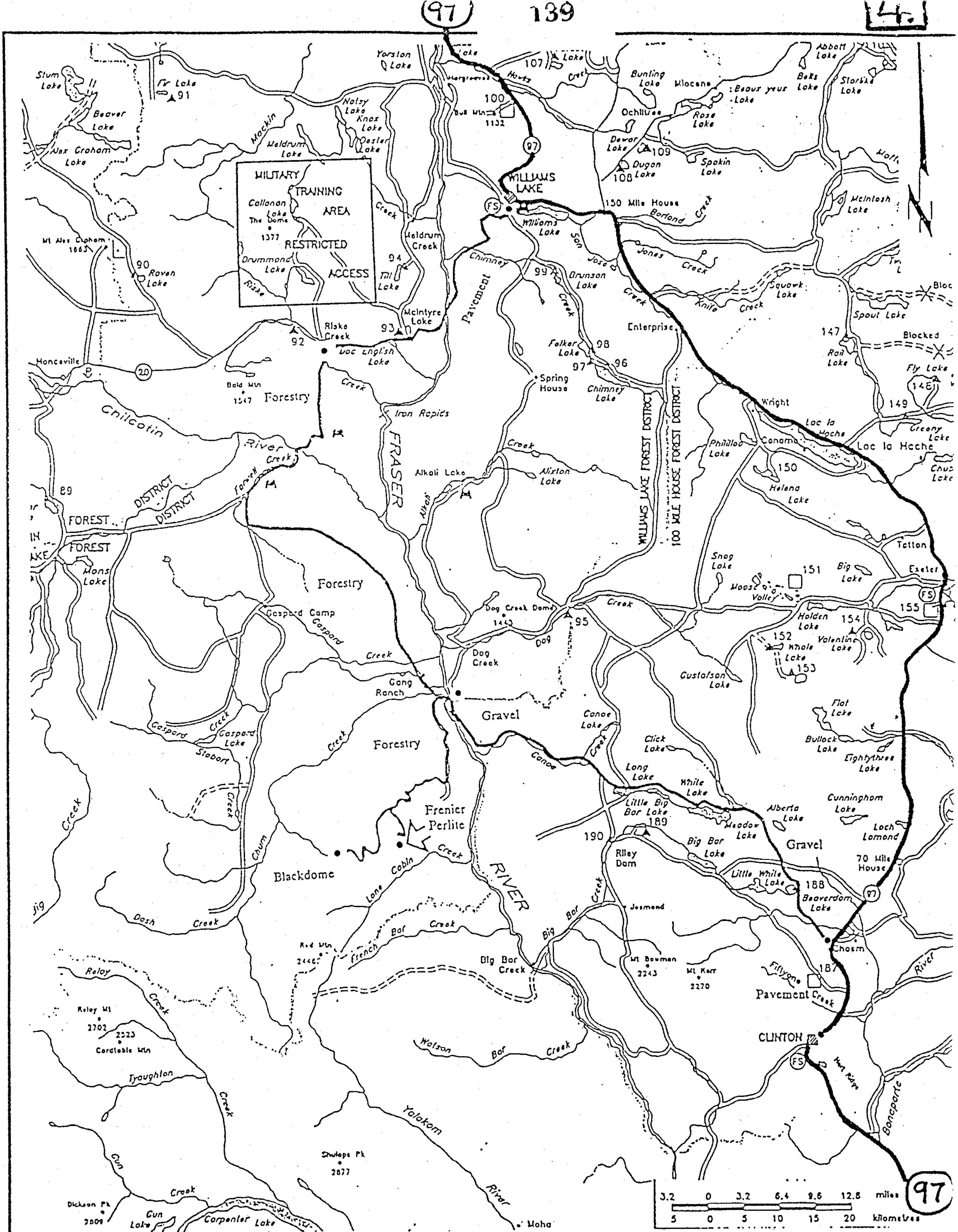
3.

Figure 4



Locations of perlite/vermiculite occurrences in British Columbia.

4.



ASSESSMENT REPORT FRENIER PERLITE DEPOSIT	May 1, 3 and 4 Claims Mining Lease 24	SITE ACCESS MAP
TERRACON GEOTECHNIQUE LTD.	Scale: 1:1,000,000	Figure 3

Short History of an Industrial Mineral Development

by

P. B. Aylen,
President,
Western Industrial Clay Products Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

What commercial users say about **STALL DRY:**

"**STALL DRY** made a world of difference in the atmosphere in the barns. I declined to comment immediately after the weekend sale because I wanted to wait and see if the **STALL DRY** had been effective. Thursday I was satisfied. I would say it worked really well. I just walked in the barn now, and you would never know the bulls were in there."

Kamloops Exhibition Association
Rob White - Groundskeeper

"I was on vacation and a friend was looking after my 10,000 layer chicken operation. He thought the ammonia was too strong so our pest control service tried **STALL DRY.** Returning after a few days, even I could notice a big improvement."

Ben Arends - Layer Chickens

"**STALL DRY** really controlled the odor and ammonia from my hutches. I gave **STALL DRY** a try and no more problem, **STALL DRY** really works. The rabbit droppings are used for my earthworms with good success. I also use **STALL DRY** with my silky chickens and it works so well that STALL DRY has increased our laying cycle."

Norm ***Schultz - Rabbit Breeder***

"**STALL DRY** has been a real bonus for my business to reduce ammonia for my clients livestock operations. It has assisted in my fly control programs with Beneficial Insects."

Lore Wolters - President, Western Pacific IPM, Livestock Fly Control

Is STALL DRY Available?

Ask your local store manager to bring some in for you.

The Absorbent Marketing Co. Ltd.
714 E. Sarcee St.
Kamloops, B.C.
V2K 1E7

For more information, please call us at:

1-800-667-0336

Product of Canada
Printed in Canada

Traps Odors

Neutralizes Ammonia

Absorbs Wetness in Barns, Pens, Cages & Trailers

STALL DRY is a natural clay absorbent and deodorizer with a pleasant minty, woody scent added.

Where to use:

Ammonia and odor absorbent STALL DRY may be used in cages, stalls and pens to trap odors, neutralize ammonia and absorb wetness.

Daily use of STALL DRY improves your animals comfort, may reduce bedding costs and clean-up time.

When transporting animals, reduce stress and discomfort by using STALL DRY in carrying cages, shipping kennels, horse and livestock trailers.

How to use:

Clean wet and soiled areas. Then cover wet areas with a thin layer of STALL DRY and spread bedding over top. STALL DRY may be used on rubber mats, wood, dirt or cement flooring.

Where to find STALL DRY:

Call us at l-800-667-0336 for the closest STALL DRY dealer.

STALL DRY works well with large and small animals.

"It's just great," says Dawn Brodie, Animal Health Technologist. "The Kamloops Wildlife Park uses it in all the large cat, grizzly, zebra and porcupine exhibits. Traditional stall products can be caustic to animals with pads on their feet so the STALL DRY is excellent for tigers and jaguar dens. Cats especially have a very strong smelling urine due to their ability to concentrate urine, the STALL DRY makes their den area very pleasant smelling."

Wildlife Park -
Exotic Animals

"STALL DRY keeps my runs and kennels clean and fresh. It has made the grooming so much easier, the dogs need very little bathing and their coats smell clean and fresh. We also use it for our pot bellied pig and it keeps our horse stalls so dry and odor free. Thanks again for this wonderful product."

Karen Hildebrandt –
K H Kennels & Dukhan Arabians

"We know STALL DRY is a wonderful product and wouldn't be without it, no more dusty lime clouds here! It's nice to have a home grown product that is inexpensive, easy to use and effective. Thank you STALL DRY."

The Kriegls –
Reg. Paint Horses

ADVANTAGES

STALL DRY is Better For You:

- Fast, effective ammonia and odor control
- Safe alternative to lime, safe for people and animals, cut your exposure to lime

STALL DRY is Better For Your Animals:

- Effective odor control means less odors which could attract fewer flies. Fewer flies will increase your animal's comfort.

STALL DRY Saves Money Too:

- STALL DRY spreads further and absorbs more
- You Need Less STALL DRY so less clean-up and less impact on the environment

STALL DRY does NOT:

- Burn the pads on animals feet when wet
- Corrode metal, wet or dry
- Swirl up into stinging white clouds into your eyes
- Clump and not spread evenly
- Mask the odor

Check it out today!

Produced in Western Canada for pet lovers everywhere

The WC Cat family of fine pet products is based on specialized formulations of natural clays. These clays have a natural chemical attraction for odorous substances in animal waste and act as superior odor-controllers. These products are produced in Kamloops, in the heart of British Columbia's sunny Southern Interior.

The Absorbent Marketing Co. Ltd. is very conscious of its environmental responsibilities. We have filed a reclamation bond with B.C.'s Ministry of Energy, Mines and Petroleum Resources. This guarantees that environmental impact will be minimized and the area will be reclaimed once mining is completed.

WC CAT LITTER

Cat Litter
Litiere Pour Chats

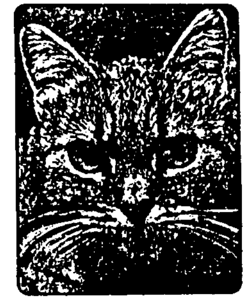
Natural & Superior Odor Control

WC Cat Litter is our original absorbent pet sanitation product. It provides a simple, cost-effective solution to litter box care.

WC Cat Litter's special diatomaceous clay has unmatched odor absorbing qualities. This superior natural product also absorbs moisture before it can collect in the bottom of the litter box. WC Cat Litter is formulated to minimize tracking and provides about 1/3 more litter box fills per bag than most competing products.

WC Cat Litter is packaged for easy handling and the paper and plastic bags are recyclable. Like other granular cat litters, this product should be changed regularly.

New Kozy Kitty Premium Blend Clumping Litter is a product for the pet owner who prefers a high quality clumping litter with all of WC Cat's superior odor controlling abilities.



A custom blend of natural days lets this litter form solid waste dumps when the litter is used, making litter box maintenance easy.

Kozy Kitty Premium Blend Clumping Litter is economical to use. Instead of refilling the litter box, simply remove the clumps of used litter. Kozy Kitty also provides more volume for the same weight than most competing clumping litters.

This litter is not toilet disposable.

Available in 5, 10 and 20 kg bags.

Kozy Kitty®
Premium Blend
Clumping Litter

WC CAT LITTER

Proudly Canadian

Crystals

WC Cat Flushable Clumping Crystals is a unique answer for the environmentally conscious pet owner who wants to dispose of animal waste neatly while avoiding the landfill.

Using the same odor-controlling raw material as WC Cat litter - with a special additvie to assist clumping -WC Cat Crystals allows the user to dispose of dumps of urine and solid waste in the toilet.

This product is not suitable for use with septic systems.

Available in 4 kg and 20 kg bags.

Printed in Canada

STALL DRY - We're not just for horses anymore!

Stall Dry is an innovative product developed for the special needsofthe horse industry to help control odor and ammonia in barns and trailers.

STALL DRY

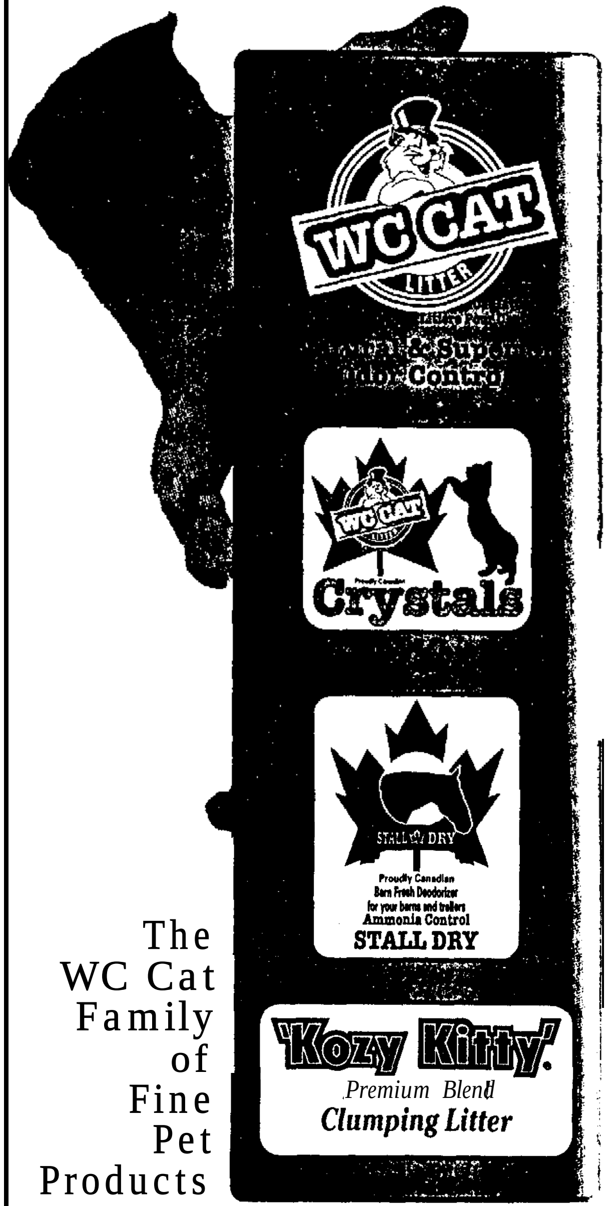
Proudly Canadian
Barn Fresh Deodorizer
for your barns and bailers
Ammonia Control
STALL DRY

Stall Dry's unique properties have turned out to be very useful as a bedding material additive to help control odor and ammonia in kennels and smaller animal cages. This product is also useful in chicken houses and piggeties.

Available in 2, 4 and 20 kg bags.

The Absorbent Marketing Co. Ltd.
714 East Sarcee St.
Kamloops, British Columbia
V2H 1E7
1-800-667-0336

You love your pets. Provide the very best



The WC Cat Family of Fine Pet Products

145

Zeolite Potential in British Columbia

by

P. B. Read,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

INDUSTRIAL ZEOLITE POTENTIAL IN BRITISH COLUMBIA

Peter B. Read

Geotex Consultants Limited: # 1200 # 100 W. Pender St., Vancouver, B.C., V6B 1R8

INTRODUCTION

The Metamorphic Map of the Canadian Cordillera (Read et al., 1991) shows that zeolite-bearing rocks are widespread in British Columbia (Fig. 1). They form the least metamorphosed parts of the Insular, Intermontane and Foreland belts of the Canadian Cordillera with a total area of about 18% of the province, but economic and geologic factors to be discussed reduce the search area for potential deposits of industrial zeolites. Industrial zeolites are those minerals of the zeolite group which are commercially used in industry. At present they include heulandite-clinoptilolite, mordenite, erionite and chabazite. Of the economic factors, easy access to a cheap and efficient transportation network on land and sea restricts the area of search to southern British Columbia, an east-west highway and railway corridor in central British between Prince George and Prince Rupert, and the coast, particularly the Queen Charlotte Islands. Geologic parameters favouring the development of industrial zeolites are suitable: (a) host rock composition; (b) syndepositional conditions of the host; and (c) post-depositional conditions affecting the host.

a) Host Rock Composition

Industrial zeolite deposits result from massive zeolitization of felsic to intermediate, aphanitic to glass-rich tuff and ash. Because it is important that the host rock should be highly permeable, even vesicular to scoriaceous flows can be a suitable though atypical host.

b) Syn-depositional Conditions of the Host

If a suitable tuff or ash is waterlain under terrestrial, not marine conditions, in a warm temperate to subtropical climate it may come in contact with Na, K and/or Ca-rich alkaline groundwater. Such waters will selectively dissolve the unstable glass shards and aphanitic volcanic fragments, and enhance the permeability of the original rock. Depending upon the composition of the host rock and fluids, a range of zeolites may develop. For example, in the Upper Cretaceous tuffs of the Sustut Group (Fig. 1), heulandite-clinoptilolite selectively develops within and immediately adjacent to rhyolite crystal-vitric tuffs where the waters are silica-charged from the dissolution of the glass (Fig. 2). The formation of laumontite, a nonindustrial zeolite, does not depend upon a high silica activity and its development is not proximal to the vitric tuffs. Whether the fluids are Ca, Na or K-rich will control whether heulandite (Ca-Al-rich end member) or clinoptilolite (Na, K or Si-rich end-member) respectively, will form. Indeed, whether a zeolite will form or not is largely dependent upon the chemcial potential Of C02 in the fluid (Albee and Zen, 1969; Thompson, 1971). If it is CO2-rich, clay minerals plus calcite are favoured over the compositionally equivalent Cazeolite.

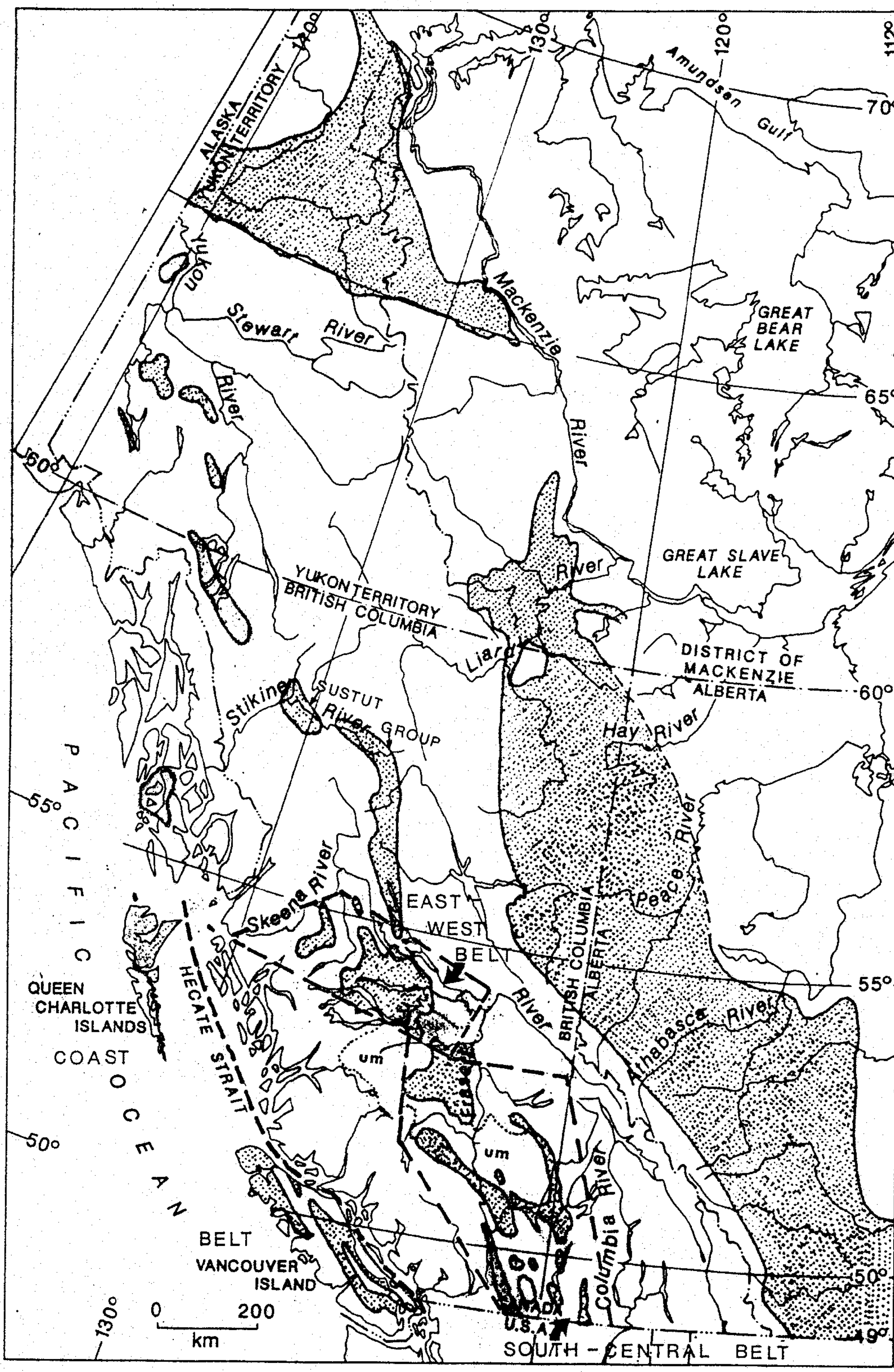


Figure 1: Distribution of zeolite facies rocks in British Columbia.

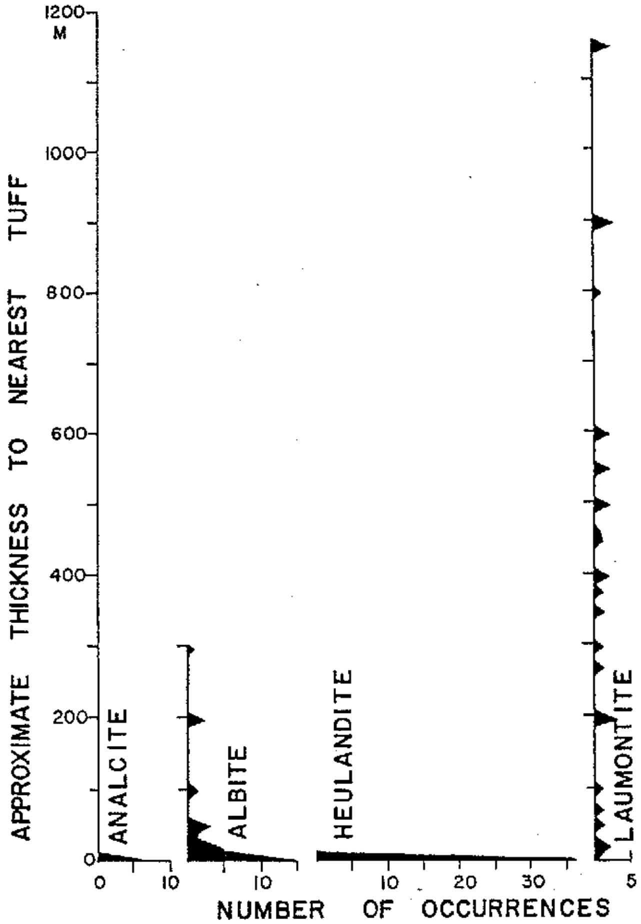


Figure 2: Distribution of analcime, albite, heulandite and laumontite relative to the nearest vitric tuff horizon in the Sustut Group (from Read and Eisbacher, 1974).

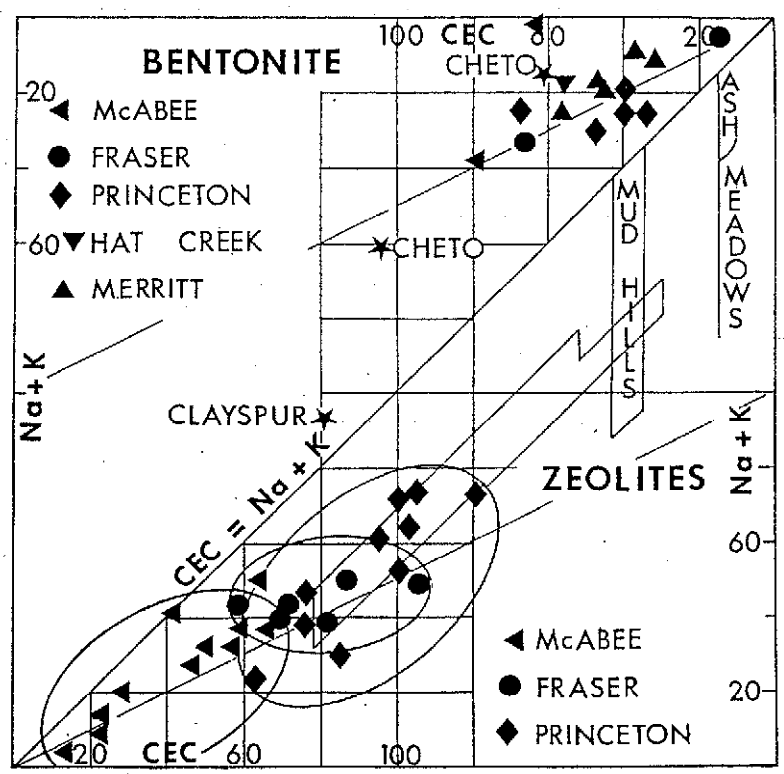


Figure 3: Na+K/CEC diagram of British Columbia zeolites and bentonites compared to some American producers (modified from Read, in press).

c) Post-depositional Conditions Affecting the Host

Industrial zeolites are highly hydrated with large diameter channels developed in their crystal structures. Zeolites with these characteristics are stable only in the low temperature and pressure portion of the zeolites facies. As judged by the organic maturity of interbedded coal in the sediments surrounding industrial zeolite showings, vitrinite reflectance values should be about 1.0 or less or the coal should have a rank of high volatile bituminous or less for industrial zeolites either to be formed or preserved (Read, in press). Although these conditions may not exist during or shortly after deposition of the host, as long as they are not exceeded after deposition, the potential for industrial zeolite deposits exists. For example, K-Ar whole-rock dating of the zeolitized vitric tuffs of the fossiliferous Brothers Peak Formation (Middle to Late Campanian to Early Maastrichtian or about 75-70 Ma) of the Upper Cretaceous Sustut Group yields mid-Eocene ages (55-50 Ma). The age difference implies that the formation of the massive heulanditeclinoptilolite occurred some 20-25 Ma after the deposition of the tuffs.

CHARACTERISTICS OF B.C. INDUSTRIAL ZEOLITE SHOWINGS

Taking into account the geographic and geologic factors outlined, the extensive Mesozoic and Paleogene volcanic and sedimentary rocks in British Columbia have the best industrial zeolite potential. The industrial zeolites consist of Cretaceous and Eocene showings in south-central British Columbia; a few occurrences in the east-west corridor, and the untested potential of the coast belt (Fig. 1). Showings of industrial zeolites in these rocks are dominantly heulandite-clinoptilolite with CEC values that range from less than 70 to 130 (Fig. 3). The typical host rocks are waterlain, rhyolite to dacite crystal-vitric tuff and ash in which the vitric portion is completely zeolitized. Although the presently known rocks with industrial zeolites range in age from Early Cretaceous (Albian) to Middle Eocene, the development of zeolites in rocks within a Late Triassic to Pliocene span may support extension of an industrial zeolite potential to rocks of the broader age range in restricted areas of the province. For example, in the Hecate Strait portion of the Queen Charlotte Basin, Galloway's report (1974) of laumontite in sedimentary rocks as young as Pliocene, in an area of presently high heat-flow, implies that a zeolite potential may exist in the Neogene as well as the Paleogene rocks of the Queen Charlotte Islands (Fig. 1); neither has been investigated properly for zeolites. However, many zeolites fill the amygdules of the Miocene and Pliocene Chilcotin plateau basalts, but the underlying and intercalated rhyolite vitric ashes and diatomaceous, lacustrine and paludal sediments are not zeolitized. The lack of zeolites indicates that the groundwater composition and/or the temperature-pressure conditions during later burial were inadequate for zeolite formation over a large area of southern and central British Columbia (area labelled um, Fig. 1).

INDUSTRIAL ZEOLITES AND THEIR POTENTIAL IN CRETACEOUS ROCKS

Although regionally developed, zeolitized rocks in British Columbia were known through the investigations of Surdam (1967a; 1967b; 1973), widespread industrial zeolites were unknown in the province until 1974 (Read and Eisbacher, 1974). In north-central British Columbia, the intercalation of waterlain, rhyolite vitric tuff and coarse conglomerate at the base of the Upper Cretaceous Brothers Peak Formation implies deposition in a high energy environment probably unsuited to the syngenetic development of zeolites. However, in the Middle Eocene, groundwater caused dissolution of the glass shards and their replacement by industrial zeolites at inferred temperature and pressure values not exceeding 65'C and 15-40 megapascals over an area of 4000 km' (Fig. 4). Nearby, a few vitrinite reflectance measurements (McKenzie, 1985) substantiate an elevated temperature.

Here and there in south-central British Columbia, Lower Cretaceous rocks, such as the Spences Bridge Group, contain industrial zeolites. In the volcanic rocks, zeolite amygdules, joint fillings and matrix replacements are widespread. Restricted to the lenses of waterlain felsic tuff and tuffaceous sediments, such as the Dot Member between Spences Bridge and Merritt (Fig. 1), massive zeolitization has produced industrial zeolites (Read, 1995). Cycles of crystal-lithic tuff grading up through several metres to zeolitized ash were deposited in a lacustrine environment (Plates I and 2). The assemblage of mordenite-analcime-quartz suggests that Na-rich waters, perhaps developed in a playa lake setting, were responsible for the zeolitization. Because most of the Lower Cretaceous rocks have undergone P-T conditions exceeding those suited to the development of industrial zeolites, the difficulty lies in defining felsic tuff-rich search areas that have undergone low P-T conditions. To date in south-central and coastal British Columbia, the sediment-rich stratigraphy of the Lower Cretaceous Jackass Mountain and Upper Cretaceous Nanaimo groups lacks both waterlain felsic tuff units and industrial zeolite showing.

INDUSTRIAL ZEOLITES AND THEIR POTENTIAL IN EOCENE ROCKS

The potential for industrial zeolite deposits is assessed best for the Eocene of south-central British Columbia. Here, several down-faulted blocks are the remnants of a formerly extensive sheet of Eocene sediments up to 2000 metres thick which stretched from the Princeton and Tulameen areas, through Merritt, Hat Creek, and Gang Ranch areas to the Quesnel area for a span of 450 kilometres (Figs. 5 and 6). Although waterlain crystal-vitric tephra occurs in the Princeton, Tulameen, Hat Creek and Gang Ranch blocks, only the Princeton block contains several clinoptilolite beds up to 20 metres thick and 4 kilometres long (Read, 1987; Plate3). The Tulameen block has a single zeolitized bed, and the fault blocks around Merritt have none (Read, 1988c). The two thick felsic tephra beds at Hat Creek lack zeolites, but instead contain montmorillonite + calcite (Read, 1990). Probably the C02-rich groundwaters derived from the thick limestone of the surrounding Marble Canyon Formation favoured the montmorillonite-calcite assemblage over a zeolite. Along the Fraser River, 100 kilometres to the northwest and distant from the Marble Canyon Formation heulandite-clinoptilolite reappears in the felsic tuffs south of Gang Ranch (Green, 1989; Read, 1988a; 1988d). North of Williams Lake, the Eocene has not been examined for industrial zeolites.

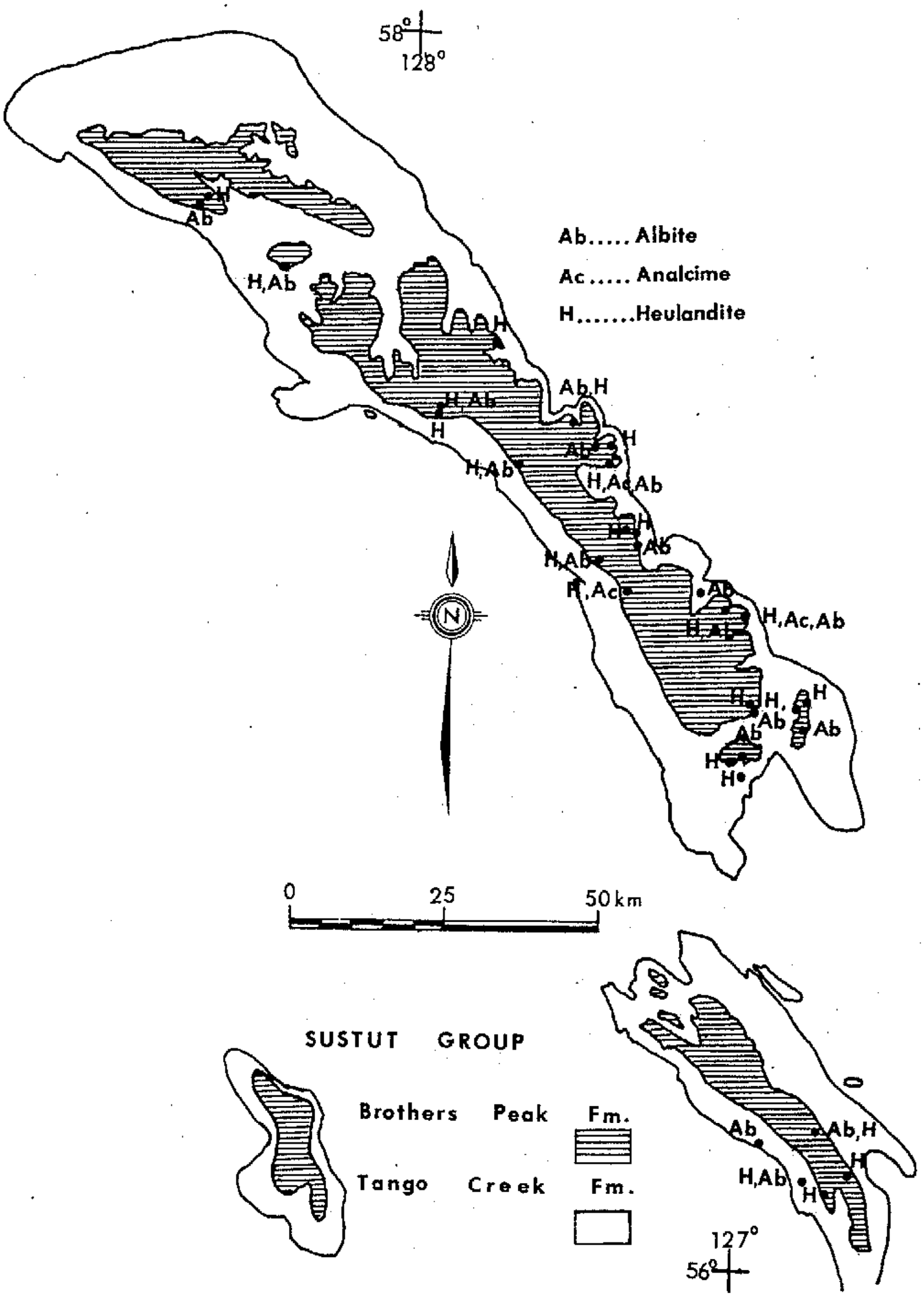


Figure 4: Regional distribution of heulandite, analcime and albite in the Sustut Group and the restriction of the industrial zeolite potential to the Brothers Peak Formation (modified from Read and Eisbacher, 1974).

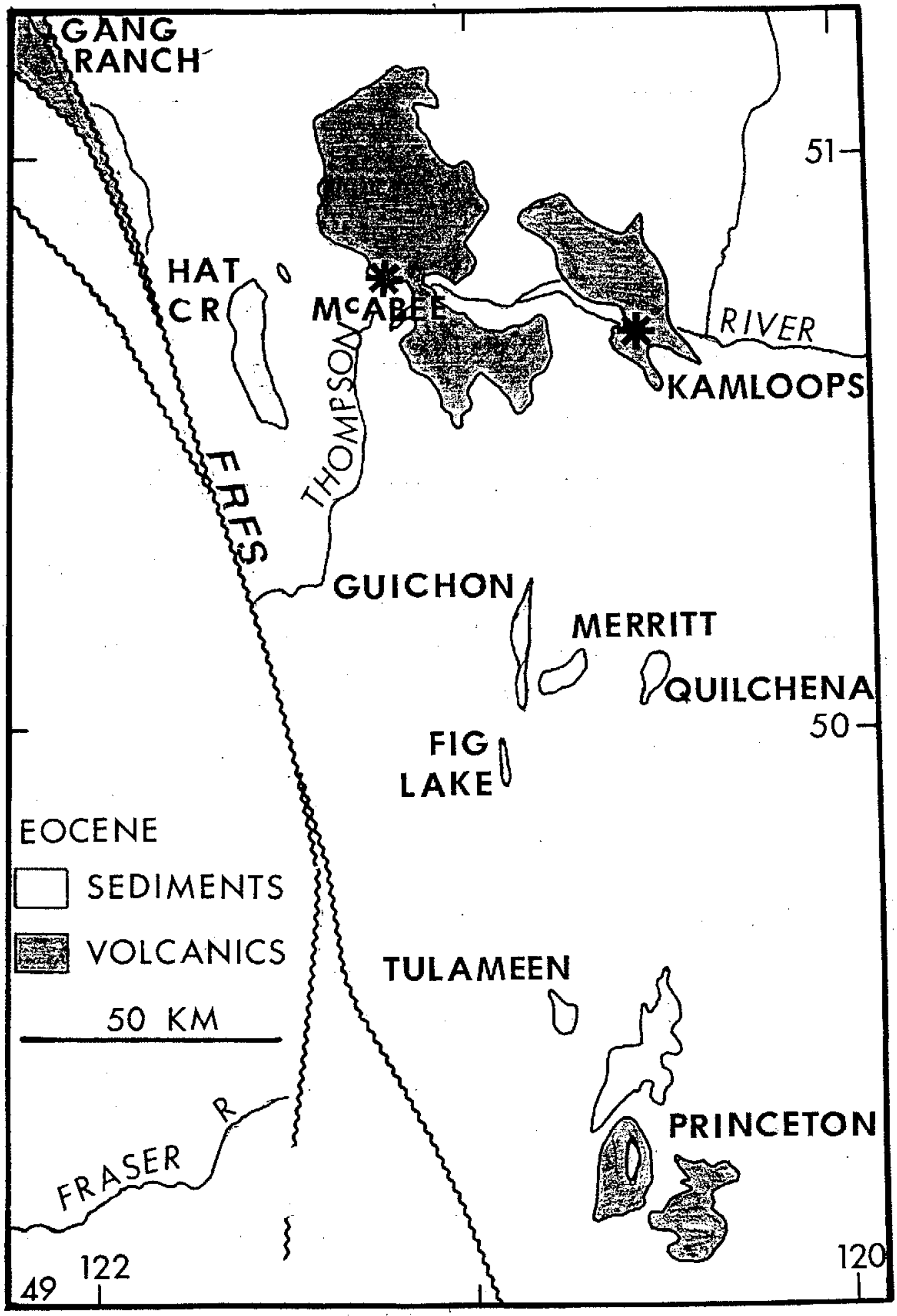


Figure 5: Regional geological map of south-central British Columbia showing the distribution of Eocene sediments and volcanic rocks.

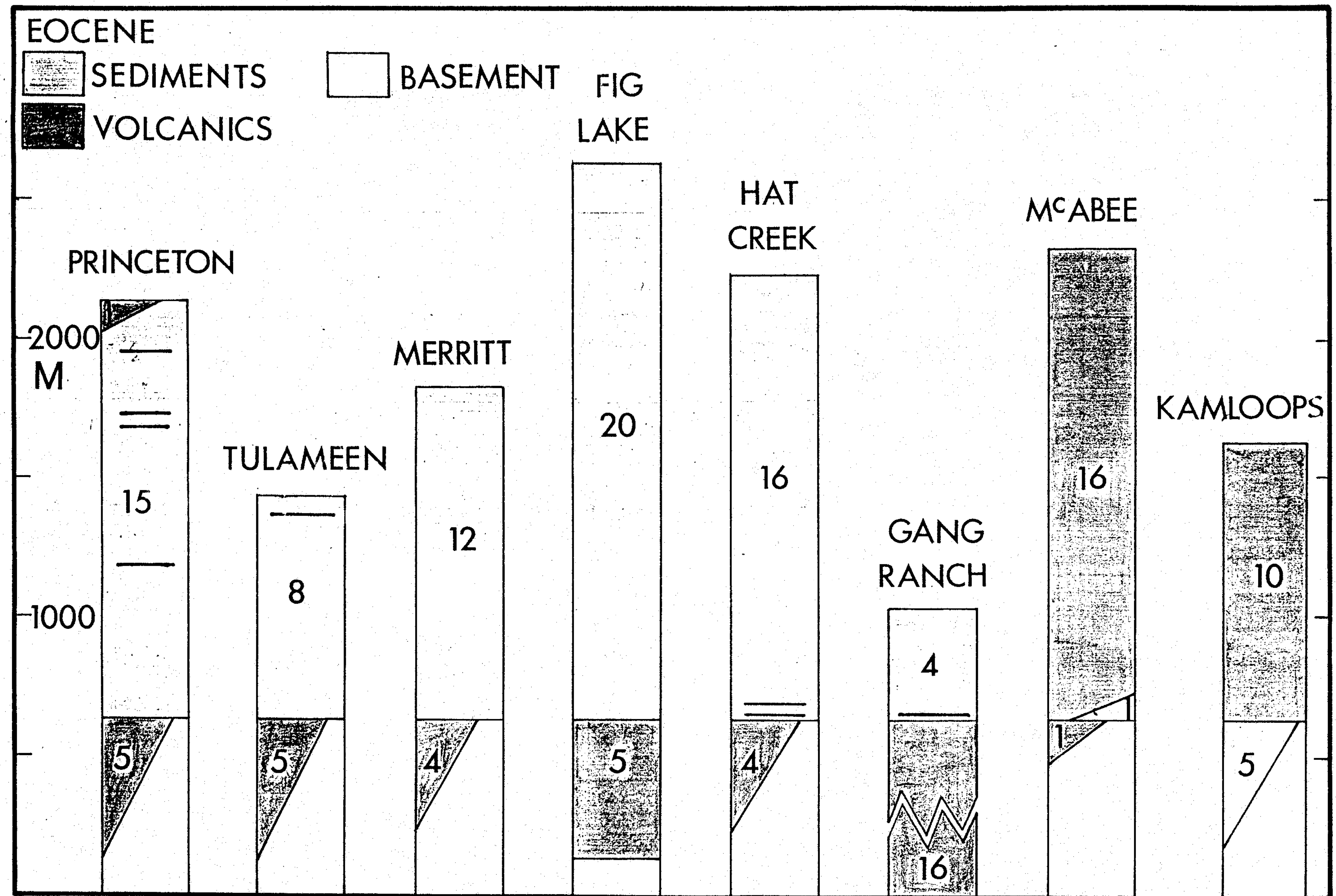


Figure 6: Stratigraphic columns of the Eocene blocks of southern British Columbia showing the thicknesses (in hundreds of metres) of the sediments, waterlain ash (black lines) and volcanics.

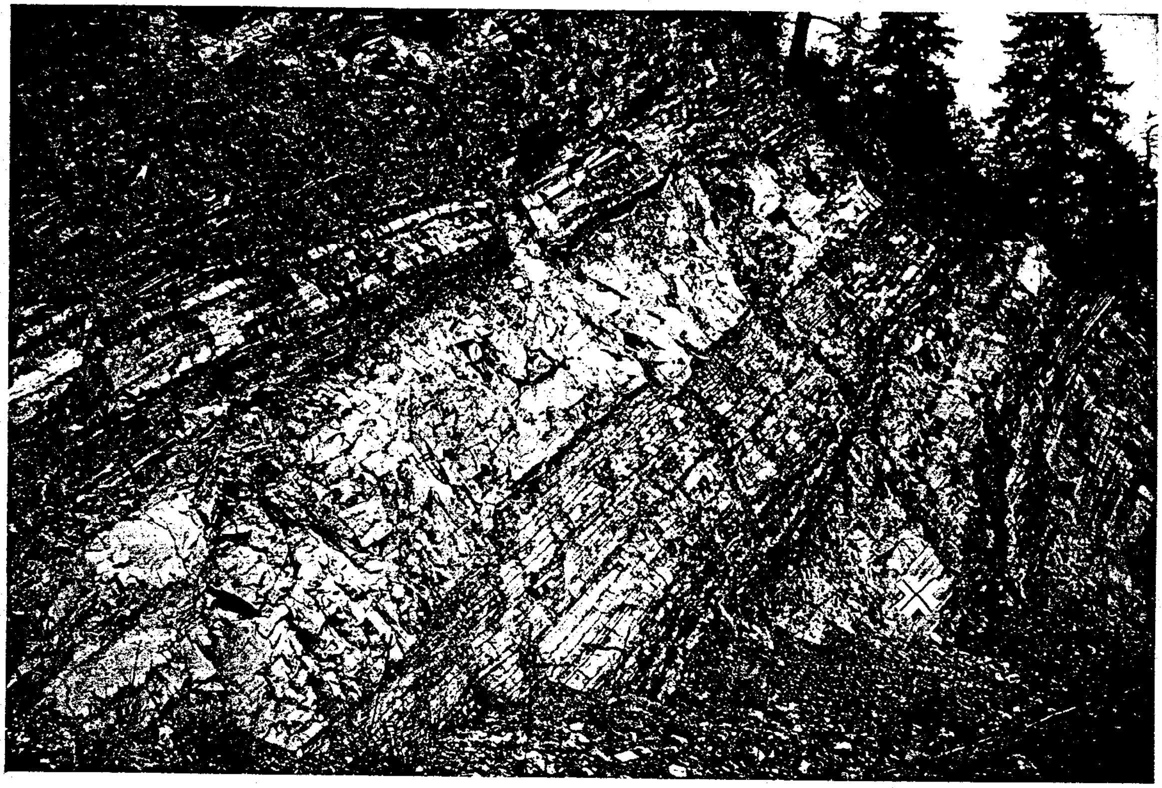


Plate 1: Exposure of the Dot Member showing four cycles of crudely layered lapilli tuff grading up to well bedded mordenite ash of the Lower Cretaceous Spences Bridge Group.

Plate 2: Detailed view of the mordenite-analcime-quartz ash from the X in Plate 1.

Plate 3: On the southern Trans-Provincial Highway 5.0 kilometres southwest of Princeton, a roadcut exposes a 13 metre thickness of the clinoptilolite-rich Tailings Ash of the Eocene Princeton Group.

Plate 4: At McAbee, on the Trans-Canada Highway 8.5 kilometres east of Cache Creek, is a white-weathering lens of heulandite-clinoptilolite altered tuff near the base of the Eocene Kamloops Group.

Lying east of the sediment-rich fault blocks is a thick Eocene volcanic succession containing thin lenses of tuffaceous sediments within 500 metres of the base. At McAbee (Fig. 5), lacustrine-deposited, felsic tephra lenses are variably altered to heulandite-clinoptilolite (Read, 1988b; 1988e; 1989; Plate 4). Because waterlain vitric tuffs lenses are few and thin in the sedimentary lenses farther east near Kamloops and Chu Chua, south of McGlashan Lake and northwest of Falkland, the heulandite-clinoptilolite showings are small. In the Okanagan Lake area southeast of Kamloops, Hora and Church (1986) substantiated the well-known occurrences of zeolites in the fractures and amygdules of the Eocene flows and noted the preferential development of clinoptilolite in volcaniclastic rocks, but did not discover any industrial zeolite occurrences. The waterlain felsic tuffs, widespread in the Eocene Kettle River Formation, were not tested in this x-ray diffraction study of 25 samples. X-ray diffractograms of porcelaneous ash-tuffs, from the Kettle River Formation exposed in the Phoenix open pit, indicate massive mordenite (Read, unpublished data). Northwest of Kamloops, exposures of a zeolitized felsic tuff east of Horsefly on Black Creek road (Lay, 1930) show that an industrial zeolite potential may exist in the Eocene felsic tuffs in the east-west corridor (Prince George to Prince Rupert) at places such as Cheslatta. Falls and Nazko where waterlain felsic tuffs are found (Rouse and Mathews, 1988). The corridor has not been investigated.

In the Queen Charlotte Islands of the coast belt, zeolitized tuffs have not been reported from the Tertiary in spite of the suitable bulk composition of the rocks and range in organic maturity. Although I made a petrographic and x-ray diffraction examination of hundreds of volcanic rocks collected by Sutherland Brown (1968) during his study of the islands, zeolitized rocks were absent. Because the collected samples were as fresh as possible, his collections probably selectively excluded zeolitized rocks and this area, so close to tidewater, requires further investigation of its industrial zeolite potential.

EPILOGUE

Today, 22 years after the first report of widespread industrial zeolites in northern British Columbia, all the industrial zeolite showings defined during and after the First Canada/British Columbia Mineral Development Agreement (1985-1990) are staked. Several properties in the Princeton and McAbee areas have been bulk sampled with test shipments exceeding 100 tonnes each. By the turn of the millenium in British Columbia, a producing, industrial zeolite deposit is possible, even probable, and more deposits await discovery.

REFERENCES

Albee, A.L. and Zen, E-An (1969): Dependence of the Zeolitic Facies on the Chemical Potentials of CO, and H20; *in* Zharikov, V.A., editor, *Contributions to Physico-Chemical Petrology* (Korzhinskii volume), pages 249-260.

Galloway, W.E. (1974): Deposition and Diagenetic Alteration of Sandstone in Northeast Pacific Arc-Related Basins: Implications for Greywacke Genesis; *Geological Society of America,* Bulletin, volume 85, pages 379-390.

Green, K.C. (1989): Geology and Industrial Minerals in the Gang Ranch Area; unpublished M.Sc. thesis, *The University of British Columbia,* Vancouver, B.C., 107 pages.

Hora, Z.D. and Church, B.N. (1986): Zeolites in Eocene Rocks of the Penticton Group, Okanagan-Boundary Region South-Central British Columbia (82E); *in* Geological Fieldwork 1985, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1986-1, pages 50-55.

Lay, D. (1930): Volcanic Ash; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Minister of Mines Annual Report 1929, page C195.

McKenzie, K.L. (1985): Sedimentology and Stratigraphy of the Southern Sustut Basin, North Central British Columbia; unpublished M.Sc. thesis, *The University of British Columbia,* Vancouver, B.C., 120 pages.

Read, P.B. (1987): Tertiary Stratigraphy & Industrial Minerals, Princeton & Tulameen Basins, British Columbia; B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 1987-19.

Read, P.B. (1988a): Industrial Minerals in Tertiary Rocks, Lytton to Gang Ranch, Southern British Columbia; *in* Geological Fieldwork 1987, B.C. *Ministry of Energy Mines and Petroleum Resources,* Paper 88-1, pages 411415.

Read, P.B. (1988b): Industrial Minerals in the Tertiary of Bonaparte to Deadman River Area, Southern British Columbia; *in* Geological Fieldwork 1987, B.C. *Ministry of Energy, Mines and Petroleum Resources,* Paper 88-1, pages 417-419.

Read, P.B. (1988c): Tertiary Stratigraphy & Industrial Minerals, Merritt Basin, British Columbia; B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 88-15.

Read, P.B. (1988d): Cenozoic Stratigraphy and Industrial Minerals: Fraser River, Lytton to Gang Ranch, Southwestern British Columbia; B.C. *Ministry Energy, Mines and Petroleum Resources,* Open File 88-29.

Read, P.B. (1988e): Tertiary Stratigraphy & Industrial Minerals, Cache Creek, British Columbia: B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 88-30.

Read, P.B. (1989): Tertiary Stratigraphy & Industrial Minerals, Bonaparte to Deadman Rivers, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1989-2 1.

Read, P.B. (1990): Tertiary Stratigraphy & Industrial Minerals, Hat Creek, British Columbia; *B. C Ministry of Energy, Mines and Petroleum Resources,* Open File 1990-23.

Read, P.B. (1995): Geological Mapping and X-ray Diffraction Analysis, MAN Claim and Surroundings, Nicola Valley, Kamloops Mining Division; private report, *Geotex Consultants Limited,* 19 pages, 2 appendices.

Read, P.B. *(in press):* Geology and Industrial Minerals of the Tertiary Basins, South-Central British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin.

Read, P.B. and Eisbacher, G.H. (1974): Regional Zeolite Alteration of the Sustut Group, North-Central British Columbia; *Canadian Mineralogist,* volume 12, pages 527-541.

Read, P.B., Woodsworth, G.J., Greenwood, H.J., Ghent, E.D. and Evenchick, C.A. (1991): Metamorphic Map of the Canadian Cordillera; *Geological Survey of Canada,* Map 1714A, Scale 1:2 000 000.

Rouse, G.E. and Mathews, W.H. (1988): Palynology and Geochronology of Eocene Beds from Cheslatta Falls and Nazko Areas, Central British Columbia; *Canadian Journal ofEarth Sciences,* volume 25, pages 1268-1276.

Surdarn, R.C. (1967a): Low-Grade Metamorphism of the Karmutsen Group, Buttle Lake area, Vancouver Island, British Columbia; *University of California,* Los Angeles, 313 pages.

Surdam, R.C. (1967b): Low-Grade Metamorphism of Tuffaceous Rocks in the Karmutsen Group, Vancouver Island, British Columbia; *Geological Society of A merica,* Bulletin, volume 84, pages 1911-1922.

Sutherland Brown, A. (1968): Geology of the Queen Charlotte Islands British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 54, 226 pages.

Thompson, A.B. (1971): PC02 in Low-Grade Metamorphism; Zeolite, Carbonate, Clay Mineral, Prehnite Relations in the System CaO-AI203-SiO2-CO2-H20; *Contributions to Mineralogy and Petrology,* volume 33, pages 145-161.

Holnam West Materials Ltd. Limestone Quarry- Texada Island

by

P M Stiles,
Vice-President,
Holnam West Materials Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Holnam West Materials Ltd.

Limestone has many uses and is an essential raw material in any developed society. The production of basic building materials, such as steel, base metals, pulp, glass, portland cement, and lime, consume large quantities of limestone providing the primary components of any community's physical growth and development.

Pulverized or precipitated white limestone has become an increasingly important industrial mineral filler for many manufactured products such as paint and other coatings, joint cement, drilling muds, plastic pipe, and fine paper.

Other growing markets that are adding to the demand for limestone include waste gas desulphurization, soil conditioning, and acid rock drainage neutralization. The almost galloping pace of environmental regulation and control is doubtless going to provide everincreasing demands for limestone and lime across a broad range of specifications.

Thus it is common to find limestone mining operations within relatively small economic zones, as it was a century ago when marbleized stone was such an important building material. Then, as now, transportation costs played a very strong role in the location of these operations. unlike deposits of precious and base metals, many high grade limestone properties remain unexploited because of distance from viable markets. It is interesting to see how this relationship has played out in the Pacific Northwest.

Holnam West Materials, and it's predecessor, Ideal Cement Company Ltd., has quarried limestone on Texada island since 1956.

Texada Island is located some sixty miles north of Vancouver, B. C. in the Georgia Strait between Vancouver Island and mainland British Columbia. It is thirty miles long in a northwest, southeast direction and is four to five miles across.

The majority of the limestone is found in the northern third of the island. The portion of this limestone being quarried by Holnam is described as the lower member and possibly part of the middle member of the Triassic marble Bay formation. The strata dip 10 to 12 degrees northeasterly and strike northwesterly. Several faults trending North 10 degrees West have fractured and offset the formation. Dykes trending in the same direction have been intruded during at least two separate periods.

Within the quarry area, dykes appear to occupy nearly vertical fracture zones, particularly those which are 10 to 15 feet thick. These dykes trend North 15 degrees West and are commonly resistant to erosion. Smaller dykes ranging from I to 3 feet, either crosscut the larger dykes at about North 45 degrees West or run parallel to them. These dykes erode slightly below the limestone surface and show no indication of past intrusive faulting.

The limestone can be described as medium to dark grey, even textured and cryptocrystalline. Minute irregular veinlets containing minor amount of silica and pyrite are present but are not readily apparent to the eye. This high quality chemical grade limestone is being used by pulp mills, smelters and in the manufacture of cement and high purity chemical grade lime.

Limestone quarries have been a facet of Texada living since the early 1890's, initially for flux for a local copper smelter, subsequently, and still early on, for other shoreline smelters on Vancouver Island pulp and paper mills up and down the Coast. Lime kilns were constructed on Texada Island - originally vertical kilns fired with wood then a rotary kiln fired with oil. Burning of lime locally halted in the mid 50's. Raw, sized stone was then shipped to lime plants in Tacoma and Portland from the Blubber Bay Quarry, now operated by Ash Grove Cement.

B. C. Cement (now Tilbury Cement) supplied their small cement plant on Vancouver Island at Bamberton from a quarry on the north end of Texada near Blubber Bay during the 1930's, 40's and 50's. A new quarry was opened at Cobble Hill and the Texada quarry operation was closed down.

Cement-grade limestone production began on Texada in earnest in 1956 when Lafarge began shipping limestone to a new cement plant in Richmond from the quarry south of Van Anda. Nearby, Imperial Limestone has continued operations since the early 50's, supplying specialty limestone markets. Ideal began shipments to the Grotto Cement plant in Washington State in 1966 and then to it's Seattle cement plant which made it's first cement in March 1967. This amount of cement-grade limestone, some 500,000 tonnes/year, gave the quarry the opportunity to expand.

Increase in demand for rip rap (over 200,000 tonnes in 1968) and other limestone products gave the Company a new credibility in the eyes of senior management. In 1972, a new crushing, screening, conveying, stockpiling, reclaiming, and barge loading facility was approved and commissioned in 1973. It is still operating today.

The present quarry covers an area of approximately 100 acres with a limestone depth potential of over 700 feet where it lies on the Karmutsen volcanic basement. The volcanics have a similar dip and strike generally to the limestone.

Down-the-hole drilling provides the 8-inch boreholes for blasting with ANFO or high explosive. A smaller track-type hydraulic drill is used for pioneering work. Bench heights average 33 feet. Front-end loaders and trucks feed an impact crusher in closed screening circuit at a capacity rate of 800 tonnes per hour to produce a minus three-inch product. This product is stockpiled and shipped to cement plants or to aggregate users in the Lower Mainland. Chemical grade limestone is crushed in the same system with a twoinch minus product being processed further on two 8'x2O' double decked screens.

Four crushing plants area used to reduce the blasted rock to customer specifications. Four loading facilities on the west side of Texada Island put the quarry production on the customer's barge. One of these is capable of loading deep sea vessels and is currently used to load coal from the Quinsam Mine near Campbell River. Panamax sized vessels are now being loaded and the capability is there to load Cape sized. Another facility, a ramp, allows the loading of rip rap and the unloading of coal directly by truck to or from barge. Coal is stockpiled on site for shipment overseas.

The million tonne shipping threshold was crossed in 1972, the 2,000,000 in 1987 and the 3,000,000 in 1992.

Current limestone shipments amount to some 2,700,000 tonnes per year, rip rap and construction materials 600,000 tonnes per year, and coal 480,000 tonnes per year. For the last five years, Holnam is also producing white limestone for the Huber's plant in Seattle. Ground product is used for a variety of filler applications. The property has reserves for many years to come and it's strategic location on tide water assures it's future as a raw material supplier and handler of basic commodities.

Garnet Market Potential in Western Canada and United States

by

D. G. Lobdel,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Paper presented 19 October 1995 at:

Focus on British Columbia Industrial Minerals

Industrial Minerals '95

Vancouver, BC

Potential For Garnet Production in British Columbia

Introduction

It is a pleasure to give this paper today, for it gives me an opportunity to clear up a few common misconceptions about garnet, and to share with you new information and my sense of direction for the garnet industry. Garnet has historically been a small specialty minerals business in the hands of a few individuals, and most of the information about the commercial aspects have either come from promotional commercial literature, or the US Bureau of Mines.

One of the most irritating misconceptions long perpetrated by the US Bureau of Mines is that almandite commercially available from Barton Mines in New York is high-quality garnet, and that almandite from Emerald Creek is low-quality garnet. I will get back to these issues at the end of the paper, but for now I would like to present a general overview of the garnet business, both historically, and its current state. I will conclude with my assessment of the opportunities presented by garnet production worldwide, and specifically in British Columbia.

Let us Start out with a some background information, Garnet is not a mineral, but a group of minerals. Commercially, garnet is valued for its high hardness (6.5 to 8.0 on the Mohs scale), and its high density (with specific gravities ranging from 3.4 to 4.2). Table 1 below summarizes the properties of the six most common varieties of garnet:

Table 1: Properties of the Six Most Common Varieties of Garnet

Variety	Ideal Formula	Hardness	Specific Gravity
Almandite	$3FeO\text{-}Al_2O_3\text{-}3SiO_2$	7.5	3.9 -4.2
Grossularite	$3CaO\text{-}Al2O_3\text{-}3SiO_2$	7.0	3.5 - 3.7
Pyrope	$3MgO\text{-}Al2O_3\text{-}3SiO_2$	6.5 - 7.5	3.5 -3.8
Spessartite	$3MnO\text{-}Al_2O_3\text{-}3SiO_2$	7.0 - 7.5	4.1 -4.3
Andradite	$3CaO\text{-}Fe_2O_3\text{-}3SiO_2$	6.5 - 7.0	3.7 - 3.8
Uvarovite	$3CaO.Cr_2O_3\text{-}3SiO_2$	7.5	3.4 - 3.5

Of these varieties of garnet, almandite is at the high end of the ranges for hardness and density, and is one of the most common varieties. Thus it should not be surprising that it would be the garnet of greatest commercial significance.

Commercial almandite never consists entirely of almandite, but rather the almandite is to some extent in solid solution with the other garnet varieties, as well as being a dominant constituent in a mixture of minerals, especially with other garnet varieties, staurolite, and contaminating minerals that have not been totally removed during beneficiation. (Note- So long as staurolite is a relatively minor constituent, commercially there is no distinction between garnet and staurolite, since their physical and chemical properties are nearly identical.) The possibilities for trace amounts of non-garnet minerals (contaminants) are numerous, but the most Common are quartz, feldspar, mica, magnetite, ilmenite, and pyrite/pyrrhotite. These contaminants are present as both distinct grains, as well as 'inclusions within the garnet crystal.

Commercial almandite typically is produced from rocks resulting from high-grade regional metamorphism, possibly some unusual coarse-grained igneous rocks, and placer deposits derived from these parent materials. Another commercial garnet consisting of principally andradite with lessor amounts of grossularite and pyrope Is produced from skarns (metamorphic rock resulting contact metamorphism by siliceous intrusions into carbonate rock). Skarn garnets are inferior in terms of both hardness and density to almandite, but find utility in that they are relatively cheap to produce (deposits are often large, with relatively little waste, and the garnet often represents a by-product of some other mineral production, such as wollastonite or metals).

Potential for Garnet Production in British Columbia

The principal markets for garnet all capitalize on the relatively high density and hardness. In water filtration garnet is valued for its density in a multi-media filters, as well as its chemical inertness, insolubility, and its non-toxic nature. As an abrasive, garnet is valued for its moderately high hardness (intermediate to inexpensive silica sand and the expensive synthetic abrasives, its inherent grain toughness (allowing It to recycled up to six times), and its low silica content (less than 1%). As an interesting aside, all varieties of garnet find their way into gem markets (it is the birthstone for January).

Historical Review

Garnet has a long history of production in the United States, beginning in 1878 with Barton Mines in upstate New York, where it was first produced as an abrasive. The material from Barton is rather unique, even today, in that it fractures into sharp, chisel-shaped particles as it breaks down in use, in effect always presenting a fresh, highly abrasive surface throughout its use. Or so the story goes (Barton also has a long history of providing commercial lore to its customers about how unique their material is, sometimes without technical basis). The Barton operation can be classed as a high-cost, high-quality producer, especially of very specialized materials which command a selling price ranging from US$300 to $2,000/ton. The operation probably grosses about $10-million/year on sales of 15,000 to 25,000 tons annually. The operation Is also somewhat unusual in that it is an underground hardrock operation working with grades of up to 80% garnet, principally almandite.

The markets for Barton's garnet is quite distinct from those of commercial garnet *in* general, and relate largely to high-end abrasive markets such as coated abrasives, micro-abrasives in electronic applications, pioneer market development in water-jet Cutting, and small scale cleaning and de-burring.

in the late 1930's and early 1940's, garnet production commenced in Idaho, particularly from two operations in the Panhandle which merged in the 1960's to become the present day Emerald Creek Garnet Company. These -materials come from placer deposits in several small creeks near Fernwood which are derived from pelitic Belt Series sediments which have undergone high-grade metamorphism to garnetiferous, quartzo-feldspathic, mica schists on the margin of the Idaho Batholith. A hardrock almandite deposit operated briefly in the early 1980's in Maine, and there is historic production reported from California, Connecticut, Florida, New Hampshire, North Carolina, and Pennsylvania. And finally, there is byproduct andradite and grossularite from NYCO's New York wollastonite operation.

While the Barton material has been the world's premier material In terms of cost, the Emerald Creek material has been the premier material in terms of the world's largest producer in terms of tonnage. I do not have any inside information to support this figure, but my estimate is that Emerald Creek produces 40,000 to 50,000 tons annually, selling for an average price of $180/ton in bulk, FOB Fernwood, Idaho. This scale has not always been the case- Until the rnid-1960's, it is thought that total production from Idaho was never over 5,000 tons annually. Much of early production was probably as a sand blast media, and Boeing was probably a major regional customer.

The 1970's saw the beginnings of new markets related to the new "environmental consciousness" and developing new technologies, which resulted in an overall growth in sales of about 10% annually. The first was the development of the trimedia filter for industrial wastewater and municipal drinking water. Greatly simplified, the tri-media filter consists three sands varying in grain-size and density. The first layer (from the bottom up), consists of tine-grained garnet sand (s.g. ~ 4.0), a medium-grained silica sand (s.g. ~2.65), and finally, a coarse-grained hard coal (s.g. ~1.7). Often these lie upon a coarse "under-drain" material composed of coarse garnet. The objective of all this is for the coarse top layer to filter out the coarsest particulate, and the bottom most media, the finest particulate.

The benefit over a single-sized filter media is that the tri-media filter does not become clogged as readily, as sediment is trapped throughout the bed depth, whereas single media filters tend to clog quickly at the surface first encountering the particulate. Thus, the tri-media filter requires less frequent backwashing, and less water to complete a backwash, on the order of 1/10 in many cases. This results in greater economy of operation. As well, it becomes more practical to remove the finer particulate, as the garnet becomes a "polishing" layer removing all but the finest sediment and micro-organisms,

In the 1980's, concerns over the hazzards of silica reached fanatic levels, and legislation resulted in increased substitution of garnet for silica, especially in enclosed sand blast situations, such as ships and petroleum tank farms.

In the 1990's, new markets have resulted from a new technology, abrasive waterjet cutting. While this market is currently small, it is growing rapidly, and opens up higher-value markets. There are currently few substitute materials in significant use.

The acquisition of Emerald Creek Garnet Company by Hawkeye Resources, now Western Garnet Company, together with a 10% annual growth rate of garnet markets for several decades, spawned considerable interest in garnet by numerous US. and Canadian companies, and there promises to be garnet production from several new operations which have, or are about to, come into production,

Potential for Garnet Production in British Columbia

The world Situation is somewhat similar. Historically, the United States has dominated both world consumption and supply of garnet. As late as 1973 US consumption and production accounted for two-thirds of the world statistics. In the last two decades, new operations started up first in Australia, then India, followed by China, and recently Europe, Current US consumption and production of garnet is probably now reversed, and accounts for only one-third of the World figures.

A final word on quality. Barton Mines garnet has always been recognized as a superior quality material, and is somewhat unique in its markets and character. The US Bureau of Mines, and others, have often referred to "low quality garnet" coming from nearly all other sources, including garnet from Emerald Creek and other sources around the world. This is a great injustice, and is simply a gross error. Certainly Emerald Creek garnet, and the GMA garnet from Australia, and the material from a now operation in New York (Patterson Materials Corporation) also supply high quality garnet. The proof of this is that the tonnage sold from these sources greatly exceeds sales from Barton Mines, and is further born out by comparing the physical and chemical character of these materials. The ultimate argument is demonstrated by the relative inability of the world mining community to find comparable deposits after considerable effort. The situation 'is rooted in comparing materials which are for the most part similar, except that the Barton materials display a few very un-garnet-like characteristics. I argue that Barton's garnet is not a higher quality garnet, but rather is simply an unusual garnet.

In fact, there is a fair bit of variation in the properties of commercial garnet from garnet in general, as well as in the properties of garnet from operation to operation. Almandite in the textbooks is said to have hardness of 7.5 on the Mohs scale, while much of the commercial literature lists hardness as 7.5 to 8.0. There are reports in the literature of almandite displaying hardnesses exceeding 8. 1 have seen data on commercial almandite in which the Knoop hardness has varied 1470 to 1540 for garnet from various sources.

Current World Market Summary

In recent years there has been a major shift in the geographic scope of the garnet business, from one which was largely centered in the US in terms of both production and consumption, to one which is now worldwide. Table 2 below summarizes estimates of current world garnet capacity:

Table 2: Estimated World Garnet Production Capacity

United States	100,000	
North America		*100,000*
Norway	8,000	
Turkey	700	
Former USSR	2,000	
Europe		10,700
Australia	65,000	
China	20,000	
India	28,000	
Sri Lanka	100	
Australasia		113,100
Others	1200	1 200
Total	225,000	225,000

World production and consumption is thought to be rapidly approaching 200,000 tonnes annually.

It appears world garnet capacity (and probably consumption) has doubled in the last seven to ten years. The interest in garnet has more than double! in the same period of time, as can be seen by the large number of garnet projects either on the drawing board, or coming into production shortly.

Table 3 is a summary of some of the garnet projects;

Table 3: Partial Summary of Current Garnet Projects Worldwide

Bittsroot Resources Ltd	Arizona, USA	Almandite	30,000 tons/year	Seeking financing
Pittson Mineral Ventures Co.	Maine, USA	Almandite	not producing	Operation for sale
Cominco American	Montana, USA	Almandite	40,000 tons/year	Coming on stream 96
Royalstar Resources	New Mexico, USA	Andradite	70,000 tons/year	On hold for permitting problems
Hampton Creek Mines	Nevada, USA	Almandite		Under evaluation
Teledyne Wsh Chang	California, USA	Andradite		Under evaluation
imperial Mining Company	North Carolina, USA	Almandite		Review of by-product from gold dredging
Rare Earth Resources Ltd.	Oregon, USA	Almandite		Evaluation as HM by-product
Polestar Exploration inc.	BC, Canada	Andradite	60,000 tons/year	Permitting problems
Tiomin Resources inc.	PO, Canada	Almandite		Evaluation as HM by product
Stralak Resources Inc./Emerald Isle Resources Inc.	ON, Canada	Almandite		Production decision and funded
North American Garnet Inc.	Mexico	Almandite	35,000 tons/year	Under evaluation
Western Garnet Co.	India	Almandite		Major expansion purchased producer
Western Garnet	Italy	Almandite		Under evaluation
Ledmore Marble Ltd	United Kingdom	Melanite		Under evaluation
Garnet A/S	Norway	Almandite		Under evaluation

The Future for Garnet and Potential for New Production

Industrial garnet in its first hundred years has been a specialty mineral relying on niche markets. Operations have been typically family operations, with supply tightly controlled. The 1990's have seen a rapid transition toward garnet becoming a commodity type mineral, with sophisticated corporate entities purchasing family operations and developing new deposits. The full impact of this transition is yet to be felt. Most likely, garnet will come into over supply, and the price of garnet will fall.

This may negatively impact some producers, namely those which lack commercial sophistication, a quality product, or have high production costs relative to direct competitors. On the whole, however, it will probably be a positive period for the garnet industry in general. I believe garnet sales would have risen even faster than the phenomenal 10% growth, had supply and service been more In line with market requirements- large garnet accounts have lost out to substitute materials, which need not have been the case. It is expected falling prices will only fuel increased demand, garnet has some very useful properties which can make a significant contribution to a more efficient society. Total dollar sales may still continue to grow at historical rates.

A few years ago a window of opportunity existed in a wide open situation for now garnet production. That window is rapidly closing, due to the proliferation of garnet production coming on stream, and the emergence of entities such as Western Garnet. Opportunity still exists, but generally not for the type of deposits currently coming on stream or being evaluated. The real opportunities in the future are for the types of deposit which can be produced and delivered at low cost. The successful future deposit may have no comparable counterpart in today's garnet industry.

Tomorrow's garnet producer will likely have greatly increased responsibilities with respect to quality control, transportation, product development, recycling and disposal, and general operating efficiency.

The opportunities in British Columbia? The answer lies in the operating environment offered by the region (which historically has not been particularly good) and the potential to find superior deposits (geologically, the terrains exist that make BC a target on par with any location in the world). Looking at markets for garnet 'in the region, the existing situation is quite discouraging- success would for the time being be dependent upon successful export to California, Texas, and to other world consuming centers.

Conclusion

The garnet industry is becoming increasing more efficient, better managed, more sophisticated, well funded, and highly structured. The internal functions of the industry are still known largely by only those on the inside. The proformas (as well as the deposits) of many garnet projects on the drawing board may be abysmally lacking in the market environment of the future. Garnet is only following the realities of industry in general, namely:

- competition and markets are global
- business acumen is accelerating
- demand for quality is increasing
- forgiveness is disappearing

Success will not be found in following what is being done, but rather in achieving the limits of what can be done. In that respect, there is tremendous opportunity on a world scale.

GARNET, INDUSTRIAL [1]

(Data in metric tons of garnet unless noted)

Domestic Production and Use: Garnet was produced in 1995 by five firms, four in New York and one in Idaho. Output of refined material was valued at $11.2 million. The end uses for garnet were abrasives in the petroleum industry, 41 %; filtration media, 20%; transport manufacturing, 19%; finishing wood furniture, 10%; electronic components, 7%; and ceramics and glass, 3%.

Salient Statistics-United States:	**1991**	**1992**	**1993**	**1994**	**1995**
Production (crude)	50,900	54,100	44,000	51,000	53,300
Sold by producers (refined)	48,000	46,100	55,800	40,600	47,900
Imports for consumption*	5,000	6,000	12,200	6,000	5,000
Exports [e]	10,000	8,880	11,400	10,000	7,260
Consumption, apparent	44,000	45,700	56,600	37,500	44,900
Price, range of value, dollars per ton	60-2,000	100-2,000	100-2,000	100-2,000	85-1,500
Stocks, producer [e]	11,100	8,640	4,900	4,000	4,720
Employment, mine and mill	150	150	150	160	180
Net import reliance [2] as a percent of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (1 991-94): Australia, 85%; India, 11 %; and China 4%

Tariff: **Item**	**Number**	**Most favored nation (MFN) 12/31/95**	**Non-MFN[3] 12/31/95**
Emery, natural corundum, natural garnet and other natural abrasives, crude	2513.21.0000	Free	Free.
Emery, natural corundum, natural garnet and other natural abrasives, other than crude	2513.29.0000	$0.60/kg.	$2.20/kg.
Natural abrasives on woven textile	6805.10.0000	2.0% ad val.	20% ad val.
Natural abrasives on paper or paperboard	6805.20.0000	2.0% ad val.	20% ad val.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.0000	2.0% ad val.	20% ad val.

Depletion Allowance: 14% (Domestic), 14% (Foreign)

Government Stockpile: None

Prepared by **Industrial Garnet Specialist,** (703) 648-7721

GARNET, INDUSTRIAL

Events, Trends, and Issues: Imports from Australia continued to be used in the U.S. filtration and blasting media markets, but did not appear to affect domestic production negatively. The market appears to be large enough to absorb additional imports without harming U.S. producers. The garnet reclaim plant in Harvey, LA, was used intermittently as a distribution warehouse. Currently, evaluation and feasibility studies are underway on major garnet deposits in Arizona, California, Colorado, Montana, and New Mexico.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves[4]	Reserve base[4]
	1994	1995*		
United States	40,600	47,900	5,000,000	25,000,000
Australia	30,000	30,000	1,000,000	7,000,000
China	18,000	15,000	Moderate to Large	Moderate to Large
India	10,000	15,000	500,000	20,000,000
Other countries	2,000	2,000	6,500,000	20,000,000
World total (rounded)	101,000	110,000	Moderate	Large

World Resources: Garnets occur worldwide in a variety of rocks, particularly gneisses and schists. They also occur as contact-metamorphic deposits In crystalline limestones, pegmatites, and serpentinites, and in high-temperature intrusive contacts and vein deposits. Alluvial garnet also Is a coproduct with many heavy mineral sand and gravel deposits In the world. Large domestic resources of garnet are concentrated In coarsely crystalline gneiss near North Creek, NY. One of the world's largest known garnet deposits in Rangley County, ME, Is not currently being mined. The medium-grained ore from this deposit, has an unusually high garnet concentration of 50% to 60%. Significant resources of garnet also occur in Idaho, Montana, Now Hampshire, North Carolina, and Oregon. World resources of garnet are large.

Substitutes: Garnet is competitive in abrasive applications with natural and manufactured abrasives, such as diamond, cubic boron nitride, fused aluminum oxide, silicon carbide, and quartz sand; in filtration media with ilmenite, magnetite, and plastics; and in nonskid surfaces with emery.

*Estimated E Net exporter

1. Excludes gem and synthetic garnet

2. Defined as imports - exports + adjustments for Government and Industry stock changes.

3. See Appendix B.

4. See Appendix C for definitions

Industrial Mineral Opportunity for B.C. Custom Processing

by

B. Ainsworth,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

The Custom Milling of Industrial Minerals in B.C.

GOOD MORNING TO YOU ALL – I AM DELIGHTED TO HAVE THE OCCASION TO FOLLOW ON FROM PETER HARBIN AND DISCUSS SOME COMPLEMENTARY APPROACHES TO DEVELOPING INDUSTRIAL MINERALS ACTIVITY IN THE PROVINCE.

In 1989, WE CARRIED OUT A STUDY, FUNDED BY THE CANADA - BRITISH COLUMBIA MINERAL DEVELOPMENT AGREEMENT, TO EVALUATE THE CUSTOM MILLING OF INDUSTRIAL MINERALS IN THE PROVINCE. PART OF THE OBJECTIVE OF THIS STUDY WAS TO SEE IF THERE WERE WAYS IN WHICH THE GOVERNMENT MIGHT INTERVENE TO ASSIST IN THE DEVELOPMENT OF THE INDUSTRIAL MINERALS SECTOR. ANOTHER OBJECTIVE OF THE STUDY WAS TO PRESENT THE POTENTIALS SO THAT PRIVATE SECTOR INDUSTRY MIGHT BE ENCOURAGED TO START UP UNITS OF PRODUCTION.

THE MAIN CONCLUSIONS OF THE STUDY WERE THAT GOVERNMENT SHOULD NOT PARTICIPATE DIRECTLY BUT RATHER ENCOURAGE AND FACILITATE ANY PROPOSED PRIVATE PROJECT - IN OTHER WORDS, BE IN THE CHEERING SECTION. I AM PLEASED TO BE ABLE TO SAY THAT THAT RECOMMENDATION WAS ADOPTED AND SEVERAL SEGMENTS OF GOVERNMENT HAVE BEEN CHEERING LOUDLY. THE PROOF OF THIS IS IN OUR MEETING TODAY AND THE SUPPORT FOR BC'S INDUSTRIAL MINERALS GIVEN AT INTERNATIONAL TRADE SHOWS THROUGH THE COOPERATIVE ACTION OF THE DEPARTMENTS OF MINES AND TRADE AND INDUSTRY. TO THE UNINITIATED IT MIGHT SEEM UNLIKELY THAT ONE MIGHT BE AGRESSIVELY SELLING SOMETHING AS SOLID AS ROCK BUT THAT IS ONE PARTICULAR AREA OF LIVELY PARTICIPATION BY OUR GOVERNMENT FRIENDS.

THE RECOMMENDATION WAS ALSO MADE IN THE STUDY THAT A LOWER MAINLAND CUSTOM PLANT COULD BE A USEFUL PROFIT CENTER GIVEN BOTH THE POSSIBILITY OF LOCAL INDUSTRIAL MINERAL SOURCES OR LOW COST BULK IMPORTS BY SEA, AND THE SIZE OF SOME OF THE MARKETS NEARBY.

THIS ONE HAS NOT BEEN FOLLOWED UP AS FAR AS I KNOW, ALTHOUGH I AM WORKING WITH A GROUP TO PURSUE THE OPPORTUNITY AT PRESENT - SORT OF PUTTING MY MONEY WHERE MY MOUTH WAS.

WELL, SINCE THE STUDY WAS DONE THERE HAVE BEEN SOME VERY IMPORTANT STRUCTURAL CHANGES IN THE EXTERNAL AND INTERNAL FRAMEWORK WITHIN WHICH A BC BASED CUSTOM PROCESSOR WILL NOW OPERATE.

AMONGST THOSE EXTERNAL FORCES, NAFTA AND THE CHEAP CANADIAN DOLLAR COULD ENCOURAGE THE SELECTION OF A BC SITE OVER ANOTHER WEST COAST PACIFIC RIM SITE.

AMONGST THE INTERNAL FORCES IS A RELATIVELY NEW PERCEPTION IN POLITICAL CIRCLES AND BUREAUCRATIC SQUARES, THAT INDUSTRIAL MINERALS ARE ENVIRONMENTALLY HAPPIER THAN SOME OF THOSE NASTY TOXIC METALS THAT MINERS USED TO BE ALLOWED TO START MINING IN THIS PROVINCE. THIS SHOULD MAKE PERMITTING OF OF AN INDUSTRIAL MINERALS PROJECT EASIER TO FAST TRACK, ESPECIALLY IF IT IS NOT A WASTE PRODUCER AND IS DELIVERING JOBS WITH THAT VALUE ADDING CACHET. EVEN MORE RECENTLY OTTAWA KILLED THE "CROW" - REMOVED THE CROW RATE SUBSIDIES FROM GOODS MOVING BY RAIL WESTWARDS INTO BRITISH COLUMBIA FROM THE FROZEN EAST. THIS COULD SIGNIFICANTLY INCREASE SOME FREIGHT COSTS FOR MOVEMENTS IN THAT WESTERLY DIRECTION.

THESE KEY CHANGES MAKE IT WORTHWHILE REVISITING SOME OF THE IDEAS ORIGINALLY PROPOSED IN OUR STUDY AND PUTTING THOSE THAT STILL APPLY TOGETHER WITH POTENTIALS THAT HAVE DEVELOPED BECAUSE OF A CHANGING INDUSTRIAL AND HUMAN DEMOGRAPHY FOR THIS PART OF THE PACIFIC RIM.

BEFORE GOING FURTHER I WOULD LIKE TO DEFINE CUSTOM PROCESSING.

FOR OUR PURPOSES, I WOULD INCLUDE EVERYTHING FROM SIMPLE PRODUCT STORAGE, TO PACKAGING FROM BULK, SIZE REDUCTION AND CLASSIFICATION, MIXING AND BLENDING.

THE CUSTOM PROCESSOR STANDS AS A KEY LINK BETWEEN THE SUPPLIER OR THE TRADER, AND THE END USER OF THE PRODUCT. THE DEGREE OF PROCESSING MAY VARY FROM SIMPLY MAKING SURE THAT THE PRODUCT IS NOT DEGRADED OR CONTAMINATED - PROPER STORAGE - TO A TECHNICALLY SOPHISTICATED MICRONIZING OF PARTICLES WITHOUT CONTAMINATION WHICH MIGHT BE FOLLOWED BY THE PROCESS STEPS TO MAKE PRECISION ADDITIONS OF HIGH COST SURFACE TREATMENT AGENTS.

CUSTOM PROCESSING IS GENERALLY NOT CUSTOM BENEFICIATION, REMOVING PRODUCT FROM WASTE MATERIAL - ALL "WASTE" TRIES TO FIND SOME MARKET AND NOT A WASTE DUMP IN THIS PART OF THE INDUSTRIAL MINERALS DISTRIBUTARY CYCLE. A REGULAR DUMPSTER SHOULD SURFICE THE WEEKLY WASTE NEEDS OF THE PLANT.

WE WERE WONDERING HOW TO GET INTO THE BUSINESS THE STUDY EXPLORED HOW SOME OF THE EXISTING CUSTOM PROCESSORS STARTED UP.

DURING VISITS TO SEVERAL CUSTOM PROCESSORS IN EUROPE AND IN THE NORTHEAST U.S., IT QUICKLY BECAME CLEAR THAT MOST CUSTOM PROCESSORS WERE EITHER AN OUTGROWTH OF A WAREHOUSING FACILITY OR AN ADJUNCT TO A TRADING COMPANY. IN BOTH CASES, THE COMPANY WAS ASKED OR SAW THE NEED TO MODIFY THE PRODUCT TO MEET REQUIREMENTS OF THE NEXT CONSUMER IN THE DISTRIBUTARY CHAIN. THE COMPANY CAUGHT A BENEFIT FROM THE RESULTANT VALUE-ADDING.

THIS MODIFICATION MAY HAVE BEEN AS SIMPLE AS PUTTING BULK SALT INTO A BAG; A BAG SMALL ENOUGH THAT THE HOUSEKEEPER DID NOT GET A HERNIA LIFTING IT OUT OF THE TRUNK OF THE CAR TO SPRINKLE SALT ON THE DRIVEWAY IN WINTER. IT MAY HAVE BEEN AS SIMPLE AS SCREENING OUT COARSE MATERIAL FOR DELIVERY TO ONE SANDBLASTER WHILE SAVING THE FINES FOR ANOTHER. IT MAY HAVE BEEN THE CRUSHING AND GRINDING OF WOLLASTONITE IN A ROD MILL TO ACHIEVE A HIGH ASPECT RATIO FILLER OF CERTAIN SPECIFICATION AND COATING THE PARTICLES WITH SILANES.

IN GENERAL, THE SIMPLE CUSTOM PROCESSOR WAS ACTING AS AN INTERMEDIARY ONLY TO CHANGE THE NATURE OF THE PRODUCT TO SUIT THE NEXT CONSUMER. THE WAREHOUSE WAS NOT ACTIVELY PURSUING MARKETS FOR THE PRODUCT NOR BUYING PRODUCT FROM EXOTIC SOURCES. THE TRADER ALREADY WAS INVOLVED IN THE PURCHASE AND SALE OF PRODUCTS BUT NEEDED TO CARRY OUT A FEW EXTRA PROCESS STEPS TO KEEP HIS CONSUMER CONTENT.

THE EXTENT TO WHICH THE SIMPLE CUSTOM PROCESSOR BECOMES INVOLVED IN ACTUALLY PURCHASING AND MARKETING PRODUCT VARIES. IT IS RECOMMENDED BY SOME AS A WAY OF TAKING CONTROL OF THE THROUGHPUT OF MATERIAL SOMEWHAT. THIS COULD GIVE SOME STABILITY TO THE VOLUMES OF BUSINESS AND REDUCE THE UNCERTAINTIES OF CUSTOMERS DEMANDS. IT WOULD BE IMPORTANT, HOWEVER, TO AVOID THE PERCEPTION OF CONFLICT OF INTEREST THAT COULD ARISE FROM INTERVENING IN A CUSTOMER'S MARKET.

A CROSS-SECTION OF THE DIFFERENT SHAPES OF PROCESSOR COMPANIES WAS INCLUDED IN THE 1989 STUDY. EGGERDING AND CO. OF THE NETHERLANDS IS A GOOD EXAMPLE OF THE WAREHOUSER WHO GREW INTO CUSTOM PROCESSING. COLIN STEWART MINERALS OF CHESHIRE, ENGLAND, IS MORE OF A TRADER AND VENDOR OF VALUE ADDED PRODUCTS, HAVING GROWN BY AGGLOMERATION OF SEVERAL SMALLER CUSTOM PROCESSORS. JAN DE POORTER B.V. OF THE NETHERLANDS STARTED AS A TRADER IN THE 30'S AND DEVELOPED THEIR CUSTOM PROCESSING AS PART OF THE NEED TO SATISFY CUSTOMERS IN THE CERAMICS INDUSTRIES.

ONE OTHER, LESS COMMON FORM OF CUSTOM PROCESSING NOTED WAS THE OCCASIONAL PIGGY-BACK OF TOLL PROCESSING ONTO AN ESTABLISHED, LARGER INDUSTRIAL MINERALS PRODUCER. HERE, THE MAIN PRODUCT LINE MIGHT BE INTEGRATED AND SOLD ON THE BASIS OF LONG TERM CONTRACTS WITH THE FINAL CONSUMER BUT, WITHIN A DIVISION OF THE INDUSTRIAL MINERALS PRODUCER, THERE IS A SOUL IN MANAGEMENT WHO IS SUFFICIENTLY ENTRPRENEURIAL TO BE ABLE TO DEVELOP A PROFIT CENTRE THAT IS SUPPLEMENTAL TO THE PRINCIPAL BUSINESS. ONE EXAMPLE OF THIS IS THE FORDAMIN DIVISION OF ENGLISH CHINA CLAYS IN THE U.K.

IF WE CONSIDER A START-UP SITUATION FOR A CUSTOM PROCESSOR HERE IN B.C., IT IS CLEAR THAT THE COMPANY WILL PROBABLY HAVE TO SEEK AND PROBABLY PURCHASE SOURCES OF PRODUCT OR JOIN FORCES WITH A SPECIALIST WAREHOUSING GROUP THAT IS ALREADY OPERATIONAL AND SERVING THE INDUSTRIAL MINERALS SECTOR.

IF WE CONSIDER THAT START-UP SITUATION A LITTLE FURTHER, WE QUICKLY REALIZE THAT THE COMPANY WILL ALSO PROBABLY HAVE TO DEVELOP MARKETS FOR THE PRODUCTS IT HAS ACQUIRED. THE GROWTH WILL NOT BE A SIMPLE ORGANIC EXPANSION OF A WAREHOUSING TYPE OF BUSINESS BUT A FULL JUMP INTO INDUSTRIAL MINERAL MARKETING OR TRADING WITH A VALUE ADDING INTERFACE. MY GUT FEELING IS THAT, IN THE SETTING OF THE PORT OF VANCOUVER AREA, ORGANIC GROWTH MAY BE SLOWER THAN A SPRUCE TREE ABOVE THE 60TH PARALLEL.

WE RECOGNIZED THIS CRITICAL DIFFERENCE AS WE DID THE STUDY AND WE DECIDED THAT THE NEXT STEP WAS TC ESTABLISH WHAT WERE THE POTENTIAL SOURCES OF SUPPLY IN THE PROVINCE AND NEARBY FOR A CUSTOM PROCESSING PLANT. IT WAS NOT THEN, AND IS NOT NOW, OBVIOUS THAT BC HAS MANY SUITABLE SOURCES OF SUPPLY OF INDUSTRIAL MINERALS TO FEED A CUSTOM MILLING FACILITY . HOWEVER THERE IS GOOD POTENTIAL FOR DEVELOPING A PROCESSING PLANT INITIALLY BASED ON MINERAL SUPPLY THROUGH THE TRANSPORTATION LINKAGES THAT EXIST, INCLUDING BY SHIP FROM OTHER PACIFIC RIM COUNTRIES. SINCE, AS PETER HARBEN HAS SO ELOQUENTLY DESCRIBED, MARKETS DEFINE EXPLORATION, WE ALSO RECOGNIZED THAT WE HAD BETTER DEFINE WHAT WERE THE INDUSTRIAL MINERALS MARKETS WITHIN REASONABLE REACH OF SUCH A PLANT.

ALL OF THE FOREGOING LEADS TO THE SHORT CONCLUSION THAT ANY PLANT WOULD HAVE TO BE AT A LOW COST SITE AT A DEEP SEA PORT, WITH GOOD RAIL AND HIGHWAY CONNECTIONS FOR THE EFFICIENT DELIVERY INCOMING AND OUTGOING PRODUCT. THAT MAY BE AN OXYMORON WHEN WE NOTE THAT THE PORT OF VANCOUVER SITES TRADITIONALLY RUN AT ABOUT $1.00 A SQUARE FOOT FOR WATERFRONT LAND AND 10 CENTS A SQUARE FOR THE WET PARTS. A LITTLE FAST ARITHMETIC SHOWS THAT TO BE ABOUT $200-400,000 ANNUAL LEASE COST FOR A REASONABLE SIZED PIECE OF WATERFRONT - AND THAT IS BEFORE ANYTHING ELSE IS BOUGHT OR BROUGHT TO THE SITE.

THE TRANSPORTATION LINKS TO A PORT OF VANCOUVER FACILITY UP SHOWED UP AS A MAJOR DIFFERENCE BETWEEN A BC PLANT AND THE SITUATION THAT PREVAILED FOR EUROPEAN AND NORTHEASTERN US PROCESSORS. THEY CAN TYPICALLY REACH THEIR CUSTOMERS WITH A ONE DAY DELIVERY SCHEDULE. OFFSETTING THAT, ONE CAN REMEMBER THAT NORTH AMERICAN FREIGHT SYSTEMS ARE IMPRESSIVE IN THEIR ABILITY TO DELIVER GOODS IN A TIMELY FASHION.

TIMELY DELIVERY FROM THE WAREHOUSE IS SO IMPORTANT BECAUSE IT EFFECTIVELY WORKS LIKE UNPAID INVENTORY CLOSE TO THE CONSUMER. THE CONSUMER CAN MAINTAIN AN APPEARANCE OF "JUST IN TIME" INVENTORY WITH THIS ARRANGEMENT AND IN THIS MAN'S LIFE PERCEPTION HAS BECOME REALITY! IN ALL SERIOUSNESS THE WAREHOUSE FUNCTION IS AN INSURANCE FOR MORE RELIABLE DELIVERY, ESPECIALLY IF WE ARE TO CONSIDER SOURCES OF SUPPLY IN CHINA, INDIA OR THE HIGH ANDES OF SOUTH AMERICA. DELAYS IN SUPPLY FROM ACROSS THE PACIFIC CAN AMOUNT TO MONTHS ACCORDING TO SOME SADDER AND WISER CHINA BUYERS - A COUPLE OF EXTRA DAYS TRAVEL BETWEEN VANCOUVER AND SAY LOS ANGELES ON A BACKHAULING TRUCK MAY BE SEEN AS QUITE AN IMPROVEMENT.

MARKETS DEFINE THE COMMODITIES WE SHOULD CONSIDER. WITH THE BROADER SPREAD OF SOURCES OF SUPPLY THAT CAN BE DELIVERED BY THE SHIPPING LINKAGES, WE NEED TO LOOK AT WHAT SEGMENTS OF MARKET ARE BIG ENOUGH TO ENTER INTO WITHOUT MAKING TO MANY RIPPLES; ALSO WHICH ARE THE LARGER LOCAL MARKETS THAT MIGHT HAVE A MAJOR FREIGHT COST ADVANTAGE IF DELIVERED FROM THE BC PROCESSOR.

PETER HARBEN HAS ALREADY SUGGESTED SOME OF THE MARKETS THAT WE SHOULD FOCUS ON FOR OUR START-UP PLANT. FOR ME, THE PULP AND PAPER SECTOR PROBABLY OFFERS THE MOST IMPORTANT POTENTIALS. THE MARKET SIZE OF PAPER MINERALS COULD BE BIG ENOUGH TO FORM A BROAD BUILDING BLOCK FOR THE START-UP CUSTOM PROCESSING PLANT UPON WHICH OTHER SMALLER PRODUCT LINES CAN BE BUILT.

CLEARLY THIS IS A CHICKEN AND EGG SORT OF SITUATION AT PRESENT AND IS NOT WITHOUT A RISK. THERE IS STILL NOT MUCH FILLED OR COATED PAPER MADE IN BC. THE PULP INDUSTRY HAS SAID LOUD AND CLEAR SEVERAL TIMES IN RECENT YEARS THAT THEY MUST MOVE INTO VALUE-ADDED PRODUCTS IF THEY ARE GOING TO CONTINUE IN BUSINESS WITH BC's HIGH COST FIBRE. PART OF THEIR PROBLEM HAS BEEN THE HIGH COST OF KAOLIN FROM GEORGIA WHEN INCLUDING THE COST OF RAIL FREIGHT. THE FILLED PAPER THEN HAS TO BE SOLD INTO MARKETS WHERE MUCH CHEAPER KAOLIN IS AVAILABLE - AND THAT INCLUDES JAPAN, WHICH GETS ITS KAOLIN FROM GEORGIA BY SHIP.

CALCIUM CARBONATE, TALC AND SODA ASH COULD ALL BE CONSIDERED WITH KAOLIN AS PART OF THE PRODUCT LINE TO OFFER TO THE PULP AND PAPER PRODUCERS. A STRATEGY COULD BE TO SUPPLY THOSE EXISTING PAPER MINERAL CONSUMERS INCLUDING SOME OF THE NEW CALCIUM CARBONATE REQUIREMENT FOR THE PORT ALBERNI 'NEXT GENERATION' PLANT OF MACMILLAN BLOEDEL. THE AVAILABILITY OF SLURRIED MINERALS FOR DIRECT APPLICATION IN THE PAPER MILL IS POSSIBLY A SERVICE THAT WOULD ENCOURAGE SOME OF THE PULP PLANTS TO LOOK AT EXPANDING THEIR PAPERMAKING CAPABILITIES.

CRITICAL IN THE CHOICE OF THE MINERALS WITH WHICH TO START THE CUSTOM PROCESSING PLANT IS THE MINERAL OR GROUP OF MINERALS THAT WILL BE BIG ENOUGH BUSINESS TO CARRY THE OPERATION WITH A REASONABLY SHORT PAY-BACK PERIOD FOR CAPITAL INSTALLATIONS. THE PAPER MINERALS MAY BE LESS ATTRACTIVE THAN BENTONITE FROM HAT CREEK OR ZEOLITES FROM CACHE CREEK. AFTER THE PAY-BACK, THERE IS A POSSIBILITY OF GOING FORWARD WITH A MORE ORGANIC TYPE GROWTH - HOPEFULLY MORE LIKE THE WEEDS IN MY FERTILIZED GARDEN THAN THAT SPRUCE TREE NORTH OF '60.

JUST BRIEFLY, TO PUT CONTEXT TO THE SIZE OF THE BUSINESS THAT WOULD BE POSSIBLE FROM THESE SORTS OF BEGINNINGS, WE COULD REASONABLY AIM FOR CASHFLOWS STARTING AT SOMETHING OVER $1 MILLION WITH POTENTIAL TO GROW TO SEVERAL MILLIONS. IF THE SPIN OFF IS ALSO TO KEEP JOBS IN THE BC PULP AND PAPER INDUSTRY, WE WILL HAVE HELPED BUILD FUTURE MARKETS FOR INDUSTRIAL MINERALS.

THANK YOU

Short History of an Industrial Mineral Development

by

P. B. Aylen,
President,
Western Industrial Clay Products Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

What commercial users say about **STALL DRY:**

"**STALL DRY** made a world of difference in the atmosphere in the barns. I declined to comment immediately after the weekend sale because I wanted to wait and see if the **STALL DRY** had been effective. Thursday I was satisfied. I would say it worked really well. I just walked in the barn now, and you would never know the bulls were in there."

Kamloops Exhibition Association
Rob White - Groundskeeper

"I was on vacation and a friend was looking after my 10,000 layer chicken operation. He thought the ammonia was too strong so our pest control service tried **STALL DRY.** Returning after a few days, even I could notice a big improvement."

Ben Arends - Layer Chickens

"**STALL DRY** really controlled the odor and ammonia from my hutches. I gave **STALL DRY** a try and no more problem, **STALL DRY** really works. The rabbit droppings are used for my earthworms with good success. I also use **STALL DRY** with my silky chickens and it works so well that STALL DRY has increased our laying cycle."

Norm ***Schultz - Rabbit Breeder***

"**STALL DRY** has been a real bonus for my business to reduce ammonia for my clients livestock operations. It has assisted in my fly control programs with Beneficial Insects."

Lore Wolters - President, Western Pacific IPM, Livestock Fly Control

Is STALL DRY Available?

Ask your local store manager to bring some in for you.

The Absorbent Marketing Co. Ltd.
714 E. Sarcee St.
Kamloops, B.C.
V2K 1E7

For more information, please call us at:

1-800-667-0336

Product of Canada
Printed in Canada

Traps Odors

Neutralizes Ammonia

Absorbs Wetness in Barns, Pens, Cages & Trailers

STALL DRY is a natural clay absorbent and deodorizer with a pleasant minty, woody scent added.

Where to use:

Ammonia and odor absorbent STALL DRY may be used in cages, stalls and pens to trap odors, neutralize ammonia and absorb wetness.

Daily use of STALL DRY improves your animals comfort, may reduce bedding costs and clean-up time.

When transporting animals, reduce stress and discomfort by using STALL DRY in carrying cages, shipping kennels, horse and livestock trailers.

How to use:

Clean wet and soiled areas. Then cover wet areas with a thin layer of STALL DRY and spread bedding over top. STALL DRY may be used on rubber mats, wood, dirt or cement flooring.

Where to find STALL DRY:

Call us at l-800-667-0336 for the closest STALL DRY dealer.

STALL DRY works well with large and small animals.

"It's just great," says Dawn Brodie, Animal Health Technologist. "The Kamloops Wildlife Park uses it in all the large cat, grizzly, zebra and porcupine exhibits. Traditional stall products can be caustic to animals with pads on their feet so the STALL DRY is excellent for tigers and jaguar dens. Cats especially have a very strong smelling urine due to their ability to concentrate urine, the STALL DRY makes their den area very pleasant smelling."

Wildlife Park -
Exotic Animals

"STALL DRY keeps my runs and kennels clean and fresh. It has made the grooming so much easier, the dogs need very little bathing and their coats smell clean and fresh. We also use it for our pot bellied pig and it keeps our horse stalls so dry and odor free. Thanks again for this wonderful product."

Karen Hildebrandt –
K H Kennels & Dukhan Arabians

"We know STALL DRY is a wonderful product and wouldn't be without it, no more dusty lime clouds here! It's nice to have a home grown product that is inexpensive, easy to use and effective. Thank you STALL DRY."

The Kriegls –
Reg. Paint Horses

ADVANTAGES

STALL DRY is Better For You:

- Fast, effective ammonia and odor control
- Safe alternative to lime, safe for people and animals, cut your exposure to lime

STALL DRY is Better For Your Animals:

- Effective odor control means less odors which could attract fewer flies. Fewer flies will increase your animal's comfort.

STALL DRY Saves Money Too:

- STALL DRY spreads further and absorbs more
- You Need Less STALL DRY so less clean-up and less impact on the environment

STALL DRY does NOT:

- Burn the pads on animals feet when wet
- Corrode metal, wet or dry
- Swirl up into stinging white clouds into your eyes
- Clump and not spread evenly
- Mask the odor

Check it out today!

Produced in Western Canada for pet lovers everywhere

The WC Cat family of fine pet products is based on specialized formulations of natural clays. These clays have a natural chemical attraction for odorous substances in animal waste and act as superior odor-controllers. These products are produced in Kamloops, in the heart of British Columbia's sunny Southern Interior.

The Absorbent Marketing Co. Ltd. is very conscious of its environmental responsibilities. We have filed a reclamation bond with B.C.'s Ministry of Energy, Mines and Petroleum Resources. This guarantees that environmental impact will be minimized and the area will be reclaimed once mining is completed.

WC CAT LITTER
Cat Litter
Litiere Pour Chats

Natural & Superior Odor Control

WC Cat Litter is our original absorbent pet sanitation product. It provides a simple, cost-effective solution to litter box care.

WC Cat Litter's special diatomaceous clay has unmatched odor-absorbing qualities. This superior natural product also absorbs moisture before it can collect in the bottom of the litter box. WC Cat Litter is formulated to minimize tracking and provides about 1/3 more litter box fills per bag than most competing products.

WC Cat Litter is packaged for easy handling and the paper and plastic bags are recyclable. Like other granular cat litters, this product should be changed regularly.

New Kozy Kitty Premium Blend Clumping Litter is a product for the pet owner who prefers a high quality clumping litter with all of WC Cat's superior odor controlling abilities.

A custom blend of natural days lets this litter form solid waste dumps when the litter is used, making litter box maintenance easy.

Kozy Kitty Premium Blend Clumping Litter is economical to use. Instead of refilling the litter box, simply remove the clumps of used litter. Kozy Kitty also provides more volume for the same weight than most competing clumping litters.

This litter is not toilet disposable.

Available in 5, 10 and 20 kg bags.

Kozy Kitty®
Premium Blend
Clumping Litter

WC Cat Flushable Clumping Crystals is a unique answer for the environmentally conscious pet owner who wants to dispose of animal waste neatly while avoiding the landfill.

Using the same odor-controlling raw material as WC Cat litter - with a special additvie to assist clumping -WC Cat Crystals allows the user to dispose of dumps of urine and solid waste in the toilet.

This product is not suitable for use with septic systems.

Available in 4 kg and 20 kg bags.

Printed in Canada

STALL DRY - We're not just for horses anymore!

Stall Dry is an innovative product developed for the special needsofthe horse industry to help control odor and ammonia in barns and trailers.

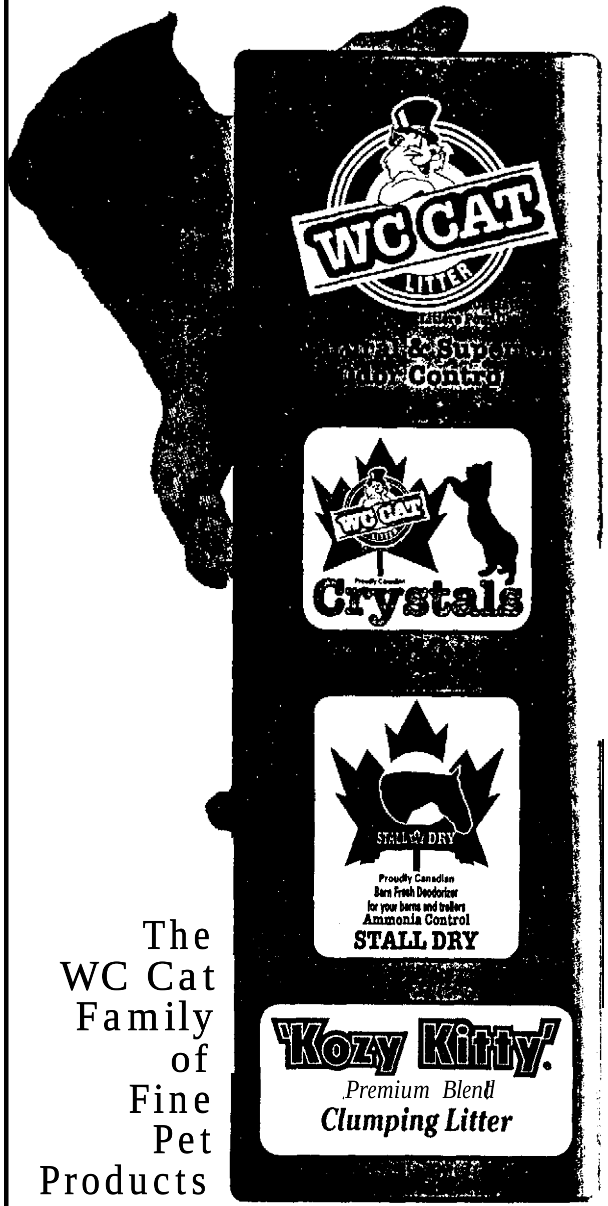
Proudly Canadian
Barn Fresh Deodorizer
for your barns and bailers
Ammonia Control
STALL DRY

Stall Dry's unique properties have turned out to be very useful as a bedding material additive to help control odor and ammonia in kennels and smaller animal cages. This product is also useful in chicken houses and piggeties.

Available in 2, 4 and 20 kg bags.

The Absorbent Marketing Co. Ltd.
714 East Sarcee St.
Kamloops, British Columbia
V2H 1E7
1-800-667-0336

You love your pets. Provide the very best



The WC Cat Family of Fine Pet Products

Challenges for the Pacific Northwest Cement Manufacturer

by

E. Cardey,
President,
I.M.P.A.C.T. Minerals Inc.

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

RAW MATERIAL CHALLENGES

TO THE

PACIFIC NORTHWEST CEMENT

MANUFACTURER

I.M.P.A.C.T. MINERALS INC.

- ***What is cement and clinker?***
- ***Industrials minerals used to produce cement***
- ***Current and historical sources of supply***
- ***Raw material challenges***
- ***Substitution opportunities***

CEMENT

- *a finely ground mixture of:*
  - *95% clinker*
  - *5% gypsum*

CLINKER

- *a mineralogical mix of calcium silicates obtained by partial fusion of raw materials containing:*
  - *lime*
  - *silica*
  - *alumina*
  - *iron*

CLINKER mineralogical composition

C_3S	50 - 60%
C_2S	73 - 23%
C_3A	5 - 8 %
C_4AF	8 - 12%

CLINKER chemical composition

CaO	66%
SiO_2	22.5%
Al_2O_3	4.5%
Fe_2O_3	3.0%
MgO	1.0%
K_2O	0.2 - 0.5%
Na_2O	0.1 - 0.4%

TYPICAL RAW MATERIALS

▪	*limestone*	- CaO	
•	*sand*	- SiO_2,	Al_2O_3 alkalis
•	*slag*	- Fe_2O_3	
•	*shale/clay*	- Al_2O_3,	SiO_2, Fe_2O_3, CaO, alkalis

REGULATORY RESTRICTIONS

$Na_2O + 0.658\ K_2O < 0.60\ \%$

$MgO < 5.0\ \%$

PROCESS RESTRICTIONS

Alkalis

MgO

Sulphur

Chlorine

HISTORICAL RAW MATERIALS

LIMESTONE

Texada Island	-	***Vananda, Blubber Bay***
Vancouver Island	-	***Cobble Hill***

ALUMINA

Vancouver Island	-	***Cobble Hill, Nanaimo, Ladysmith***
Texada Island	-	***Vananda***
Fraser Valley	-	***Matsqui***

SILICA

Vancouver Island	-	***Cobble Hill***
Squamish area	-	***Brittania***
B. C. Interior	-	***Oliver***
U.S.A.	-	***Wenatchee***

IRON

B.C.	-	***Vancouver***
USA	-	***Tacoma***

GYPSUM

Kootneys
Falkland
Mexico
Spain

CURRENT RAW MATERIALS

LIMESTONE
- ***Texada Island***

ALUMINA
- ***Sumas***

SILICA
- ***Sumas***
- ***Washington***
- ***Fraser River***

IRON
- ***Anyox, B.C.***

GYPSUM
- ***Mexico***
- ***Falkland***

TYPICAL QUANTITIES

- ***For 1,000,000 tonnes of cement***

  require approximately

  - ***1,220,OOO tonnes - limestone***
  - ***235,000 tonnes - alumina***
  - ***60,000 tonnes - silica***
  - ***50,000 tonnes - iron***
  - ***50,000 tonnes - gypsum***

RAW MATERIAL CHALLENGES

- ***raw materials should be on tide water***
- ***long term availability of low alkali silica***
- ***long term availability of low alkali alumina***
- ***long term availability of local gypsum***
- ***alternate man-made and waste materials***

SUBSTITUTION OPPORTUNITIES

- ***low alkali alumina***
- ***low alkali silica***
- ***alternate materials***
    - ***wollastonite***
    - ***foundry sand***
    - ***sand blasting material***
    - ***gypsum from de-papered drywall***
    - ***petroleum contaminated soils***
    - ***steel belted tires***
    - ***low sulfur fuels***
    - ***diatomaceous earth - brewery waste***

Update on Perlite

by

D. F Gunning, Consultant
B. C. Trade Development Corporation

presented at
Focus on British Columbia Industrial Minerals
October 19, 1995
Vancouver, Canada

UPDATE ON PERLITE

Donald F. Gunning, P.Eng.
October, 1995

INTRODUCTION

The industrial mineral "Perlite" is a hydrated rhyolitic volcanic glass that typically contains between two and five percent of chemically combined water, which permits the production of an expanded cellular material of extremely low bulk density when the ore is heated to its softening temperature in the range of 900-11000 C.

Raw perlite can in fact be expanded to up to twenty times its volume, creating a unique mineral product that finds application in many horticultural, construction and manufacturing sectors.

There is virtually no demand for raw perlite, other than for expansion. Since most expanders require a relatively tightly sized product, the mining and processing of the ore can generate significant quantities (up to 30%) of unmarketable fines, increasing the net cost of production. This problem is mitigated with less friable ores. Of course, product mix is also an important factor.

One other very significant customer requirement is the need to keep the sized ore completely dry prior to expansion. This necessitates close control of post-processing storage and transportation methods and facilities.

TRADE

Worldwide demand for perlite is modest by most industrial mineral standards, totaling less than 2.0 million tonnes per year, and has changed very little over the past ten years or so.

The production of perlite in the U.S. was relatively stagnant from 1989 to 1993 ranging between 515 and 575,000 tonnes per year. This increased to 610,000 tonnes in 1994, according to the U.S. Bureau of Mines. Apparent consumption is slightly higher at 660,000 tonnes, with imports of raw ore on the east coast, largely from Greece, exceeding exports of western ore, mainly to Canada.

Prior to the '80's, only one small attempt at commercial operation is recorded. It was undertaken by Western Gypsum Products of Winnipeg very briefly in 1953 at the Francois Lake deposit near Burns Lake in central B.C.

As noted earlier, Canada now imports 100% of its perlite requirements from Greece and the U.S.

Currently, a Quebec company - Canada Perlite Inc. - is attempting to develop a mine and processing facility at a perlite deposit on the Gaspe Peninsula, and efforts are being made to re-open the Frenier deposit in B.C., to supply raw ore to well-established expanders in Alberta, B.C. and the Pacific Northwest states.

UNITED STATES DEVELOPMENTS

The perlite mine at Malad City in southern Idaho, owned by the Oglebay Norton Company of Cleveland, Ohio, once a major supplier of raw ore to expanders in Alberta, B.C. and the Pacific Northwest states, remains closed; it has been rumoured to be for sale since its shutdown in 1991.

Atlas Perlite Inc. of Denver, Colorado, is actively proceeding with the development of its vast deposit at Tucker Hill in southern Oregon. A plant site has been purchased in nearby Lakeview, extensive product testing has been carried out, and an environmental impact statement completed and distributed for public input. On receipt of permits, the company plans to construct the required facilities during early 1996, with an initial capacity of 50,000 tonnes per year. Atlas could have a substantial impact on perlite trading patterns in the Pacific Northwest, given their favourable location and shipping costs compared to New Mexico producers. Atlas claims that their ore is less friable than most, and that the energy required for expansion is significantly less than for many other U.S. ores.

MAJOR U.S. PRODUCERS

As noted earlier, mines in New Mexico account for 80% of U.S. perlite production. The balance comes from Arizona, California, Colorado, Nevada and at one time, Idaho. The New Mexico operations are located at Socorro, Grants, and No Agua Peaks near the Colorado border as shown in this overhead by Chamberlin and Barker. The No Agua resource is said to be the largest perlite deposit in the world. It hosts two of the State's largest mines, one owned by Harborlite (previous Celite and Johns Manville); the other by Dicaperl (a subsidiary of Grefco, previously General Refractories). Dicaperl also mines a deposit near Socorro, and U.S. Gypsum has a small operation in Grants, in west-central New Mexico.

All of the mines are open-pit, extracting by simple ripping and scraping; only a minor amount of drilling and blasting is required. Dicaperl's processing plant for its No Agua perlite is located on railhead in Antonito, Colorado, 25 miles north of the mine. It produces up to 200,000 short tons per year of sized crude perlite, over one-quarter of total U.S. output. Over 90% is shipped to expanders; 7% is expanded on-site.

The Harborlite mine is adjacent to Dicaperl's. Their ore is also trucked to Antonito for sizing and rail shipment. Output is comparable to Dicaperl's.

Dicaperl's Socorro mine has a similarly large capacity. It is estimated that 1995 sales will exceed 200,000 short tons; 98% of shipments are by rail.

The U.S. Gypsum operation at Grants is very small by comparison, with an annual throughput of less than 10,000 tonnes.

PRICING TRENDS

Wallace Bolen of the U.S. Bureau of Mines, and Peter Harben in the I.M. Handybook, report selling prices for 1989 through 1993 ranging from $29 to $31 U.S. per metric tonne, f.o.b. mine or plant. It would appear that major long-term contract customers have been successful in preventing any meaningful price escalation over the five-year period.

From discussion with other sources, however, it is learned that lower volume consumers are paying considerably more for sized raw ore, in the neighbourhood of $50 U.S. per short ton, f.o.b. mine or plant, in truckload quantities. While this increment of $20 or more is large, it is perhaps not atypical for industrial minerals commodities generally, where suppliers compete very aggressively for the high volume business they consider essential to sustain their desired operating rates.

Suffice it to say that pricing obviously varies from source to source, and also from any one producer as a function of grade, volume and competitive environment.

APPLICATIONS

The uses for expanded perlite are numerous and varied. In terms of overall U.S. consumption, Harbin shows almost 60% of all output going into formed products such as acoustic ceiling tile, pipe insulation and roof insulation board. Filter aids account for about 112% and horticultural uses 9%.

Regional markets can reflect quite different weightings. With no formed product plants in Western Canada, almost 100% of uncoated expanded perlite sales are directed at horticultural end-users.

In recent years, perlite has lost much of its beverage filter aid market share to diatomaceous earth. Further, there is little or no demand in the Pacific Northwest for perlite in lightweight concrete, either poured or pumped.

A very significant application for expanded perlite in North America is in coated microsphere form for use in lightweight joint cement. The minus 100 mesh, silicone-coated, low-density perlite particles repel water, retaining their cellular voids and dramatically reducing the weight of the applied coating. The microsphere product can cost as much as $1,000 Cdn per metric tonne, delivered to Vancouver. The total B.C., Alberta and Washington market is about 2,700 tonnes. There are only about three producers of this specialty value-added product in North America, all in the midwest and southwest states.

BRITISH COLUMBIA RESOURCES

The B.C. Geological Survey Branch lists 18 perlite occurrences in the Province in its MINFILE database compilation, some of which are located near tidewater but without road access. The interior deposits are generally readily accessible by logging road or better.

This overhead by White shows the location of several of these deposits -namely those with some commercial history or positive exploration and test data.

These showings were all investigated by Gary White of the B.C. Geological Survey Branch in 1989. The results were published in "B.C. Geological Fieldwork - 1989, Paper 1990-1, pp. 481-487". A year later, CANMET tested the expansion properties of the ores studied by White and published their findings in B.C. Geological Fieldwork - 1990, which can be summarized as follows:

1. Total weight loss during expansion:
   - Frenier, near Clinton 3.6%
   - Uncha Lake near Burns Lake 3.2%
   - Francois Lake near Burns Lake 3.0%
   - Port Clements Blackwater Creek 4.3%,
   - Port Clements Gold Creek 7.9%

2. Softening temperatures ranged from 12401 to 1290'C
3. They confirmed White's conclusion that all of these perlite ores are expandable, stating that the Gold Creek ore had the best potential as a filler. Expanded bulk densities ranged from 16 to 58 lb, per cu. ft., Frenier having the lowest. All four samples had a raw density of about 150 lb. per cu. ft.

As noted earlier, the Francois Lake deposit was mined briefly in 1953, but no published property or product data is available.

The Queen Charlotte Island deposits near Port Clements remain relatively unexplored, but showed positive test results at CANMET, and are favourably located close to tidewater, with the potential for low cost barge or ship transport to processing facilities at or near expanded product market centres.

FRENIER DEPOSIT

There is a great deal of information available about the Frenier perlite deposit, about 80 km. north of Lillooet and 60 km west of Clinton, on the Chilcotin Plateau, on the west side of the Fraser River, some 4,000 ft above sea level, as shown on this overhead. It is well described in the GSB MINFILE and the B.C. Geological Fieldwork Reports of 1988 and 1989. Mining was carried out on the property by Aurun Mines Ltd. from 1983 through 1987**,** a total of 6,500 metric tonnes being removed and shipped by truck to Aurun's expansion plant in Vancouver where a variety of expanded products were produced and successfully marketed throughout B.C., particularly in the horticultural sector.

The Frenier ore analysis is similar to others, containing on a dry basis:

- 77% silica
- 12% alumina
- 5% potassium oxide
- 2% sodium oxide
- 1 % iron oxide

The Aurun reported PH of 8.3 is slightly higher than normal.

In addition to the high level of customer acceptance of Aurun's expanded Frenier products - they quickly dominated the B.C. market -its credibility was further enhanced by research done by Giles and Poling at U.B.C. wherein they determined optimum parameters for the manufacture of commercial filter aids grades of expanded perlite at Aurun, concluding that competitive products could readily be produced.

CONCLUSIONS

Markets for expanded perlite in Western Canada and the Pacific Northwest states are relatively stable and within industry sectors exhibiting better-than-average mid-term growth prospects.

There is a strong demand for raw perlite within the region, well over 30,000 metric tonnes per year. A substantial portion of the total, however, is vested in one northwest Oregon consumer.

At least one B.C. perlite deposit is of proven commercial quality and several others appear to have good potential.

Coated perlite microspheres represent a substantial dollar volume of business in the region - in excess of $2.5 million per year.

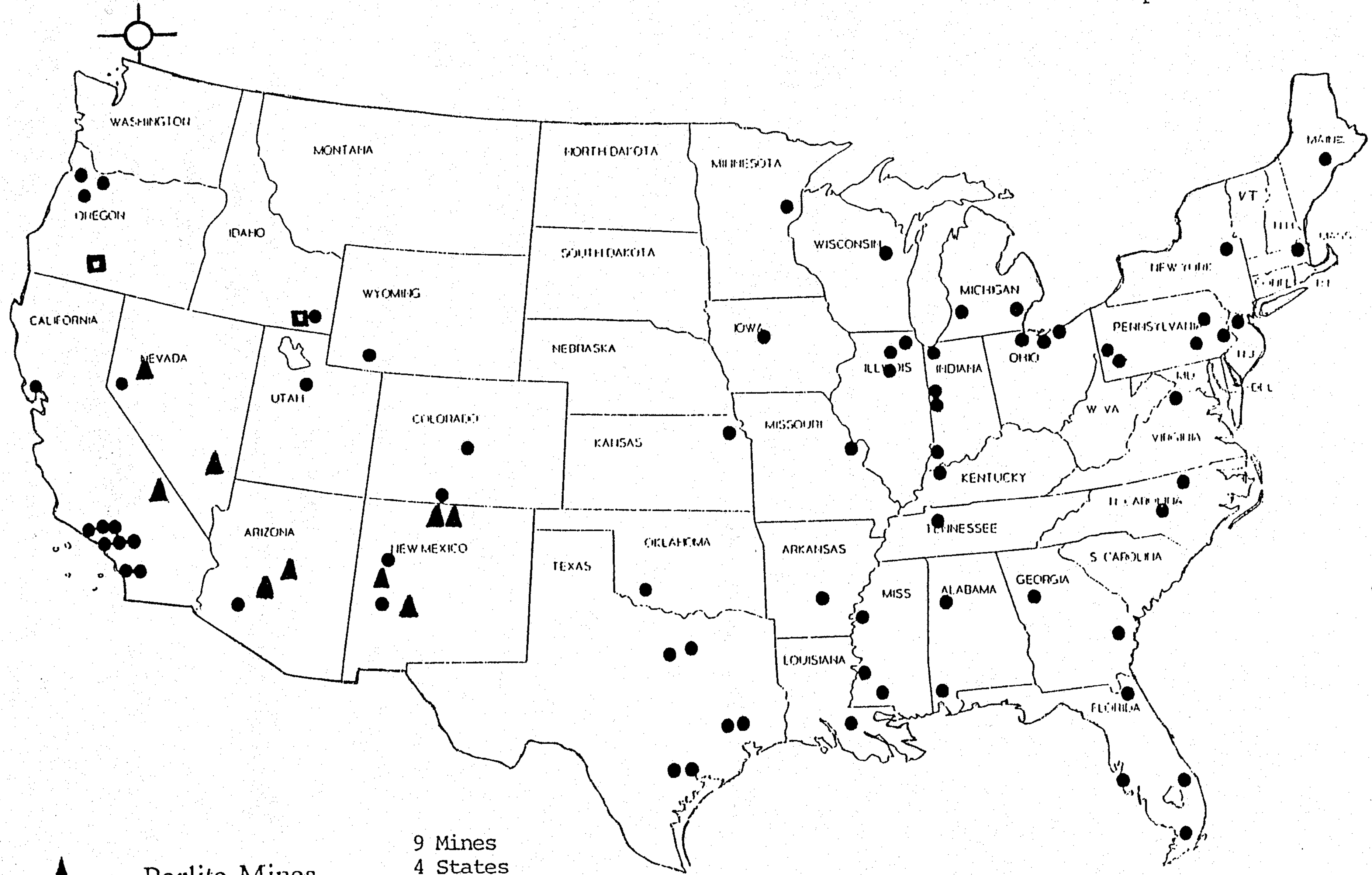
And now, in the time remaining, I would like to show some slides of the Frenier mine and the Aurun plant in Surrey, for which I am indebted to Bill Kure of Calgary, owner of the property.

/mcidgO17

1.

● Perlite Expansion Plants

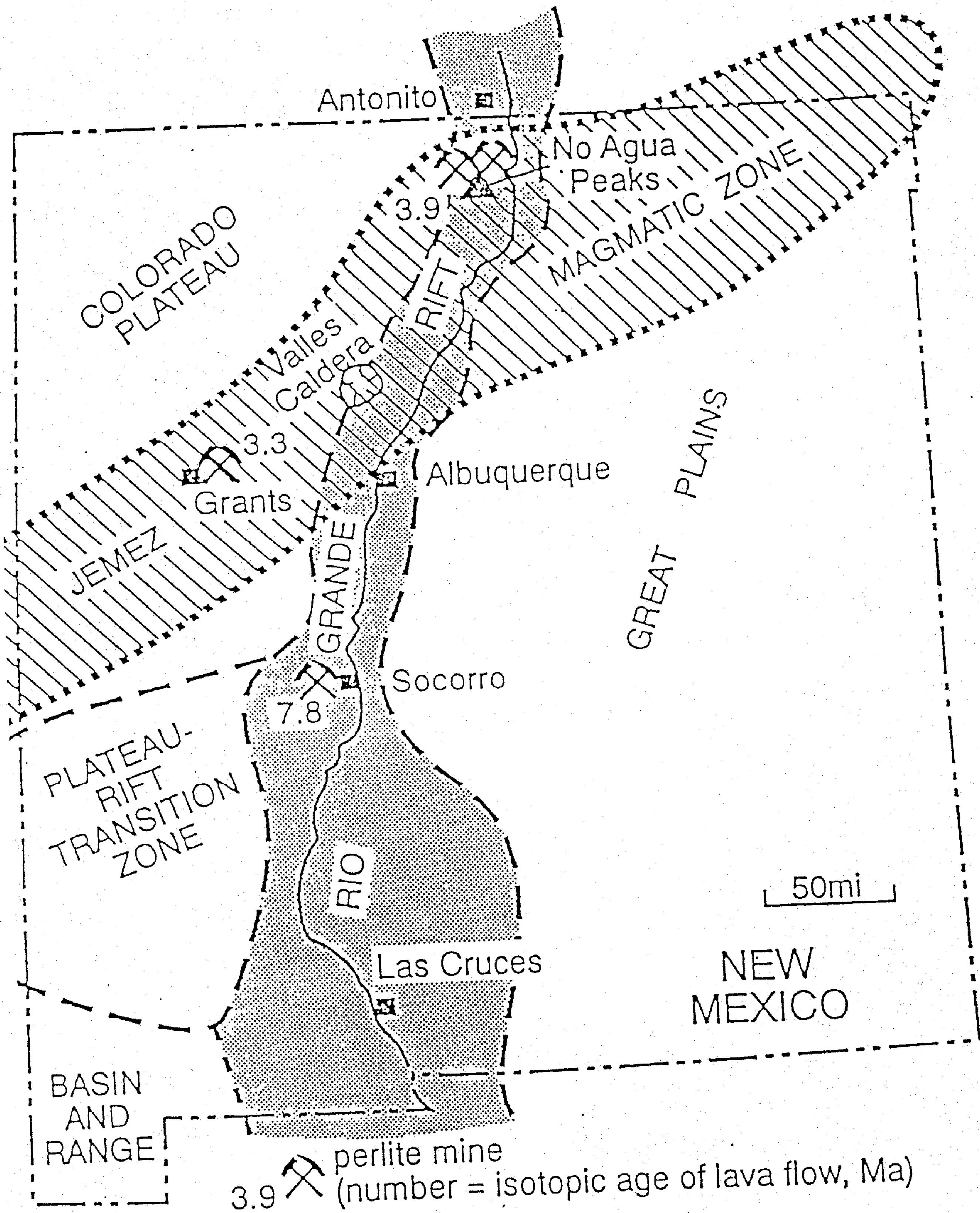
71 Plants
34 States
45 Companies



▲ Perlite Mines

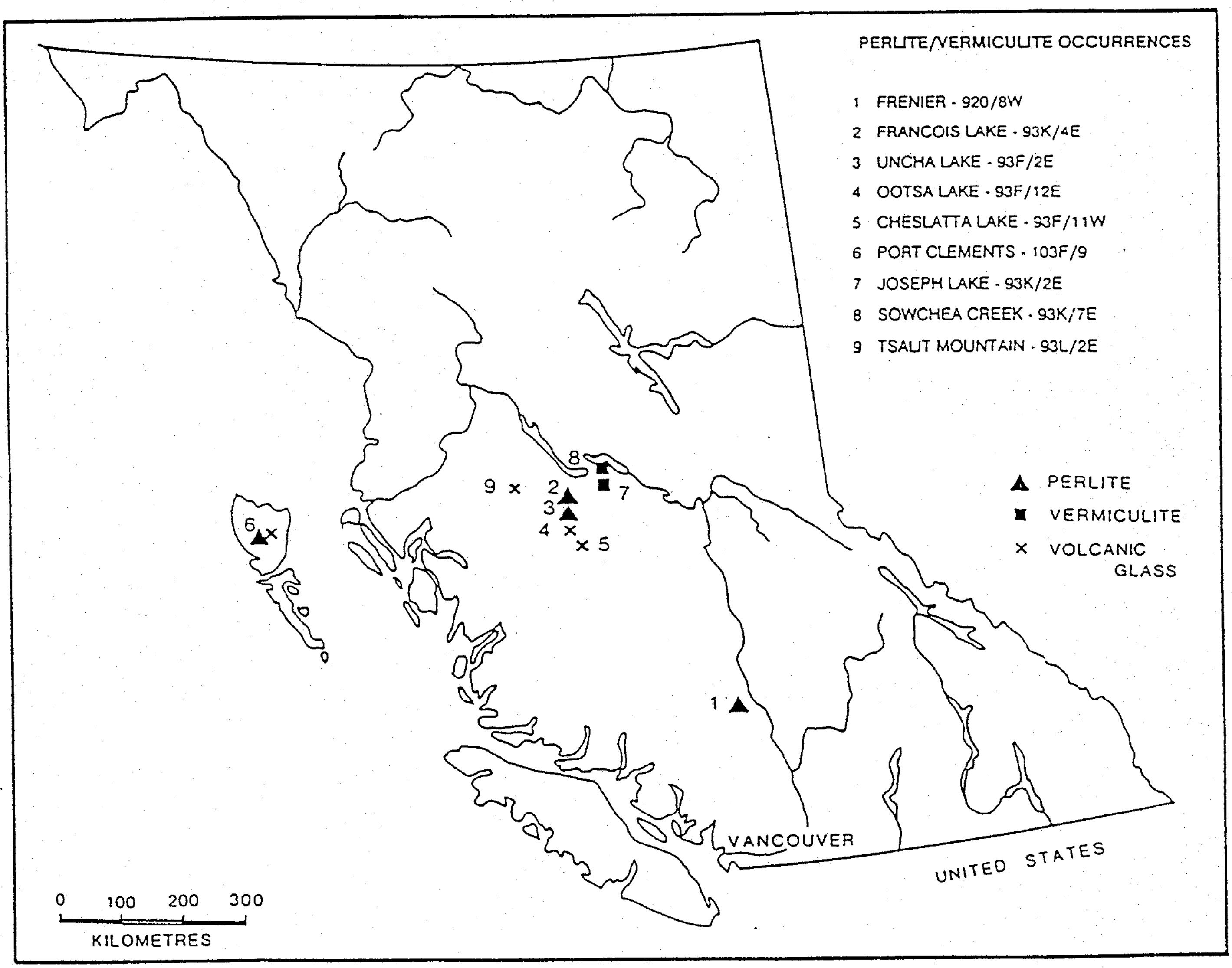
9 Mines
4 States
6 Companies

2.

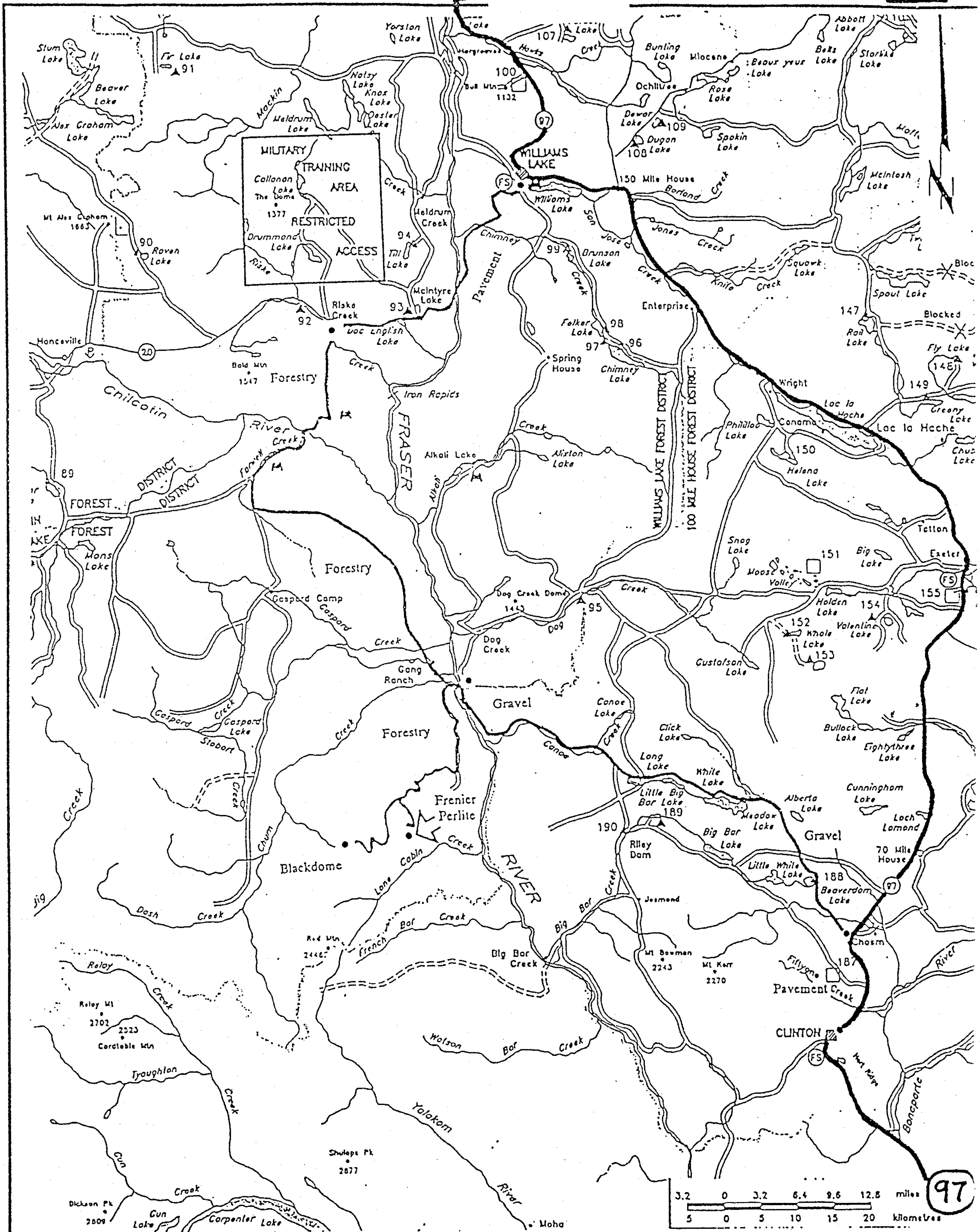

Antonito
No Agua Peaks
3.9
MAGMATIC ZONE
COLORADO PLATEAU
RIFT
Valles Caldera
3.3
Grants
Albuquerque
PLAINS
JEMEZ
GRANDE
GREAT
Socorro
7.8
PLATEAU-RIFT TRANSITION ZONE
RIO
50mi
Las Cruces
NEW MEXICO
BASIN AND RANGE
perlite mine
3.9
(number = isotopic age of lava flow, Ma)

3.

Figure 4



Locations of perlite/vermiculite occurrences in British Columbia.



ASSESSMENT REPORT FRENIER PERLITE DEPOSIT	May 1, 3 and 4 Claims Mining Lease 24	SITE ACCESS MAP
TERRACON GEOTECHNIQUE LTD.	Scale: 1:1,000,000	Figure 3

Demand Defines Exploration Targets for Industrial Minerals

by

P. W. Harben,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Demand in Latin America Defines Exploration Targets for Industrial Minerals

Peter W. Harben

Peter W. Harben Inc., P.O. Box 800, Morris, NY 13808, USA

-INTRODUCTION

Without a market, a non-metallic mineral deposit is merely a geological curiosity. This market driver points to great opportunities for industrial minerals in Latin America, a region that encompasses more than 30 countries stretching from Mexico in the north to Argentina in the south and includes Caribbean countries such as Cuba, Jamaica, Haiti, and the Dominican Republic. Six countries --- Brazil, Mexico, Argentina, Colombia, Peru, and Venezuela -- account for 75% of the 450-million population. More importantly for future mineral consumption, this population level is expected to grow to almost 490 million by the year 2000 and 654 million by 2025.

Within this market is an increasing amount of intra-regional trade, particularly within trading blocks such as Mercosur, the Andean Pact, Caricom, and the Central American Common Market Free trade is expanding as, for example, Bolivia and Chile have been invited to join Brazil, Argentina, Paraguay, and Uruguay as members of Mercosur. The region's strength as a trading block may be fortified still further with the inclusion of the United States and Canada in a new trading club -- 34 countries comprising the Western Hemisphere minus Cuba have begun talks aimed at creating a free-trade zone of the Americas (FTAA) by the year 2005. If all goes to plan, custom officials will be made redundant from Alaska to Argentina in what would be the world's largest single market -- $13 trillion from a population of 850 million. Even now shipments to fellow North and South American countries account for 90% of the exports from Mexico, 80% from Canada, 50% from Argentina and Brazil, and 40% from the United States. A meeting in Denver in June 1995 reaffirmed the goal of establishing FTAA within ten years.

THE MARKET IS DRIVEN

Latin America has already emerged as an important supplier of a variety of industrial minerals to regional and world markets. For example, Mexico accounts for about half of the world's celestite production which is used as a feedstock to produce most of the world's strontium carbonate so that there is a little piece of Mexico in most television sets. Unlikely candidates such as gypsum (5 million t/y) and salt (7 million t/y) are exported from Mexico to North America and Asian markets. Unique natural nitrate deposits found in the arid northernmost Chilean provinces of Tarapaca and Antofagasta are mined and exported all over the world; in addition, these deposits yield 33% of the world's iodine supply. Chile also exploits multimineral-rich salars containing lithium, soda ash, potash, sodium sulphate, salt, and magnesium. Production of lithium from the Salar de Atacama brines in Chile has gradually replaced supplies from US pegmatites, and this will be strengthened with the start-up of production from Salar de Hombre Muerto, Argentina, in 1997. Argentina, Chile, Bolivia, and Peru share a 880-km-long boron-rich stretch of the Andes. Increased production and exports from this region have disrupted the traditionally neat pattern of boron supply from the United States and Turkey which between them control 70% of the world's known borate reserves.

Brazil is one of the few large-scale producers of paper coating-grade kaolin in the world. Although the current refined kaolin capacity of 820,000 t/y is relatively small compared with the United States (9 million t/y) and United Kingdom (3.7 million t/y), most of the Brazilian production serves an extremely wide geographic area and capacity is expanding rapidly. Latin America contributes almost 30% of the world's bauxite production, largely from Jamaica (11 million t/y), Brazil (9 million t/y), Surinam, Guyana, and Venezuela (3 million t/y each). Although not the largest producer, Guyana is particularly important since it sets the standard for calcined refractory-grade bauxite and feeds the refractory industry throughout North America, Europe, and the Pacific-Rim region.

Other important, industrial minerals produced within the region include asbestos in Brazil and Colombia; barite, bentonite, feldspar, magnesite/magnesia, manganese, and phosphate rock in Brazil and Mexico; chromite in Brazil; fluorspar in -Mexico; salt in Argentina, the Bahamas, Brazil, and Mexico; sulphur in Brazil, Chile, and Mexico; and talc -in Brazil. A table of historical production of industrial minerals in Latin America with its percentage of world production is given in the Appendix.

MARKET DEVELOPMENT

Although Latin America has a long history of mining and plays an important role in the international industrial minerals industry, it is future production from yet-to-be discovered mineral deposits that will sustain its growth into and through the next century. Targeting these minerals deposits will be the key to commercial success. Ironically, studying the past may well provide an indication of what minerals will be required in future at what stage of a country's development.

As a nation's economy evolves from a largely rural through an urban and eventually to an industrialised base, the pattern of mineral consumption alters drastically. There is a fairly good correlation between per capita mineral consumption and per capita GDP which in turn reflects the stage of a country's development (that is degree of industrialisation). This correlation can be illustrated through a series of graphs plotting the GDP per capita in 1992 US$ against the consumption of a particular mineral in kilograms per capita. The original graphs for some 30 minerals published by Richard N&staller for the World Bank in 1987 where recalculated and redrawn during a consulting project for BHP Minerals Inc." N&staller used the United States as the base since consumption data was readily available and the economy had developed through all of the various stages, that is early (GDP per capita of <$2,400), middle (GDP per capita of $2,400 - $8,000), and advanced development (GDP per capita of > $8,000). Using these graphs, the GDP/capita of selected countries can be superimposed to indicate their positions on the development curves. Examples for Latin America are outlined below.

STAGE OF DEVELOPMENT	GDP/Capita
EARLY	< $2,400
Guatemala	$1,079
Ecuador	$1,137
Colombia	$1,345
Paraguay	$1,460

Cuba	$1,580
Peru	$2,191
Middle	**$2,400 - $8,000**
Brazil	$2,525
Chile	$2,828
Venezuela	$2,972
Uruguay	$2,935
Argentina	$3,250
Trinidad & Tobago	$3,600
Mexico	$3,690

This exercise is particularly useful for a company that is seeking growth prospects within a broad range of industrial minerals throughout the world. The graphs may be used to identify (or more often to confirm) specific minerals or industries and particular regions where growth may be expected in the future. One example is to justify to company management the selection of a number of target minerals in a given region. Clearly, more detailed work is required on both the minerals and regions selected, but it is a useful first step in the selection process.

A slightly more sophisticated approach is to plot mineral consumption per thousand dollars of GDP versus GDP per capita, that is "mineral intensity of use" or IOU. Most industrial minerals show a peak in the rate of consumption, for example, crushed stone and sand & gravel tend to peak during the early development period following the initial rush to build infrastructure whereas cement, soda ash, and feldspar peak in the middle development period as the construction and glass and ceramic industries begin to mature. Gypsum, vermiculite, and perlite, on the other hand, survive because of their use in the more sophisticated forms of buildings. Several minerals tend not to peak and decline, for example nitrogen, phosphate, and potash which are primary nutrients in fertilisers.

INDUSTRY APPROACH

Rather then focusing on individual minerals, an industry approach can be taken. As a country's economy develops and matures, certain industries grow in somewhat of an orderly sequence which is the real driver for mineral demand. The sequence could be:

- ☐ Construction raw materials
- ☐ Fertilisers and agricultural minerals
- ☐ Glass ceramic raw materials
- ☐ Chemical raw material
- ☐ Metallurgical, foundry, and refractory minerals
- ☐ Pigments and Fillers
- ☐ Energy materials
- ☐ Human consumption raw materials

For the purposes of this paper, the graphs of the individual minerals have been combined into the first three industries, that is:

- ☐ Construction *(Figure I)*
  - ◆ **Crushed stone**
  - ◆ **Sand & gravel**
  - ◆ **Cement**
  - ◆ **Gypsum**
  - ◆ **Vermiculite**
  - ◆ **Perlite**

- ☐ **Fertilisers** *(Figure 2)*
  - ◆ **Phosphates**
  - ◆ **Potash**
  - ◆ **Nitrogen**
  - ◆ **Sulphur**

- ☐ Glass and ceramics *(Figure 3)*
  - ◆ **Clays**
  - ◆ **Feldspar**
  - ◆ **Talc & pyrophyllite**
  - ◆ **Soda ash**
  - ◆ **Boron**

CONSTRUCTION

A sound infrastructure is the foundation of commercial development. Adequate shelter is necessary for the growing population and a reliable transportation system is necessary to get the goods to market. Imports and exports require improved and efficient port facilities and airports need to be built and enlarged (it was recently announced the new Hong Kong airport would cost $23 billion!). This growth is fed by large quantities of various construction raw materials.

***Early days*: In the early stages of a nation's development there is a sharp increase in the consumption of sand and gravel reflecting the initial stages of infrastructure building, the availability of local sand and gravel using simple mining techniques, and a lack of expertise and equipment to crush stone to the required specifications. Although slower to start than sand & gravel, crushed stone, cement, and gypsum show moderate increases in demand during this period because of the generally widespread availability of crushed stone (some of which is used in cement production), increasing supply of cement initially through imports and then domestic supplies, and the gradual beginning of a more sophisticated building industry using gypsum wallboard (as well as the use of fertilisers and soil amendments in agriculture). Wallboard production may require technology transfer and/or joint ventures with international wallboard producers such as USG in the United States, Yoshino Plasterboard in Japan, and British Gypsum in the UK. Perlite and vermiculite show a very slow initial growth rate reflecting lack of facilities requiring such sophisticated building materials.**

***Middle Age:* During the middle development stage sand and gravel tends to continue its sharp increase followed by slight slowdown after mid-middle development reflecting a maturing of initial**

infrastructure building activity. At the same time crushed stone shows a sharper growth rate than sand and gravel although still unspectacular (a.k.a. steady?) increase without the slowdown experienced by sand and gravel; this reflects the broader based availability of crushed stone gradually replacing depleted and less widespread sand and gravel reserves and the establishment of facilities designed to supply customised grades of various sizes. Cement and gypsum both show a similar pattern based on increased availability of domestic supplies and downstream products gradually replacing imported material, and possibly reduced price through economies of scale and supply availability. Perlite and vermiculite show a moderately steep and steady growth reflecting a gradual increase in industrial sophistication including the insulation and fireproofing of buildings.

Maturity: As development advances sand and gravel continue to slow down slightly followed by a fairly sharp slowdown reflecting continued maturity of initial infrastructure building, the depletion of easily mined sand and gravel deposits often through urban sterilisation of reserves, and the increased availability and popularity of cement. Crushed stone continues its increase without the slowdown experienced by sand and gravel reflecting the establishment of crushed stone as the main construction raw material and the increased use of crushed stone for use with cement such as ready mixed concrete. Consequently, cement demand continues to increase with a later and less rapid slowdown compared with sand and gravel reflecting development of alternative building materials such as dimension stone, bricks, etc. Gypsum has a similar pattern to cement because of the establishment of wallboard plants and increased popularity of the product and the introduction of more diverse building materials (plus the application of calcia and sulphate via more complex fertilisers). Perlite and vermiculite show increased consumption rate followed by a marked slowdown reflecting rapid diversification of use into non-building uses, for example, filter media and horticulture, and competition from other materials such as diatomite. There is a continued increase in industrial sophistication including the insulation of buildings.

Taking gypsum as an example, a detailed apparent consumption table can be produced for the region based on production plus imports minus exports for individual countries (Table 4). Overall, Latin America is a net supplier of 2.5 million tons/year virtually all from Mexico. The table highlights several 50,000 t/y shortfalls including Colombia, Ecuador, and Honduras.

FERTILISERS

It would seem logical that with urbanisation, farming becomes more intensive and efficient in order to feed more sophisticated people using less and more expensive land which in turn increases the demand for fertilisers. The limited sources of supply of phosphates and potash often means that most countries have to rely on imports. in addition, when one nutrient is used, the others have to be added in order to maintain the nutrient balance (the ratio depends on the crop and on the background level of nutrients). Therefore, all three primary nutrients -- phosphates, potash, and nitrates -- have a similar consumption pattern.

Early days: During the period when the country’s economy is largely agricultural, phosphates, potash, and nitrates have a moderate consumption rate followed by an increase midway through the period. This pattern reflects expanding fertiliser demand as urbanisation and population growth increase the demand for food which in turn increases the sophistication of the agricultural industry and need for fertilise. This is served initially through imported finished and blended products and/or the use of direct application phosphate rock due to the lack of facilities to process crude phosphate rock. In the case of lime, there is a fairly rapid initial increase reflecting the same criteria. The rapid and consistent increase in sulphur consumption reflects its widespread use in virtually every manufacturing process.

Middle age: The increased and steady growth in demand of all fertiliser raw materials reflects urbanisation and population growth increasing the demand for food, the escalating price of land forcing efficiency methods including fertiliser application, the availability of facilities to convert phosphate rock into more concentrated products, and the increased availability of blending facilities to produce mixed fertilisers. Except for nitrogen products which can be manufactured through chemical means, the main fertiliser raw materials are imported. Sulphur tends to continue its rapid and consistent increase reflecting the use of sulphur in the manufacture of fertilisers, particularly the treatment of phosphate rock, as well as the foundation of the chemical industry.

Maturity: Shows a continued increase with little sign of a consistent slowdown reflecting continued urbanisation and demand for food, an increased need for fertilisers to increase crop yield per acre, the increased sophistication of fertilisers including mixed fertilisers. Sulphur demand continues to increase with an almost imperceptible slowdown reflecting the broadbased use of sulphur, the beginnings of the maturity of the basic chemical industry, increased production costs (land and labour) and concern over environment and worker safety driving a preference to import basic chemicals, and movement away from manufacturing and towards the service industry.

Data is available to generate an apparent consumption table for phosphate rock and potash (Table 5). As would be expected with fertiliser raw materials, there is a marked deficit in Latin America. Mexico imports over 2 million t/y of phosphate rock and Brazil takes about 1.75 t/y of potash. There are numerous smaller consumers that could be fed from within the region. Most countries except for Mexico have a deficit of sulphur, although there is a great deal of potential from by-product sources.

GLASS AND CERAMICS

Urbanisation encourages the construction of buildings which in turn requires products such as glass (windows), ceramic plumbing fixtures (toilets, wall and floor tiles), and possibly gypsum wallboard and plaster (see construction). It would seem logical that these products are first imported, but given a reasonable domestic demand, local production is encouraged. This may well require the assistance of large overseas manufacturers together with technology transfer and joint ventures. Some glass examples are PPG Industries, Guardian Industries, and OCF from the United States, Pilkington of the UK, Saint-Gobain in France, and Asahi Glass and Nippon Sheet Glass from Japan.

Once again, this growth could initially be based on imported raw material, but more likely domestically produced minerals. This is particularly true for low-priced minerals such as silica sand, although those less common minerals requiring more exact specifications such as kaolin, feldspar, soda ash, and asbestos may be imported.

Early days: During the early stages of economic development, demand for soda ash, feldspar, and clays is slow but then tends to pick up in the second half of the period reflecting small-scale uses such as water treatment, the early establishment of domestic glass production capacity in order to serve the fast-growing construction industry. Soda ash and feldspar are generally served through imports with clays sourced locally. Borates have a steady but slow growth reflecting their early use as chemicals and in agriculture rather than fibreglass.

Middle Age: Soda ash shows increasing growth because of the expansion of the domestic glass industry including flat glass and fibreglass plus container glass serving the food and beverage industry, increased availability of soda ash through regional or even domestic Solvay plants, and diversification of use into pulp and paper, soaps & detergents. Feldspar has a similar steady growth with a slowdown near the end of the period reflecting expansion of the domestic glass industry and increased availability of feldspar from domestic operations. Borates continue to grow steadily reflecting the development of a speciality glass industry including fibreglass and borosilicate glass and continued diversification. Clays experience increasingly rapid growth in demand particularly in the second half of the period reflecting continued development of domestic ceramics, refractories, and similar industries, establishment of a domestic refractory production capacity based on clays to serve the steel and foundry industries, a wider availability of various types of clay through domestic production, and diversification into more sophisticated uses.

Maturity: soda ash continues to grow but at a slower pace reflecting a gradual maturity of the glass and chemicals manufacturing sectors, a reduction in the consumption of raw material per unit of glass produced through increased efficiency and recycling, and competition from aluminium and PET containers. However, consumption is helped by a lack of substitutes for soda ash in the glass industry and any slowdown is less severe compared with say feldspar since soda ash uses are more diversified. Feldspar and clay have a fairly rapid slowdown in consumption for the same reasons as soda ash plus increased competition in the ceramics sector from synthetic material such as cultured marble, fibreglass, and PVC pipes, increased availability of cheap imported ceramics and glass, and a lack of diversification in the uses (some 95% of feldspar is used in glass and ceramics). In the case of clay there is increasing sophistication of refractories utilising high-grade magnesia, alumina, and graphite rather than refractory clays. Boron continues to grow steadily as fibreglass and borosilicate glass demand increases with little opportunity for substitution.

LEARNING FROM THE NICs

Studying the successes and failures of the Newly Industrialised Countries (NICs) such as Hong Kong, Singapore, South Korea, and Taiwan can help foretell the path of the Rapidly Industrialising Countries (RICs) such as Brazil, Mexico, and Chile. Since 1965 these four Asian NICs have quadrupled their share of world production and trade and quintupled their per capita incomes. Between 1965 and 1986 the per capita GNP in each country grew at least 5% per annum compared with 4.3% for Japan and just 1.6% for the United States. Positive effects of the growth included increased levels of education and health care promoting a more literate and healthier population (the literacy rate in South Korea, for example, increased from 30% in 1953 to 80% in 1963), a highly skilled workforce, improved income distribution, and in certain cases land reform. On the negative side, this phenomenal growth came at a high environmental price which only now is being tackled at a huge financial cost.

The contribution to GPD by industry has changed over the period 1963 to 1988 for three countries at different stages of development -- Japan, Korea, and Indonesia.

Japan

Industrialisation for Japan started well before World War II and was boosted by the "special procurements" of the Korean War which in 1951 increased industrial production by 50%, pushed exports to unprecedented levels, and generated a positive balance of payments. In the 1960s, during a period of import substitution and domestic investment, Japanese GDP grew at an annual compound rate of 10.4% and almost tripled within the decade. The oil shocks of 1973 and 1979 slowed growth, although a shift to the manufacture of value-added products encouraged exports to increase and formed the foundation for Japan's dominance in automobiles and electronic goods (the ultimate in value-added goods). In the 1980s exports of value-added goods continued to grow, albeit at a slower rate due to exchange rate fluctuations, to reach 15% of GDP. Over this entire period, agriculture fell from 12 to less than 3% of GDP.

South Korea

South Korea trailed Japan in this industrialisation process. After World War II, Korea was an agrarian country and in the 1950s it concentrated on its natural resources sector as the basis for economic development. In 1963 agriculture accounted for 42% of real GDP and manufacturing just 8.2%. In an effort to reduce imports, Korea developed its light manufacturing industry. The next step in industrialisation was kick started by a government policy change that encouraged exports and foreign investment (mainly by US and Japanese multinationals seeking cheap labour). This resulted in an average annual growth rate of 8% in the 1960s. Success in the export market provided employment in the growing cities and provided the capital for re-investment. Despite the oil shocks of the 1970s, growth has continued to exceed most industrialised countries and by 1988 manufacturing accounted for 38.2% compared with agriculture at 10%.

Indonesia

In 1963 Indonesia was still farther behind in the industrialisation path with agriculture accounting for 36.5% of the country's GDP. Industrialisation really began to take off in 1966 when the Suharto government came to power and adopted the "New Order" economic policy designed to liberalise trade and foreign exchange and to encourage foreign investment. It is reported that manufacturing increased at 13.9% per annum for 1970-1981 which was the driver behind the 7.7% annual growth of the real GDP. Consequently, the manufacturing share of GDP doubled in ten years to reach 21.6% in 1988. Indonesia remains one of the fastest growing economies in the world feeding off its large population and revenues from natural resources.

CONCLUSIONS

Latin America offers investors an opportunity to participate in a rapidly escalating market. Only parts of Asia can offer similar growth prospects. In contrast, the traditional markets of North America, Europe, and Japan are mature, and consumption is flat or even declining because of the lack of population growth and the need to conserve dwindling resources. Investment is discouraged by high labour rates and production costs, punitive taxation schedules, and an increasingly vociferous anti-mining sector. In contrast, the market in Latin America will grow based on its expanding population and the increasing buying power of the people. Investment is being encouraged by governments that see the responsible exploitation of natural resources as a means to improve the country's standard of living. Reform of trade, tax, and mining laws, industrial deregulation, and large-scale privatisation have spurred private sector investment and opened up

the market for foreign capital. Since most Latin American countries are somewhere between the late stages of the Early Development Period (GDP/capita of $1,000) and the early stages of the Middle Development Period (GDP/capita of $3,600), there is a strong possibility that economic growth will speed up still further in the early part of the 21st century just as the Korean economy expanded in the 1970s and 1980s.

Although certain refined industrial minerals like paper-coating grade kaolin and strontium carbonate will continue to find extensive markets outside the region, increased manufacturing capacity within the RICs of Latin America will require large volumes of raw materials. At the same time, imports of finished goods like fibreglass and ceramic toilets will be replaced by domestic products manufactured in factories set up through joint ventures or technology transfer. All this will encourage the exploitation of indigenous raw materials, even the relatively low-cost items like silica sand and ceramic clay. As illustrated in an earlier section, construction, fertilisers, and glass and ceramics are the first industries to grow with an expanding economy.

As well as the potential for business development in Latin America, there is also the potential for business disaster. Regional growth rates provide a firm foundation for increased demand of industrial minerals, and the natural mineral wealth and diversity of many countries allow for the possibility of self sufficiency and export market share. However, the political instability and currency devaluations experienced recently in Venezuela and Mexico can be regarded as a reminder of what could happen. It quickly creates a feeling of uncertainty that can interrupt the flow of investment dollars. Nevertheless. while the opportunities are spiced with danger there is no denving that industrial minerals, being market driven, are prime targets for development as well as the crucial means to develop this challenging region.

* *the author wouid like to acknowledge BHP Minerals Inc. for some of the data and concepts outlined in this presentation.*

REFERENCES

Alatorre, A., Harben, P., McVey, H., and Santini, K., 1995, "Mexico: Opportunities in Industrial Minerals" in Proceedings, 29th. Forum on the Geology of Industrial Minerals, Long Beach CA (1993), M. Tabilio & D. Dupras, Eds., California Dept. of Conservation, Div. of Mines & Geology, Sp. Pub. 110, pp. 269-312.

Bourne, H.L., 1994, "Glass Raw Materials" in *Industrial Minerals and Rocks,* 6th ed., D.D. Carr, Editor, SME, Littleton, CO, pp. 543-550.

Chang, J.C., 1993, *The Role of Major Nonfuel Minerals in the Asian Pacific Rim Economies,* Mineral Issues, US Bureau of Mines, 51 pp.

Crozier, R.D., 1987, "The Chilean nitrate industry vs the US Department of Commerce", *Industrial Minerals,* no. 237, June, pp. 62-67.

Dickson, T., and Harben, P., 1986, "Refractory bauxite" in *Raw Materials for the Refractories Industry,* 2nd. Ed., E.M. Dickson, ed., Industrial Minerals, pp. 70-75.

Ericksen, GE., 1981, "Geology and origin of the Chilean nitrate deposits", US Geol. Sur-v. *Prof. Paper-* 1188, 37 pp.

Hinds, S.A., 1983, "Refractory bauxite" in *Proceedings, Minerals in the Refractories Industr-y -- assessing the decade ahead,* E.M. Dickson and P.W. Harben, eds., Industrial Minerals, no. 187, April, pp. *55-60.*

Harben, P.W., and Bates, R. L., 1990, Industrial Minerals - Geology and World Deposits, Industrial Minerals Div., Metal. Bulletin PLC, London, 3 12 pp.

Harben, P.W., 1995, *Industrial Minerals HandyBook: A Guide to Markets, Specifications, & Prices, Second Edition,* Metal Bulletin plc, London, 254 pp.

Harben, P.W., 1995, "Industrial Minerals South of the (Mexican) Border", 31st. Forum on the Geology of Industrial Minerals, New Mexico Bureau of Mines and Mineral Resources, El Paso, Texas, in press.

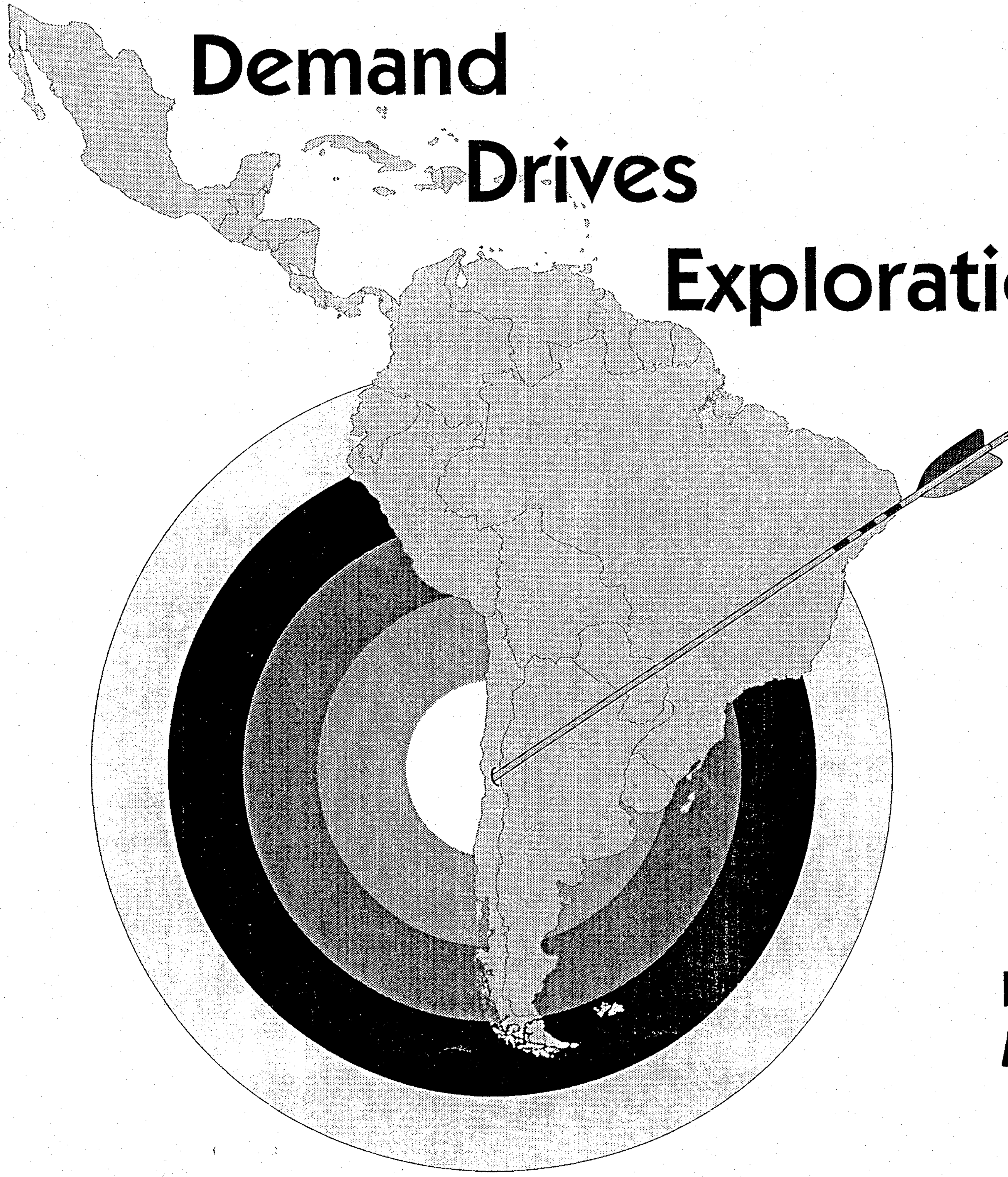
Kistler, R.B., and Smith, W.C., 1983, "Boron and borates" in *Industrial Minerals and Rocks,* 5th ed., S.J. Lefond, ed., AIME, New York, pp. *533-560.*

Notstaller, R., 1987, *Industrial Minerals - A Technical Review,* World Bank Technical Paper No. 76, 117 pp.

Patterson, S.H., 1967, "Bauxite reserves and potential aluminum resources of the world", US Geol. Surv. Bull. 1228, 176pp.

Pickering, S.M. and Murray, H.H., 1994, "Kaolin" in *Industrial Minerals and Rocks,* 6th ed., D.D. Carr, Editor, SME, Littleton, CO, pp. 255-277.

Demand Drives Exploration Targets



Peter W. Harben
Morris, NY, USA

17

GDP by Industry (%)

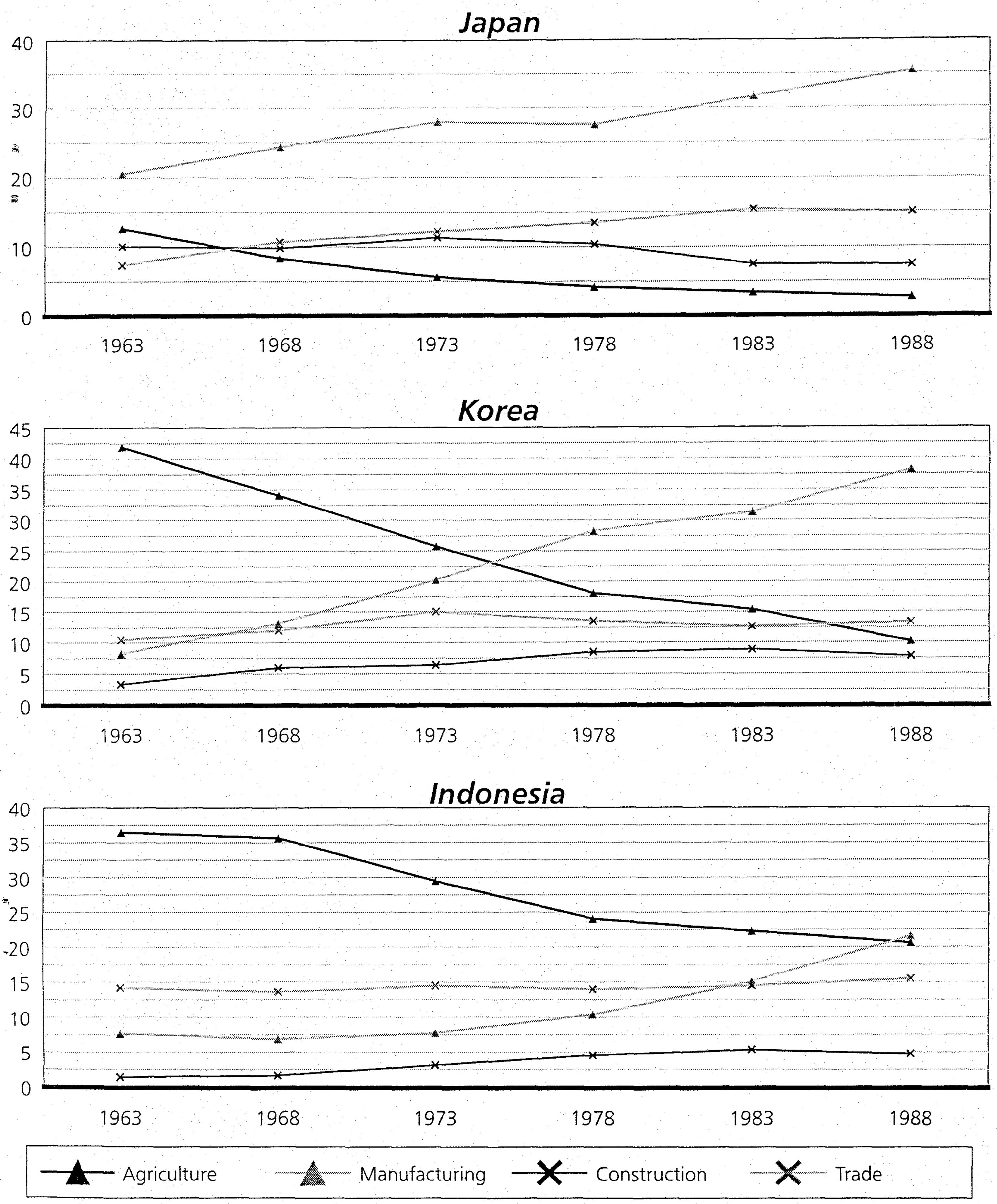
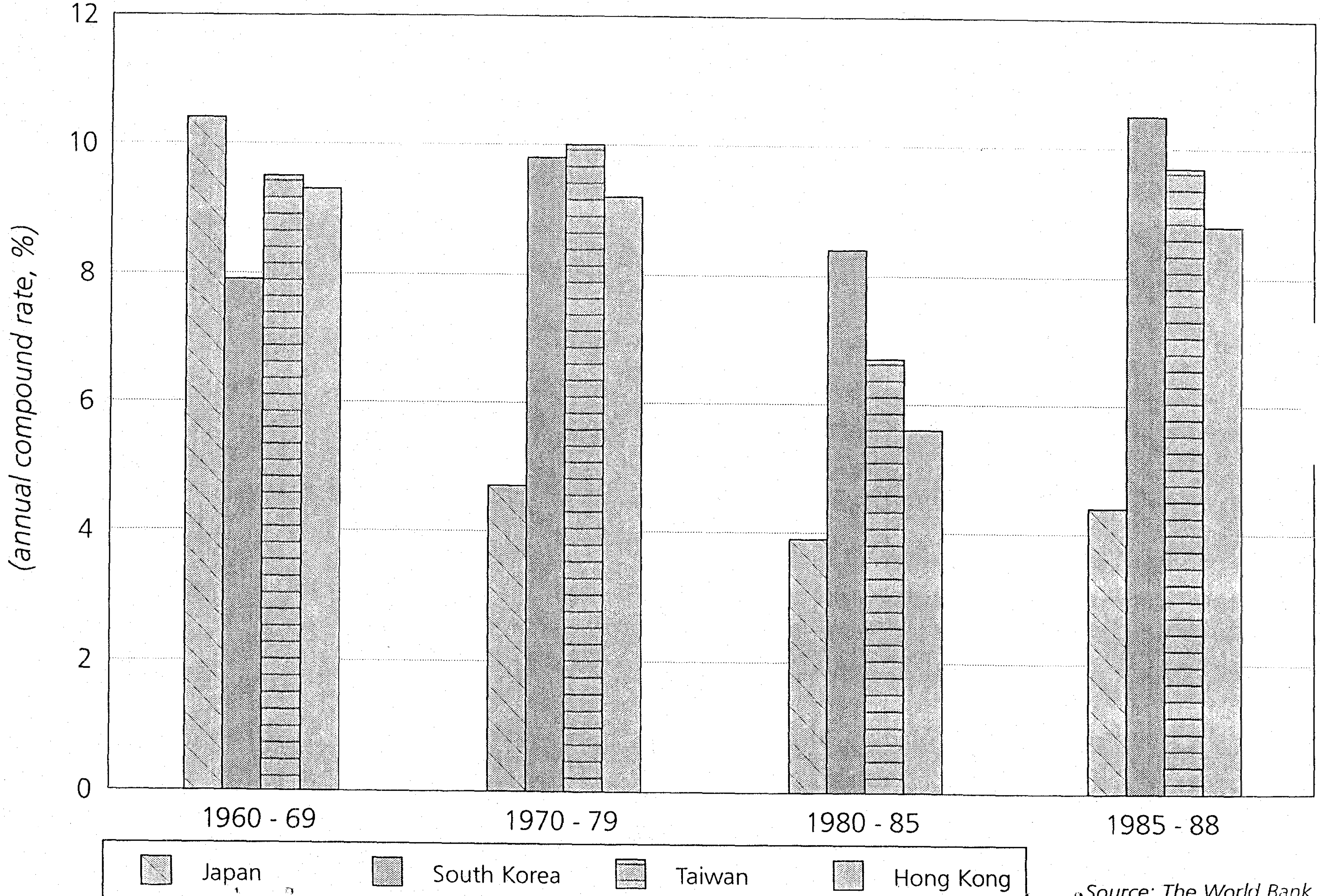


Figure 6
Real GDP Growth in Asia



Source: *The World Bank*

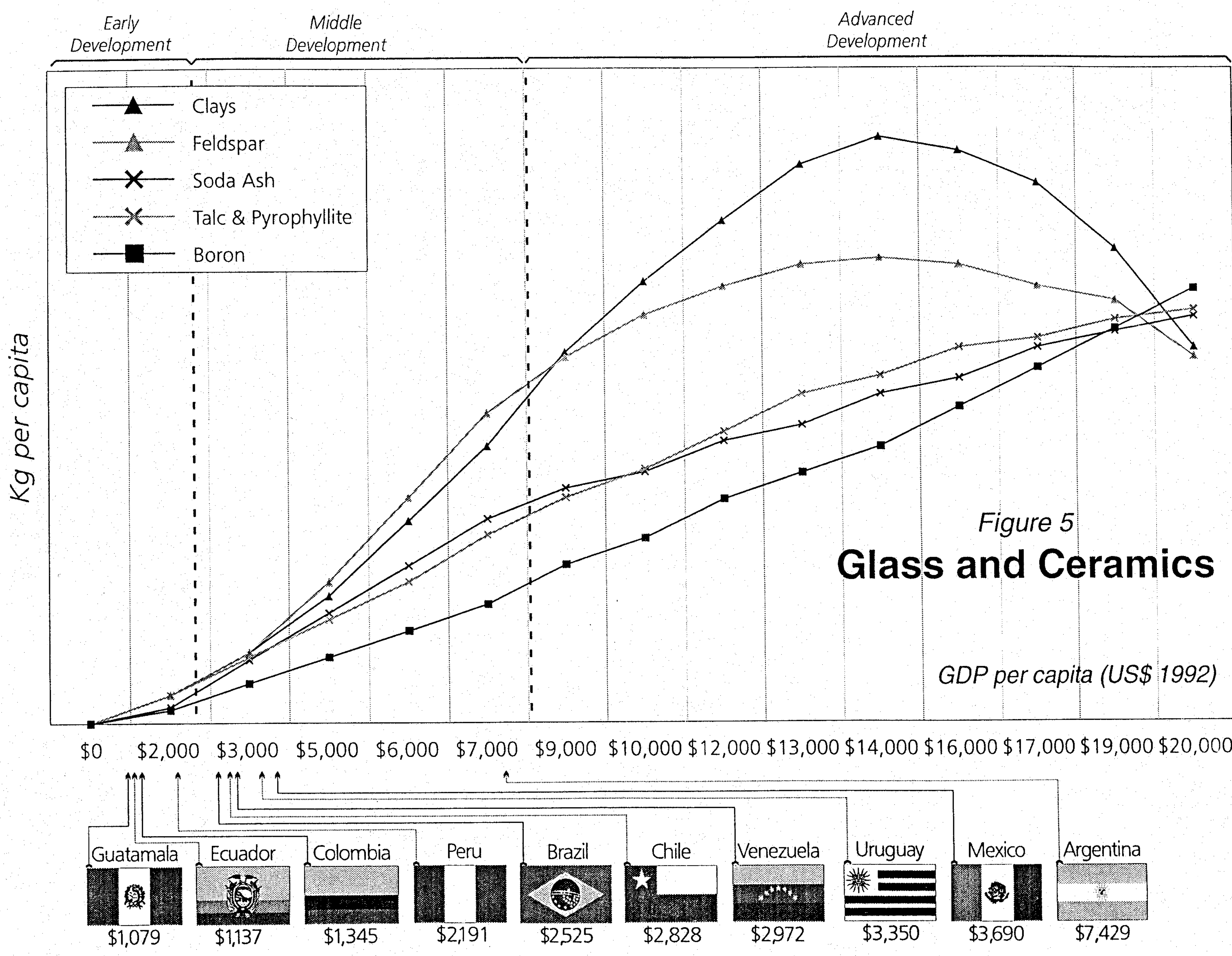
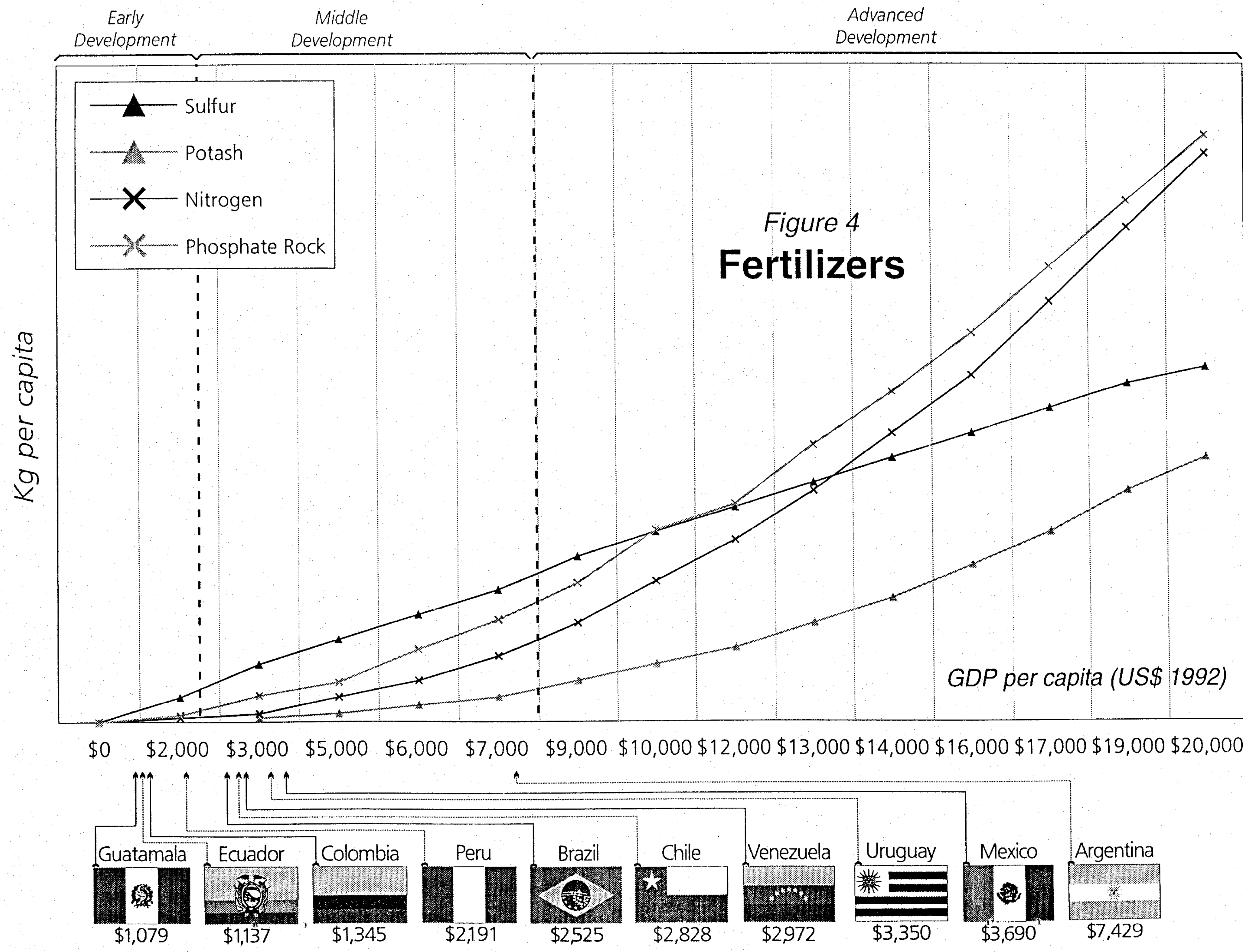


Figure 5
Glass and Ceramics


Early Development
Middle Development
Advanced Development
Sulfur
Potash
Nitrogen
Phosphate Rock
Figure 4
Fertilizers
Kg per capita
GDP per capita (US$ 1992)
$0
$2,000
$3,000
$5,000
$6,000
$7,000
$9,000
$10,000
$12,000
$13,000
$14,000
$16,000
$17,000
$19,000
$20,000
Guatamala
$1,079
Ecuador
$1,137
Colombia
$1,345
Peru
$2,191
Brazil
$2,525
Chile
$2,828
Venezuela
$2,972
Uruguay
$3,350
Mexico
$3,690
Argentina
$7,429

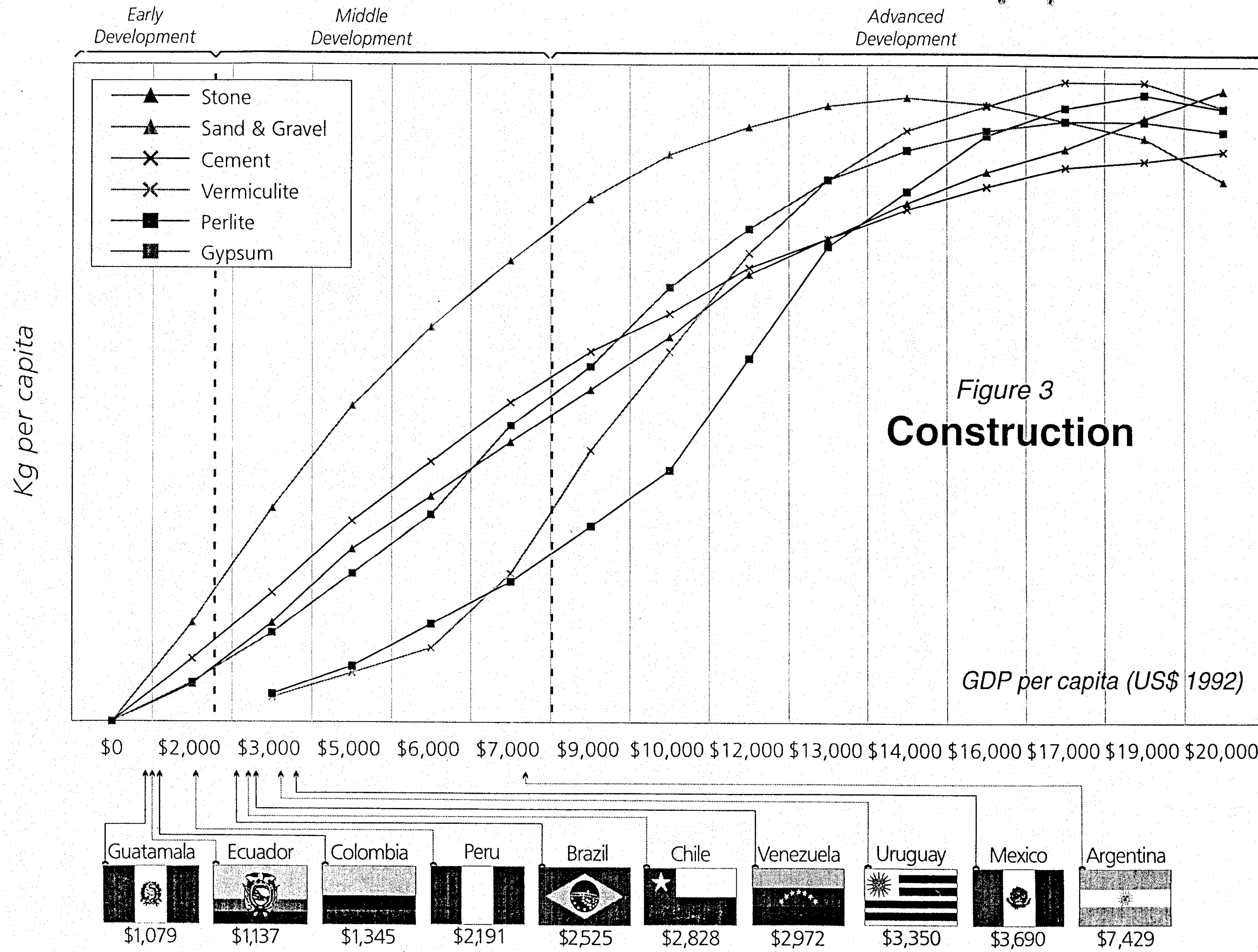


Figure 3

Construction

Clayburn Industries Ltd.

by

D. Harris,
President,
Clayburn Industries Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

Abstract

Clayburn Industries Ltd.

Clayburn Industries Ltd. of Abbotsford, B.C. has continuously mined clays and shales on Sumas Mountain since 1905. This source of materials found just to the east of Abbotsford has been used to produce brick, both for the cladding of buildings and for high temperature applications since the inception of the company. Today, the company is focused upon the production of refractory materials, both brick and monolithics. The locally available clays and shales are the predominate source of materials for such production.

A description of the shales, clays and host formation will be given along with slides showing the deposit and its workings. A brief description of the markets that are served and why these materials are applicable to the various applications will be given.

Industrial Kaolin and Market Growth on the Pacific Rim

by

C. C. Harvey
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Industrial Kaolin Resources in the Pacific Northwest and Central Canada

Colin C. Harvey
Department of Geological Sciences, Indiana University, Bloomington, IN 47405

Abstract

The very large paper industry in the Pacific Northwest is a potentially large market for industrial clays. Current trends within the paper industry towards higher quality newsprint, filled and coated papers offers an incentive for exploration in the region since the current supply of kaolin is from Georgia in the southeastern US. This long distance attracts freight rates which commonly exceed $100/mt.

The regional kaolin resources require very expensive processing technologies to meet the required specifications and it is doubtful that any large development of the local resources can be supported at the present time.

Competition from high quality regional resources of carbonates is another factor weighing against the development of local kaolin resources while there is a potential threat from shipments of Asian kaolin in the early part of the 21st century.

1. Introduction

Industrial kaolins are used in a wide range of industrial processes. They are amongst the world's largest tonnage of processed industrial minerals and can command prices as high as US$600 per ton.

The largest industrial user of kaolins on the world scene is the paper industry. In British Columbia, the paper industry is a very significant contributor to the commercial strength of the Province of British Columbia although currently little clay is used. With the current trend towards the increasing use of mineral fillers, it is essential to determine whether or not commercially viable kaolin resources are present in the region.

The paper industry utilizes large tonnages of a wide range of raw materials for both the chemical processing of pulp and the manufacture of filled and coated paper and board. British Columbia produces about 35% of Canada's pulp and paper products. Until the early 1990's the industry was commodity driven, providing relatively low value-added products of market pulp and newsprint to the North American and world markets (Temanex, 1994).

Note: The currency used in the study is US$ with tonnages in metric (2204 lb) tons.

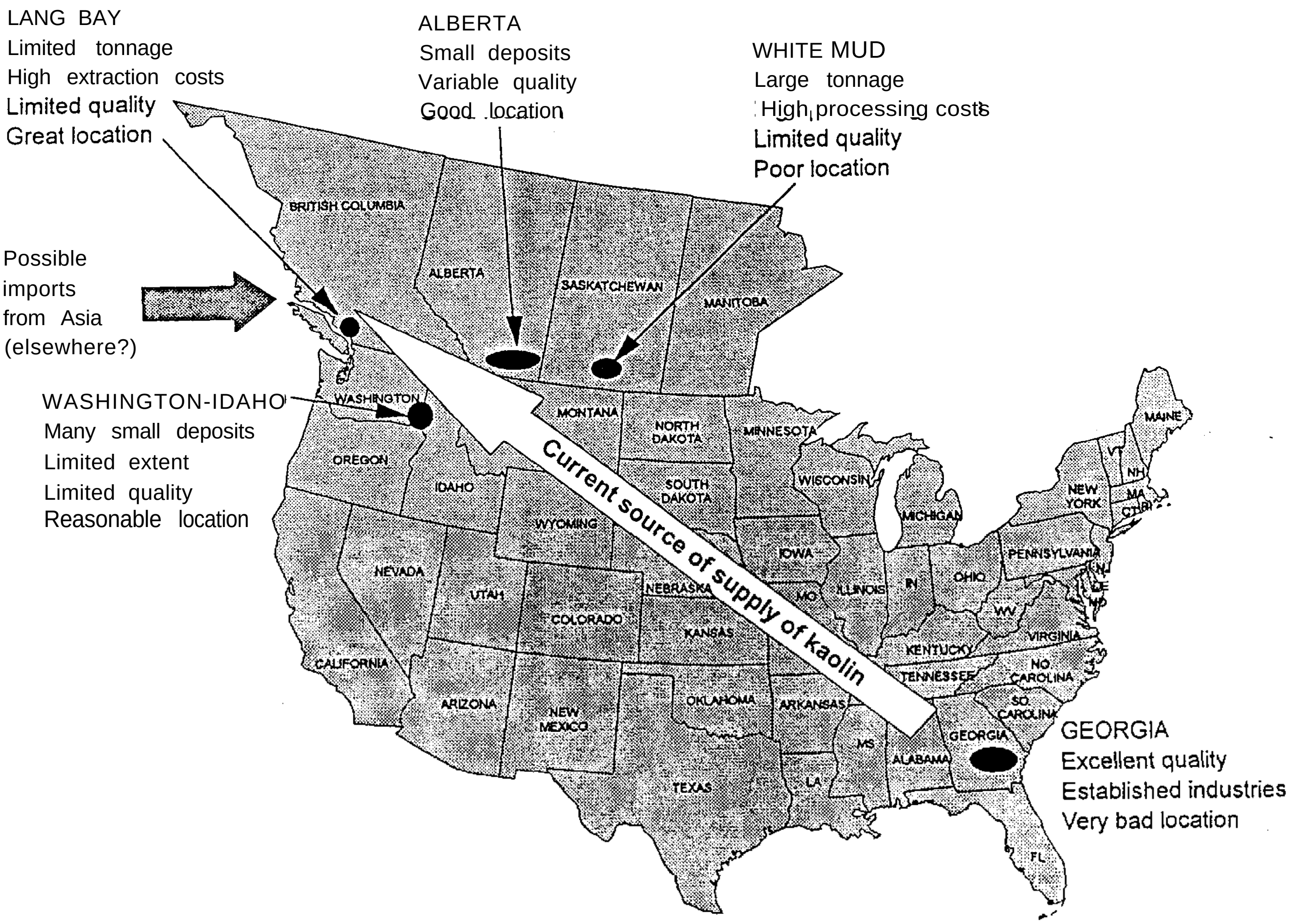


Figure 1 - Regional distribution patterns and options for kaolin supply to the Pacific Northwest

3. Market trends

Over the past five years, a rapid increase in the utilization of both GCC and PCC for fillers and coating in the paper industry has occurred. This increase is reflected in Figures 2 and 3 which illustrate the projected growth in the use of filler materials in the North American paper industry in the period from 1989 to 1994 (Figure 2) and the proportions of kaolin and carbonate used east and west of the Rockies (Figure 3). Virtually all the growth has been in the uses of PCC and GCC. The calcium carbonate used in the North American paper industry is in the form of either GCC or PCC. The former is usually used as a coating pigment and the latter as a filler. Consumption of both of these mineral forms is rapidly increasing as paper makers switch to alkaline or neutral paper processes. Some of the first paper makers to switch to the new techniques were producers of woodfree papers in both the coated and uncoated market sectors.

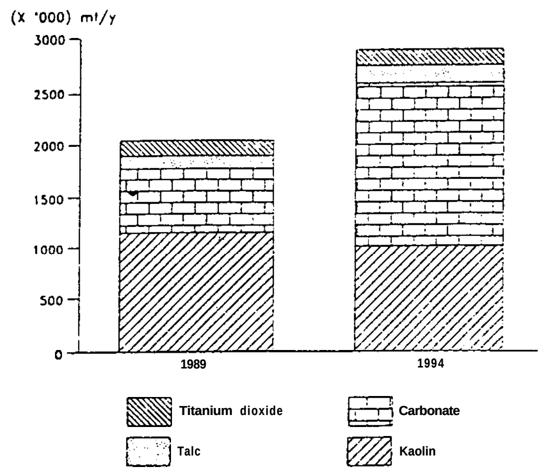


Figure 2 - Growth trends in pigment usage in the paper industry projected for the period 1989-1994 (Temanex, 1993)

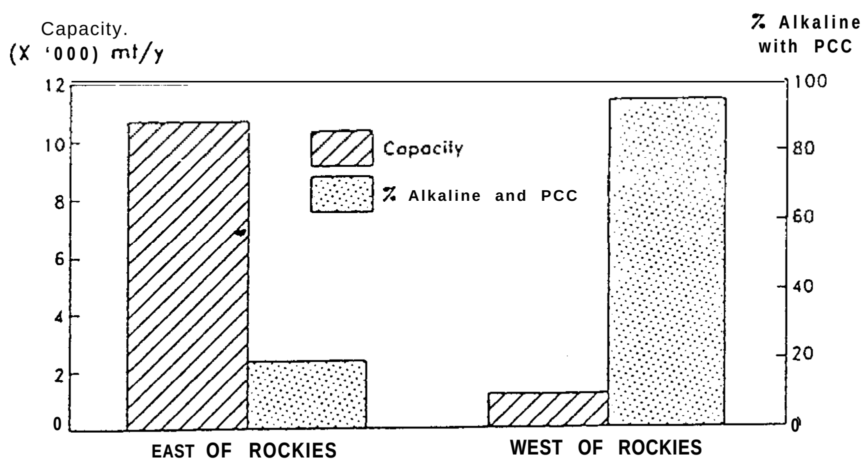


Figure 3 - Trends in pigment usage in the paper industry in North America (west of the Rockies) (Temanex, 1993)

4. Kaolin resources in the region

Despite these trends towards the use of carbonates over the past decades, considerable effort has been directed towards the location and evaluation of regional kaolin resources. Detailed work has been carried out on the primary and secondary kaolins of Idaho-Washington (Hosterman et al., 1960; Pruett and Murray, 1993), the primary kaolins of Lang Bay, British Columbia (Harvey and Farris, 1992) and the secondary kaolins of the White Mud Formation in southern Saskatchewan (Pruett and Murray, 1991).

A series of primary and secondary kaolin deposits associated with weathering and perhaps some hydrothermal alteration of the Idaho batholith are located in Latah County, Idaho. These deposits have been exploited for many years as refractory clays. Unsuccessful attempts have been made to establish a filler clay operation for use in paper and other industries but current activities are confined to refractory applications. A locality map of the area is shown in Figure 4, while a section through the deposits is illustrated in Figure 5.

The primary kaolins are weathering profiles on granodiorite rocks while several sedimentary kaolin deposits downstream from the primary clays are interbedded with basalts of the Columbia River Basalts (Keller and Ponder, 1959). The natural brightness of the clays are typically in the low 70's (GE scale) and with bleaching many can reach the low 80's (GE scale). However the size of the individual deposits is small and there are insufficient proven tonnages of 'good quality reserves to justify commercial development for supply to the paper industry.

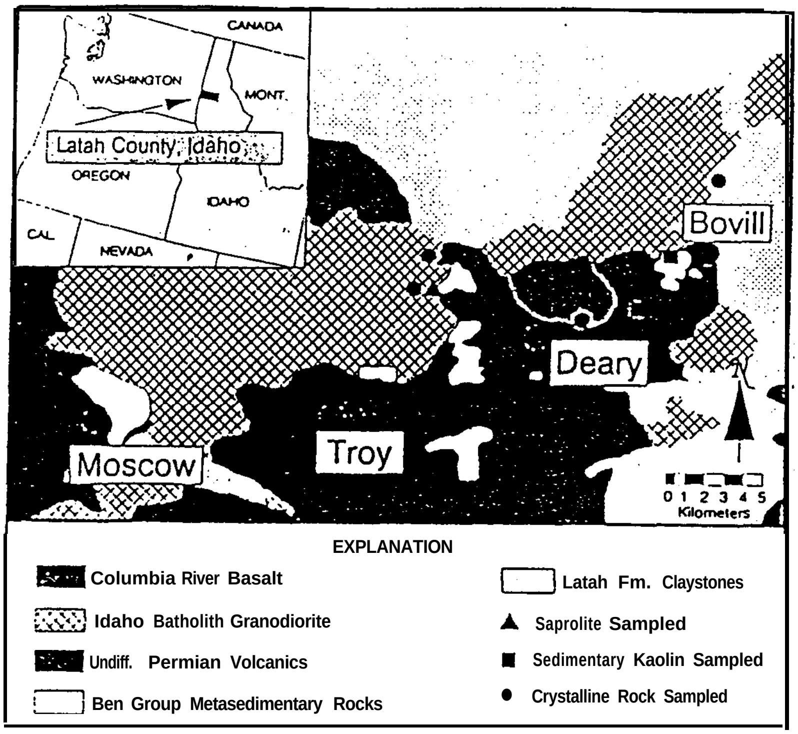


Figure 4 - **Location of kaolin resources in Latah County, Idaho (modified from Hosterman, et al., 1960)**

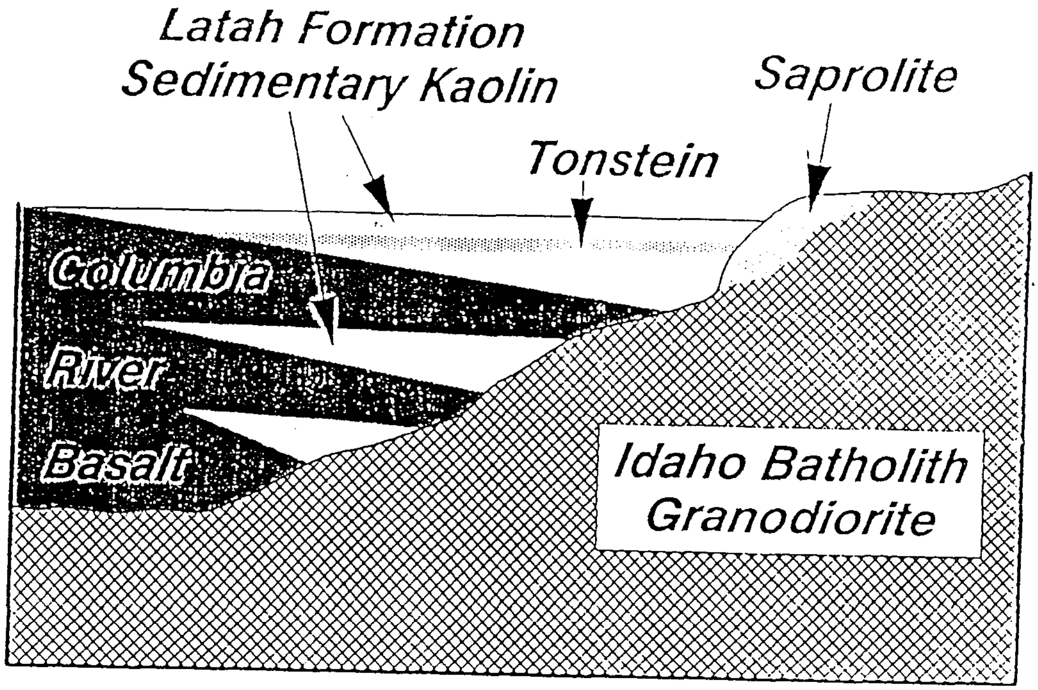


Figure 5 - **Cross-section of kaolin resources in Latah County, Idaho (modified from Ponder and Keller, 1959)**

At Lang Bay, approximately 80 km north of Vancouver, a small primary kaolin resource (approximately 6 Mmt of crude ore) is located close to tidewater 8 km south of Powell River township (Figure 6). The resource is formed from low temperature hydrothermal alteration and weathering of a granodiorite rock of the Coastal Plutonic Complex (Harvey and Farris, 1992). The natural brightness of the kaolin varies between 60 and 70% (GE scale). The resource is located beneath 20 to 30 m of glacial till and alternatives of opencast and underground mining have been investigated. The crystallinity of the kaolin is low and this fact in combination with low brightness classifies this material as a wood fiber replacement or at best, a low quality filler clay.

The location of the resource is excellent for the supply of kaolin filler clays to the adjacent paper mills but the quality of kaolin and the high overburden ratio in combination with the limited size of the resource has weighed against its commercial development.

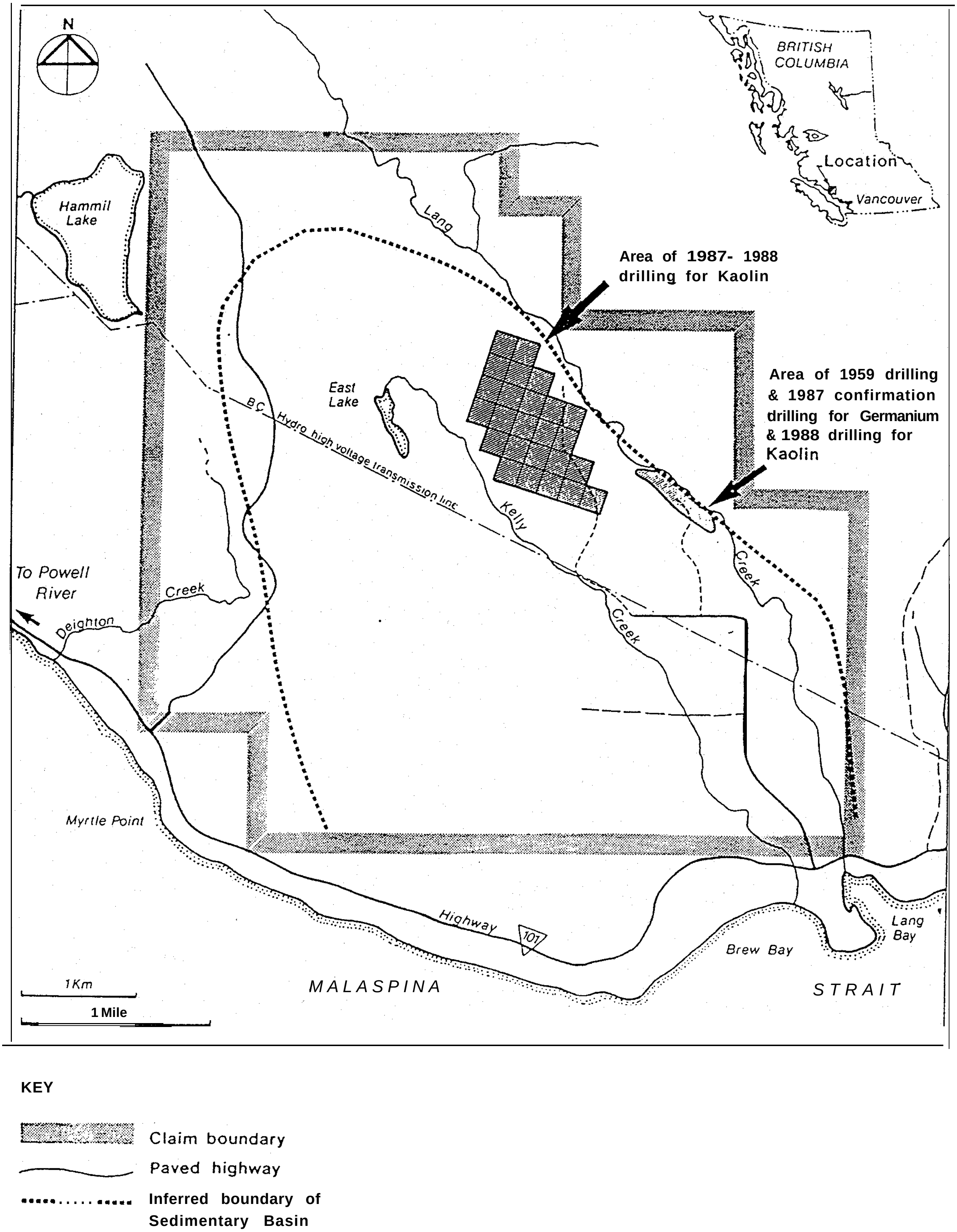


Figure 6 - Location of the Lang Bay kaolin resource in British Columbia

In southern Saskatchewan and southeastern Alberta (Figure 7), large exposures of white clays of the Whitemud Formation have been known for many years (Byers, 1969). The natural brightness of the clays is generally in the mid 70's (Pruett and Murray, 1991). In the 1980's considerable effort was expended by Ekaton Industries to prove the technical and commercial viability of these clays to supply the paper industry in both Canada and the midwestem United States. The clays are composed of a mixture of kaolin, illite and quartz. The kaolin is of relatively low crystallinity and was considered to have limited potential as a coating clay (Pruett and Murray, 1991). The deposits are located relatively distant from both the east and west coasts of Canada and freight factors are therefore not advantageous. Ekaton applied a wide range of enhanced upgrading techniques to meet the quality specifications for filler and calcined kaolin but the complex technology requirements were a strong disincentive to commercial investment.

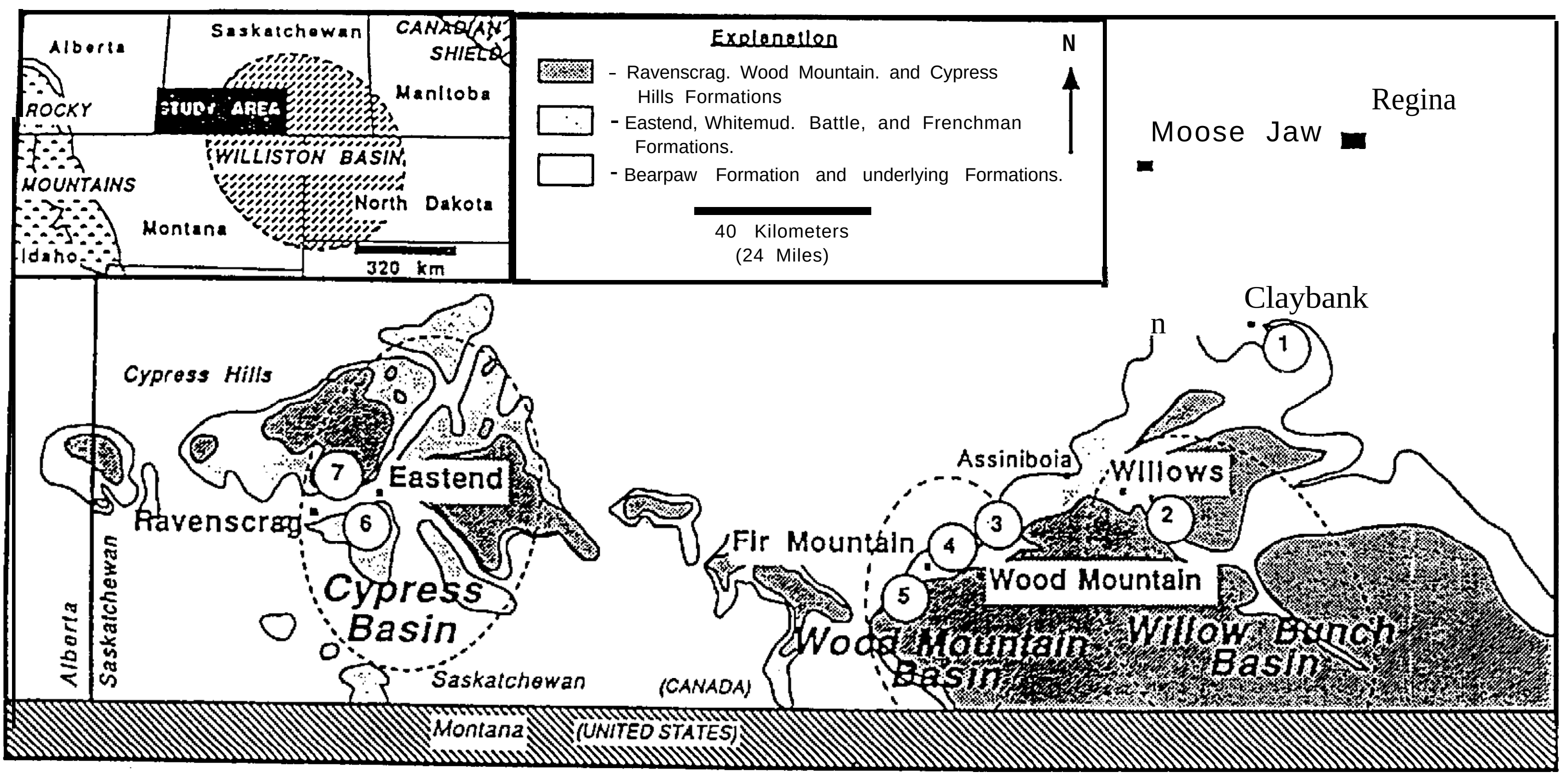


Figure 7 - Location of the Whitemud kaolin deposit in southern Saskatchewan and southeastern Alberta (Whitaker and Pearson, 1972)

Table 1 - Summary table of economic potential of western North American resources of kaolin for paper clays

Province or State	Location	Developer	Comment
British Columbia	Lang Bay	Lang Bay Resources	Great location, limited tonnage, high overburden ratio, quality limited to filler clay
Idaho	Latah County	Simplot, A.P. Green and others	Reasonable location, large tonnages spread between many deposits, quality variable
Saskatchewan and Alberta	Wood Mountain and southeastern Alberta	Ekaton	Poor location, large tonnages, complex processing requirements

In summary, it is unfortunate that none of these deposits are of sufficient quality to be classified as potential coating clays using conventional economically-proven processing technologies. Although the studies on these deposits in most cases have shown that it is technically feasible to upgrade the raw materials to current commercial specifications, the costs involved in implementing such complex processes have tended to make investment decisions too risky to justify entering a highly competitive market (i.e. local high quality carbonates versus local (or distant) low grade kaolins requiring high capital, high operating cost operations).

Note on conventional economically-proven technology: Over the past thirty years the kaolin industries in Georgia and Europe have introduced several revolutionary breakthroughs in processing technology which have enabled marginal raw materials to be upgraded significantly. It is beyond the scope of this paper to go into this in detail although several papers have been written on the subject (Murray, 1991; Harvey, 1995).

5. Potential for Asian kaolins

The current developments of kaolin processing operations in Asia frequently benefit from low mining costs and low labor costs. A summary of present delivered costs into Japan are detailed in Table 2. For example, shipments of Indonesia tiller clay in 1994 were delivered CIF to Japan for $135/mt. Providing that sufficiently low freight costs can be obtained it is conceivable that processed Asian kaolins could competitively enter the filler or coating clay markets of the Pacific Northwest.

It should be noted that over the past ten years tonnages of over 1 Mmt/y of cement and clinker have sometimes been imported into California and Washington from Japan and other Asian countries (Harvey, 1996). Such shipments have attracted very attractive freight rates because of the imbalance in bulk freight movements across the Pacific (tonnages heavily weighed in favor of movements east to west meaning potentially lower cost backhaul freight rates from west to east).

Although such movements in kaolin from Asia have yet to become a reality, the potential for such developments cannot be ignored.

Table 2 - Import statistics for kaolin in Japan

	1992			1993			1994		
	Tons	Value	Cost /mt	Tons	Value	Cost /mt	Tons	Value	Cost /mt
USA	76 1,447	186,223	245	799,181	188,947	236	841,114	202,148	240
Australia	94,275	14,536	154	115,021	17,870	155	118,010	18,669	158
Brazil	88,906	17,001	191	82,634	16,086	195	99,149	19,923	201
Indonesia	62,452	8,729	140	66,086	9,320	141	83,035	11,247	135
China	57,523	5,190	90	46,193	4,477	97	44,579	5,559	125
Korea	35,897	3,238	90	28,540	2,805	98	25,508	2,434	95
UK	21,072	5,285	251	26,024	5,795	223	31,959	7,482	234
Malaysia	16,197	2,626	162	12,834	2,000	156	16,717	2,659	159
New Zealand	11,660	5,552	476	9,440	4,866	515	9,039	5,475	606
Others	3,794	471	124	3,667	495	135	14,659	3,362	229
Total	1,153,223	248,851	216	1,189,611	252,661	212	1,283,769	278,958	217

References

Byers, P.N. (1969) Mineralogy and origin of the upper Eastend and Whitemud formations of south-central and southwestern Saskatchewan and southeastern Alberta: Can. J. Earth Sci., 6, pp. 317-334.

Harvey, C.C. and Farris, L.F. (1991) The Lang Bay Kaolin Resource, British Columbia: Proc. of the 27th Forum on the Geology of Industrial Minerals. Alberta Geological Survey Information Series, pp. 93-98.

Harvey, C.C. (1995) Kaolin Resources of the United States and their Industrial Utilization: Proc. of the 1993 UN. Workshop for Industrial Minerals Development in Asia and the Pacific, Vol. 8, pp. 252-265,

Harvey, C.C. (1996) Carbonate resources of British Columbia and potential for new markets (published in this volume).

Hosterman, J.W., Scheid, V.E., Allen, V.T. and Sohn, I.G. (1960) Investigations of some clay deposits in parts of Washington and Idaho: U.S. Geol. Survey Bull. 1091, 39.

Murray, H.H. (1991) Overview - clay mineral applications: Applied Clay Science, 5, pp. 379-395.

Ponder, H. and Keller, W.D. (1959) Geology, mineralogy and genesis of selected fireclays from Latah County, Idaho. Clays and Clay Minerals, 8, pp. 44-62.

Pruett, R.J. and Murray (1991) Clay mineralogy, alteration history and economic geology of the Whitemud Formation, Southern Saskatchewan, Canada: Clays and Clay Minerals, 39, pp. 586-596.

Pruett, R.J. and Murray, H.H. (1993) The mineralogical and geochemical controls that source rocks impose on sedimentary kaolins: in Kaolin Genesis and Utilization, Murray, H.H., Bundy,W.M., and Harvey, C.C., eds. The Clay Minerals Society, Boulder, Colorado, pp. 149-170.

Temanex Consulting Inc. (1994) Industrial minerals opportunities in pulp and Paper in British Columbia to the year 2003. British Columbia Geological Survey Branch Open File Report 1994-23, 70p.

Whitaker, S.H. and Pearson, D.E. (1972) Geological Map of Saskatchewan. Saskatchewan Dept. Min. Res. and Sask. Res. Counc. (1:1,267,000).

Resources, Applications and Market Trends of Calcium Carbonates in the Northern Pacific Rim

by

C. C Harvey,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Carbonate Resources of British Columbia and Potential for New Markets

Colin C. Harvey

Department of Geological Sciences, Indiana University, Bloomington, IN 47405

Abstract

British Columbia is endowed with very large carbonate resources which are utilized in a wide range of applications. This study reviews the tonnages and market applications for their utilization on the west coast of North America and presents an overview of production and markets in selected Pacific Rim countries.

A potential export market is considered to exist in Japan, South Korea and Taiwan for high brightness calcium carbonate suitable for making ground calcium carbonate (GCC). This product is used as a tiller, coating pigment and extender. In these countries the supply shortage has been caused by the inability of Japanese producers to selectively mine sufficient high quality material to supply these markets. The market requires high brightness/high whiteness calcium carbonate chips which can be bulk shipped for final processing close to the end user. The delivered price to Japan of these marble or limestone chips is reported to be US$50 to $60/mt.

A growth market for GCC also exists on the west coast of North America. The largely coastal markets are currently supplied from large established resources in British Columbia, Washington State and south-central California. Additional resources have been defined on the Ketchikan Peninsula in southwest Alaska, which are of uncertain commercial value because of their isolation and the limited size of the Alaskan market.

1. Introduction

This study reviews the carbonate resources in British Columbia which are exported to Washington Oregon and Alaska. Data also is presented on California, Mexico and current export and delivered prices for the various grades and specifications of limestone in the Pacific Rim. The depth of coverage in specific countries has been governed by the consideration of whether or not a British Columbia product might realistically compete to fill current demand or shortages in any particular application or country. The study area has included the western United States, Mexico and western Canada, and briefly reviews current activities in Asia and Japan. The study also includes a review of freight rates and commodity prices.

Note: Throughout this paper all values are in US% and all tonnages are metric tons.

2. British Columbia

2.1. Resources

The location of British Columbia’s resources is shown in Figure 1. Although limestones are scattered throughout the southern half of British Columbia, the dominant resources are focussed on Texada Island in the southwest comer.

2.2. Demand, supply and uses

British Columbia’s production of limestone and dolomite from 1986 to 1991 is detailed in Table 1. This table also includes export tonnages to western U.S. markets. Production figures for 1992 are not yet available but they are reported to be very close to 1991 production (Pilon and Associates, 1993).

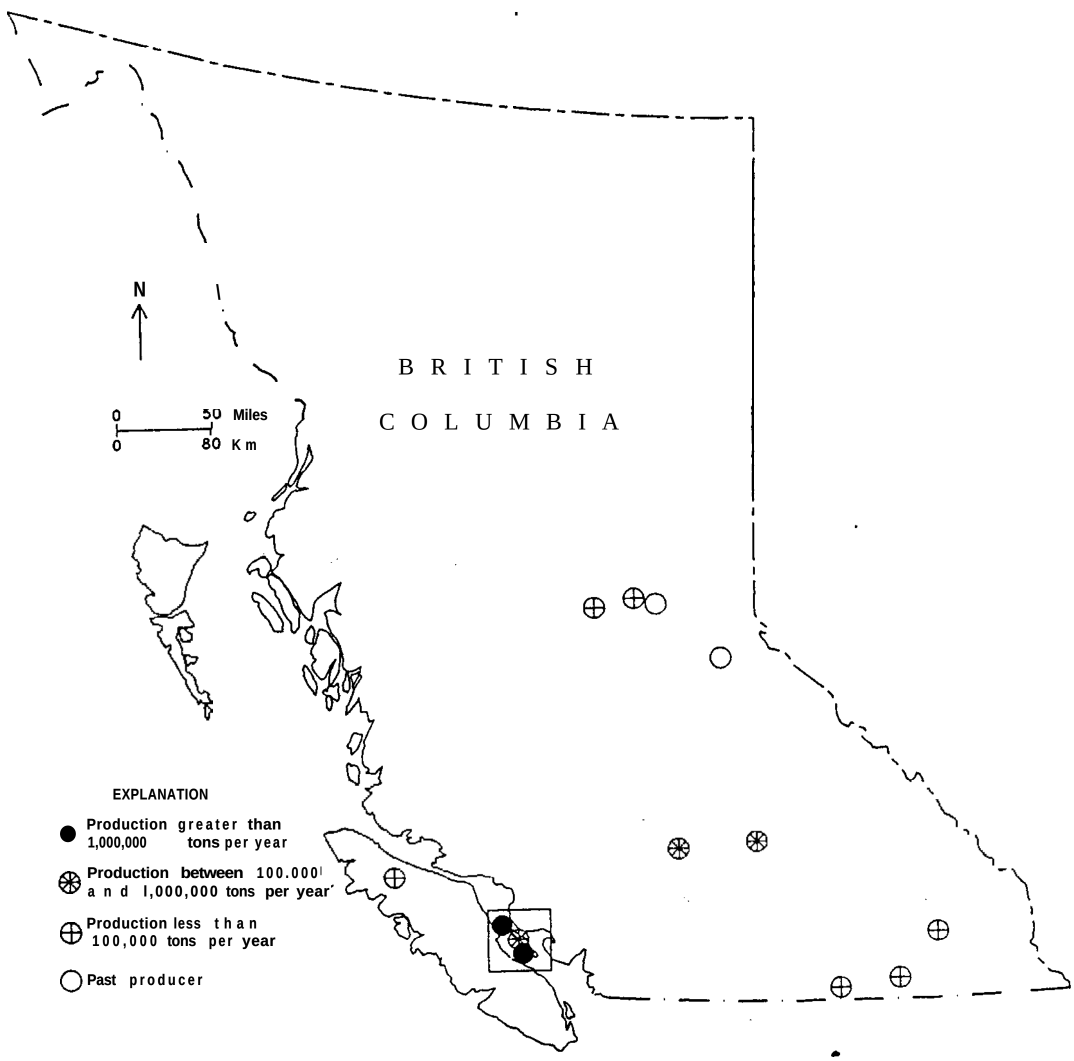


Figure 1 - Locality map of British Columbia limestone producers (Bleek, Sherar and Gulick, 1993)

Table 1 - Limestone and dolomite consumption in British Columbia (1986-1991)

(Thousands of metric tons)

Use	1988	1989	1990	**1991**
Cement Manufacture				
Domestic	1,510.0	1,615.0	1,623.0	NA
Export	575.0	805.0	867.0	NA
Lime Manufacture				
Domestic	157.0	162.0	167.0	NA
Export	339.0	236.0	236.0	NA
Pulp and Paper	102.0	87.0	92.0	NA
Agriculture	8.3	8.1	14.4	NA
Fillers (Whiting]	38.5	54.3	53.5	NA
Stucco Dash	24.1	9.7	10.7	NA
Crushed Rock	300.0	368.0	438.0	NA
Other Uses	140.0	490.0	332.0	NA
Domestic	NA	NA	NA	NA
Export	NA	NA	NA	NA
Total	3,193.9	3,835.l	3,833.6	3,781.0

Source: Canadian Government statistics
NA = Domestic/foreign breakdown not available due to a change in policy regarding industry confidentiality; combined tonnage listed with "Other Uses."

Between 1986 and 1989 the total production of limestone in British Columbia showed an increase of almost 25%. From 1989 until 1990 there was no growth, while in 1991 there was a drop in tonnage of approximately 2%. The major cause of this decrease in production has been the downturn in the economy of western Canada. Throughout the period 1986 to 1991 exports to Washington and Oregon have shown a significant growth (see below).

2.3. GCC

IMASCO (International Marble & Stone Co.) has operating quarries on Vancouver Island and at Sirdar, B.C. White limestones are produced for filler. Total production is close to 50,000 mt/y.

2.4. PCC

As far is known there, are no PCC plants currently operational in British Columbia although at least three are operating in Washington.

2.5. Potential for backhaul shipments to Asian markets

The shipment of bulk commodities in the Pacific Rim is traditionally a one-way traffic from the west coasts of Mexico, the U.S. and Canada to the nations in the Orient. The traffic in the other direction is dominated by finished goods which are almost exclusively moved in ocean containers which are carried on specialized vessels. Such container carriers are high cost, specialized vessels which would suffer substantial damage to their specialized fittings if they should carry heavy (dense) bulk material such as crushed limestone.

The carriers which will consider crushed limestone or limestone chips as freight are so-called bulk carriers, including vessels known as ore carriers or OBOs (ore-bulk-oil carriers). There are a few cargoes, including cement and alumina, which move into the Pacific Northwest and California from the Orient and Oceania on bulk carriers. Cement and alumina volumes have dropped in the past few years because of the increased value of the Japanese yen and the downward trend in aluminum pricing due to the flood of inexpensive material from China.

We are aware that the Pacific Northwest has an active logging trade to Asian countries but this offers no opportunity for backloads.

3. Washington-Oregon

3.1. Resources

Limestone is mined in both Washington and Oregon. In Washington, the availability of the high quality limestones from Texada Island, B.C., has constrained the development of local limestone resources to those located in the northeast portion of the state. The major exploited limestone deposits in Oregon are in Durkee County. A locality map of Washington and Oregon is shown in Figure 2.

3.2. Demand, supply and uses

The Washington and Oregon markets for limestone and lime are very closely related and have similar market activities, with the exception of magnesium production in Washington. They are both well serviced by inland waterways which provide access to much of the region. Virtually the whole spectrum of limestone products and processing is undertaken in these two states. These products range from agricultural lime through cement and lime production to various chemical applications to GCC and PCC and the utilization of local dolomite for magnesium refining (O’Driscoll, 1989).

Figure 2 - Locality map of Washington and Oregon (O'Driscoll, 1989)

Statistics of domestic production of cement and lime within Washington and Oregon are not available because of single producer confidentiality. However overall production in 1991 was reported to be 13% less than in 1990 (Minarik, 1991). Cement production in Oregon was estimated to be 226,000 mt with a value of $18.7 million or $82.63/mt (Minarik, 1991). Statistics prior to 1990 are not available because of single supplier confidentiality status.

Shipments of Canadian limestone for lime manufacture and cement in 1990 were reported to be just over 1.1 Mmt (1.2 Mt). Imports of hydraulic cement and clinker in the four year period 1988-1991 are given in Table 2. This shows a growth in imports of 26% in the four year period from 1987 to 1990 but no growth in 1991. The CIF value of these shipments calculate to CIF prices (1991) of $53.34/mt from Canada and $40.60/mt from Japan.

The Continental Lime Company is strongly established in Washington and imports significant tonnages of crushed high-calcium limestone from British Columbia. This limestone is barged from Texada Island to feed lime kilns in Tacoma, Washington, and a 310 mt/d plant (340 t/d) plant in Portland, Oregon. Waste CO, from the lime kilns is utilized in Continental's PCC plant which is also located on the site in Tacoma. The PCC is utilized as a high quality filler in the paper and paint industries. These PCC plants are located adjacent to the paper mills and are termed "satellite plants".

Lime production in Oregon in 1987 increased by 17% over the 1986 production levels, 87% of this increase being quicklime. The market areas for this production are the steel, chemical, and paper markets. In southern Oregon, limestone is mined in Durkee by Ashgrove Cement West Inc. and is supplied to lime plants in Malheur, Oregon, and Nampa and Twin Falls, Idaho. These lime plants are owned by Amalgamated Sugar Co. and their output is almost exclusively used in the sugar beet industry. Lime sold or used in Washington and Oregon increased from 357,000 mt (393,000 t) in 1989 to 365,000 mt (406,000 t) in 1990. In 1991 lime production dropped by 30% which was at least in part due to a decrease in magnesium production.

Table 2 - Imports of hydraulic cement and clinker to Seattle

(Thousand metric tons and thousand dollars)

From	1988 Quantity	1988 Value CIF	1989 Quantity	1989 Value CIF	1990 Quantity	1990 Value CIF	1991 Quantity	1991 Value CIF
Canada	516	22,026	501	21,405	454	21,723,	646	35,104
Japan	215	7,787	225	9,267	258	10,596	22	893
Spain	0	0	0	0	52	2,521	0	0
Others	0	0	0	0	46	2,331	141	1,186
Total	731	29,813	726	30,672	810	37,171	809	37,183

Source: USBM Statistics.

Cement

Large tonnages of limestone are used in cement manufacture. In 1987, Washington produced 1 Mmt of cement. The reliance on limestone and clinker imports from Texada Island in British Columbia has increased in recent years.. The Durkee limestone resources in southern Oregon provide material for Oregon's and Idaho's only cement operator, Ashgrove Cement West, Inc. Reserves of the high-calcium limestone at Durkee are estimated to be 40 Mmt (O'Driscoll, 1989). The sugar beet industry dominates the agricultural uses of lime while limestone is also used for agricultural purposes in both Washington and Oregon.

GCC

GCC is used primarily in the paper industry with smaller tonnages used in paint and plastics. A 22,500 mt/y operation near Seattle (J.M. Huber) produces a dry ground product; pigment grades are produced by Columbia River Carbonates which in 1986 started production from a 90,000 mt/y plant located near Woodland, Washington. The plant uses wet processing to produce finely ground calcium carbonate in a slurry form. Over 50% of this material is supplied to the west coast paper industry for use as a coating pigment, and the balance goes into plastics and paint. The raw material for this plant comes from a lenticular pod of calcitic marble near Wauconda in Okanogan County in northern Washington. The deposit has an average composition of 98% $CaCO_3$, 1% $MgCO_3$, and 1% of acid insolubles (O'Driscoll, 1989). Processed brightness values exceed 96% (against a smoked MgO standard) (Bleeck, Sherar and Gulick, 1993).

GCC is used as in coatings in the Pacific Northwest (i.e. Oregon, Washington and British Columbia). They can contain up to 25-30% by weight of GCC with some PCC possible as a filler in the base sheet. The total GCC tonnage is therefore estimated to be 60,000 to 75,000 mt/y (Temanex, 1993). These coated papers are within the woodfree sector, the term woodfree referring to the fact that only chemical pulp and no mechanically ground pulp is used in the manufacturing process.

Note: These market estimates are considered to be within 10% of the actual (Temanex, 1993).

PCC

PCC is used as both a filler and coating pigment in the paper industry. The total annual production of uncoated woodfree grades in the last two years in the Pacific Northwest is estimated to be 1.2 Mmt/y. The pigment loading for this production (almost entirely PCC) averages about 15-20%. The estimated PCC usage is 180 to 240,000 mt/y (Temanex, 1993).

Several PCC production units are located in Washington state to service the filler market in the Pacific Northwest. They are located in Longview in southwest Washington and in Tacoma. The raw material for both operations is Texada Island limestone. This limestone is calcined at Longview and then processed to convert recovered carbon dioxide, lime, and water into Pfizer's specialty pigment, Albacar HO. The operation at Longview supplies filler to the adjacent Weyerhauser Paper Company for use in coated and uncoated paper.

4. Alaska

4.1. Resources

Exploration and sampling performed by the U.S. Bureau of Mines on Prince of Wales, Dall, Kosciusko, and Heceta Islands revealed several localities containing high-calcium and ultra-high calcium limestones (Maas et al., 1991, 1992). In addition to these highly pure limestones, marble with brightness approaching 94.5% against MgO standards were also found. Large resources of high purity material are inferred at El Capitan, Calder, Port Alice, Edna Bay, View Cove, Breezy Bay and Cleva Bay. The economic potential of these resources has yet to be determined.

4.2. Demand, supply and uses

The domestic limestone industry in Alaska consists of the mining and grinding of aggregates and agricultural limestone. Portland cement was formerly produced in Anchorage by Alaska Basic Industries Ltd. from domestic clinker supplied by Anchorage Sand and Gravel Company in Cook Inlet. Discussions with Anchorage Sand and Gravel Company revealed that they no longer grind the clinker and prefer instead to import the finished cement. There is no recorded Alaskan production of lime and small tonnages are imported from Canada or shipped from Seattle. Imports of hydraulic cement in 1990 were 131,000 mt. Hydraulic cement is a general term used to cover all grades of cement. This was made up of 62,000 mt from domestic sources (Seattle) and 69,000 mt imported from Canada and Japan. In 1991 the imported tonnage was 61,000 mt while data on domestic shipments are not yet available. Imports of lime from Canada totalled 450 mt in 1992. Domestic limestone was mined and used for aggregate and agricultural purposes. Data are not available for 1992.

With the growth in population, the demand for aggregates and cement for highways and construction will continue to increase. The use of lime for water treatment and agricultural lime is also predicted to grow at a steady rate. The mining industry in Alaska is a significant growth market which will require lime and/or limestone as process reagents, for pH control, for cyanide destruction and for waste water treatment. No accurate figures of projected market growth for lime and limestone are possible since the rate of development will be controlled by such factors as international metal prices, quality and quantity of resources and regulatory requirements,

4.3. Potential for-future development of an Alaskan limestone industry

The small local market of several hundred thousand tons for cement and lime weighs heavily against the development of any Alaska based processing operations. To achieve the benefits of large scale production typical of lime and cement plants being installed around the world, the size of a large lime plant is 500,000 mt/y while a large cement operation would be at least several million tons per year.

5. California

5.1. Resources

Limestone resources are exploited throughout California. Ultra-high calcium carbonate production is focussed in the Lucerne Valley in Southern California.

5.2. Demand, supply and uses

California consumed nearly 20 Mmt of limestone in 1992. The state is ranked number 1 in the U.S. in both clinker and cement grinding capacity. Not all of this tonnage is produced locally; a significant tonnage is imported from several countries and from Nevada and Texas. Current domestic production of lime and cement in California is summarized in Table 3 along with tonnages obtained from adjacent states The economic recession in California over the past two years has significantly reduced the demand for limestone products.

Ultra-high calcium carbonate production is focused in the Lucerne Valley in Southern California where 1.35 Mmt of limestone and calcite marble are mined (Brown, 1994). The major producers are Pluess-Staufer Inc., Pfizer Inc., and Riverside Cement. Of this tonnage, more than 300,000 mt/y is GCC. Reserves are extensive, and these industries have been established for many years, so much of their infrastructure and capital costs have been amortized.

Cement

California's hydraulic cement production in 1992 was 7.9 Mmt with a value of $522 million. This equates to an average price of $66.09/mt. California also imports significant tonnages of cement and clinker. Imports for hydraulic cement and clinker during 1988-1991 are listed in Table 4. In 1991, a total of 1.43 Mmt was imported at a CIF value of $32.60/mt to $60.40/mt. The lowest imported price was $32.60/mt from Spain.

Table 3 - Californian cement and limestone production (1989-1992)

(Thousand of metric tons and thousands of dollars)

	1989	1990	1991*	1992*
<u>California Tonnages</u>				
Lime	358	313	318	278
Cement	9,928	9,614	8,294	7,893
<u>Value</u>				
Cement	NA	NA	548,000	522,120
<u>Other States</u>				
Lime	197	267	NA	NA
Cement	323	926	NA	NA

Source: USBM Data. *Preliminary data from CA Division of Mines and Geology. NA=Not Available

Table 4 - Californian imports of hydraulic cement and clinker

(Thousands of metric tons and thousands of dollars)

Entry Port and Source	1988 Quantity	1988 Value	1989 Quantity	1989 Value	1990 Quantity	1990 Value	1991 Quantity	1991 Value
Los <u>Angeles</u>								
Japan	1,050	37,847	1,453	50,115	1,076	40,751	-	-
Korea	461	13,878	122	5,052	-	-	-	-
Spain	21	974	194	8,650	92	4,033	33	1,083
Mexico	-	-	-	-	338	13,544	510	22,739
Greece	-	-	-	-	-	-	134	6,946
France	-	-	-	-	-	-	171	7,877
Others	312	7,597	193	8,200	175	8,241	95	4,449
<u>San Diego</u>								
Columbia	=	-	-	-	19	924	140	7,615
Mexico	600	23,595	569	22,685	444	16,840	102	4,132
Japan	23	909	-	-	-	-	-	-
Others	-	4	-	-	-	-	-	-
San <u>Francisco</u>								
Columbia	-	-	-	-	-	-	160	9,670
Japan	36	1,605	145	5,732	136	6,003	-	-
S. Korea	-	-	70	2,388	79	2,949	-	-
Mexico	249	7,78 1	263	8,173	138	5,439	-	--
Others	7	7	49	12	72	1,908	88	4,651
Total for California	2,759	94,197	3,058	111,oo	2,569	100,632	1,433	69,162

Source: USBM Data (-) Indicates no tonnage or less than 500 mt.

The supply of cement was formerly dominated by Japan but because of the strengthening of the Japanese yen against many currencies Japan has now all but withdrawn from the western US market. Its place has been taken by Mexico and, more recently by Columbia, France and Greece. No detailed explanation was obtained regarding why such countries as Spain, Greece and France have been able to enter the Californian market. Possible explanations are:

- the hydraulic cement category includes all categories of cement. It is possible that specialized grades of cement were imported.

- production from very large plants in these countries means minimum production costs due to benefits of large scale production. In combination with low freight rates, this enables them to deliver to California at a CIF price competitive with local production.

The patterns of overseas supply have also been affected by anti-dumping legislation imposed by the U.S. on certain foreign importers including Japan. Imports of quicklime, slaked lime, and hydraulic lime are tariff free from countries with most-favored-nation (MFN) status. Non MFN countries have tariffs of 0.2 cents per kg (about $2.40/mt) for quicklime and hydraulic lime and 0.3 cent per kg for slaked lime. Since 1989, Mexican lime has been assessed a countervailing duty of 1.21% because the Mexican government has been involved in ownership of these exporting companies and some government cost subsidies were involved. These duties are now under review as a result of the North American Free Trade Agreement (NAFTA). Imports of cement and clinker are tariff free for nations with MFN status.

The average price of domestically produced cement in the U.S. in 1991 was $66.15/mt. The price differential between the imported and domestic price is considered to be balanced by internal freight costs and certain captive markets for cement in which production costs are typically somewhat higher.

6. Mexico

6. I. Resources

Mexico has very large resources of dolomite and high-calcium limestone. Twenty-one Mexican states are known to produce high-calcium limestone and/or high-magnesium limestone. Deposits of high quality carbonates suitable for GCC production are located near Guadalajara and in San Juan Del Rio (Queretaro Province).

6.2. Demand, supply, and uses

Annual production of limestone is 30 Mmt/y of which the majority is used in the construction industry (Griffiths, 1988). Market growth is about 4% per year.

Large tonnages of cement are exported to Texas and other Gulf States but the most relevant export shipments are those to California. Future supplies to Californian may however be affected by:

- anti-dumping legislation brought against Mexican cement shipments in 1990.

- competition from other suppliers.

- the drop in the Californian domestic market (particularly in southern California).

Mexico exploits high quality carbonates from resources near Guadalajara which are ground locally in a 25,000 t/y facility owned jointly by Technica Minerals and Pluess-Staufer. For the highest quality paper markets some U.S. carbonates are imported. Pluess-Staufer/Omya has recently announced its intention to establish a GCC grinding facility in San Juan Del Rio (Queretaro Province) in central Mexico. This plant is projected to be operational by late 1994 and will use local raw materials. The finely ground GCC will supply the local paper, paint, plastics and other filler markets.

The establishment of NAFTA will provide encouragement for the exploration and development of Mexico‘s carbonate resources. The California market is a logical target for such developments. At the present time we have no knowledge of any coastally located GCC quality carbonates which might be competitive in the California market.

7.0 Japan

7.1 Resources

Limestone is probably the best known and most abundant industrial mineral in Japan. It is widely distributed throughout the islands of Japan and estimated reserves approach 58,000 Mmt (Saito, 1982). Production in 1990 was 198 Mmt predominantly for the local market, but some quantity was exported to Pacific Rim countries including Australia.

7.2. Demand, supply, and uses

Limestone

A summary of limestone production and its uses in Japan during the three year period 1989-1991 is given in Table 5. The category of “Fillers” refers to the use of limestone as low grade fillers in asphalt, animal feed, acid neutralization, and fertilizers. The category of “Others” includes both low grade and higher grade GCC and PCC fillers.

Table 5 - Iimestone production and consumption in Japan

(Thousands of metric tons)

	1989	1990	1991 (Jan-Nov)
Production	190,860	198,199	206,684
<u>End Use</u>			
Cement	87,562 44.9%	93,130 45.6%	99,486 47.1%
Aggregate	56,237 28.9%	58,739 28.8%	60,383 28.8%
Iron/Stee1	21,982 11.3%	22,375 11.0%	21,928 10.4%
Lime	11,612 5.9%	11,734 5.8%	11,670 5.5%
Soda glass	1,935 1.0%	1,846 0.9%	1,804 0.8%
Fillers	6,659 3.4%	6,720 3.3%	6,605 3.1%
Others	8,821 4.6%	9,420 4.6%	9,510 4.5%
Total	194,808	203,964	211,386

Source: O'Driscoll (1992)

It may appear unusual that Japan, traditionally a dominant importer of raw materiaIs, should actually be an exporter of limestone. This situation arises because of the following factors:

- Japan has extensive resources of high quality limestone suitable for cement manufacture.

- by importing such large tonnages of other raw materials from around the world, Japan has a significant freight imbalance in terms of outward cargos from Japan. For this reason, Japan is able to export high grade limestone to Australia and cement and clinker to the west coast of the U.S. at very low freight rates.

Figures 3 and 4 are based on the compilation of data in this report. Figure 3 summarizes the major shipping movements of cement and clinker within the Pacific Rim in 1990 with the focus being on shipments from Japan. Figure 4 summarizes the situation for 1991.

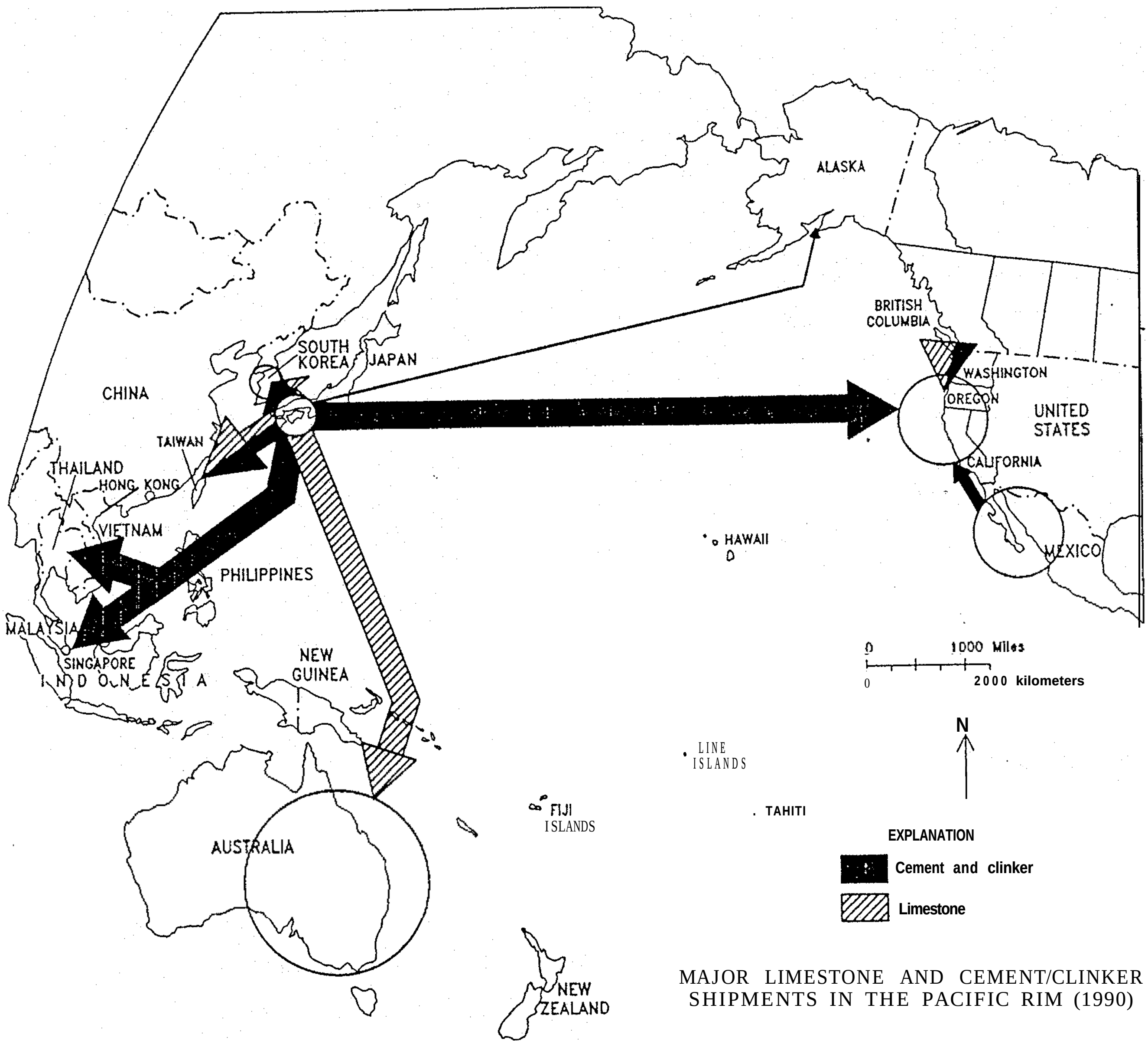


Figure 3- Major shipments of limestone, clinker and cement in the Pacific Rim in 1990

Table 6 - Specification of Japanese export chemical grade limestone

Component	%
CaO	55.40
MgO	0.25
Al_2O_3	0.04
Fe_2O_3	0.03
SiO_2	0.15
P	0.004

Note: Product of the Nittetsu Mining Company Ltd., Torigatayama Quarry, S. Shikoku which produced 14.7 Mmt in 1991.

Within Table 5 the column headed "Others" includes ground calcium carbonate (GCC) used in high value filler markets such as paint, paper, plastics, and rubber. Although this category also includes other end uses, its total demand has tripled from 3.3 Mmt in 1987 to 9.4 Mmt in 1990 to over 10 Mmt in 1991 (O'Driscoll, 1992). This growth includes many low cost applications within the construction and process industries, but there has also been a significant increase in consumption of the more finely ground, higher quality carbonate fillers. The coarser particle sized GCC products are dry ground to 100% finer than 44µm while the highest quality GCC is subsequently wet ground to much finer sizes. Japanese imports of high brightness limestone are shown in Table 7.

Table 7 - Japanese imports of high brightness limestone

(Metric tons and thousands of dollars)

Source	1989 Tons	1989 Value	1990 Tons	1990 Value	1991 Tons	1991 Value	1992 Tons	1992 Value
France	794	166	799	199	1,080	245	960	230
Malaysia	-	-	-	-	-	-	22,687	1,382
Philippines	5,041	51	-	-	2	6	-	-
Taiwan			40	4	3,170	160	3,307	214
Others	104	21	59	139	86	36	173	127
Total	5,939	238	898	342	4,338	447	27,127	1,953

Source: Japanese government statistics.

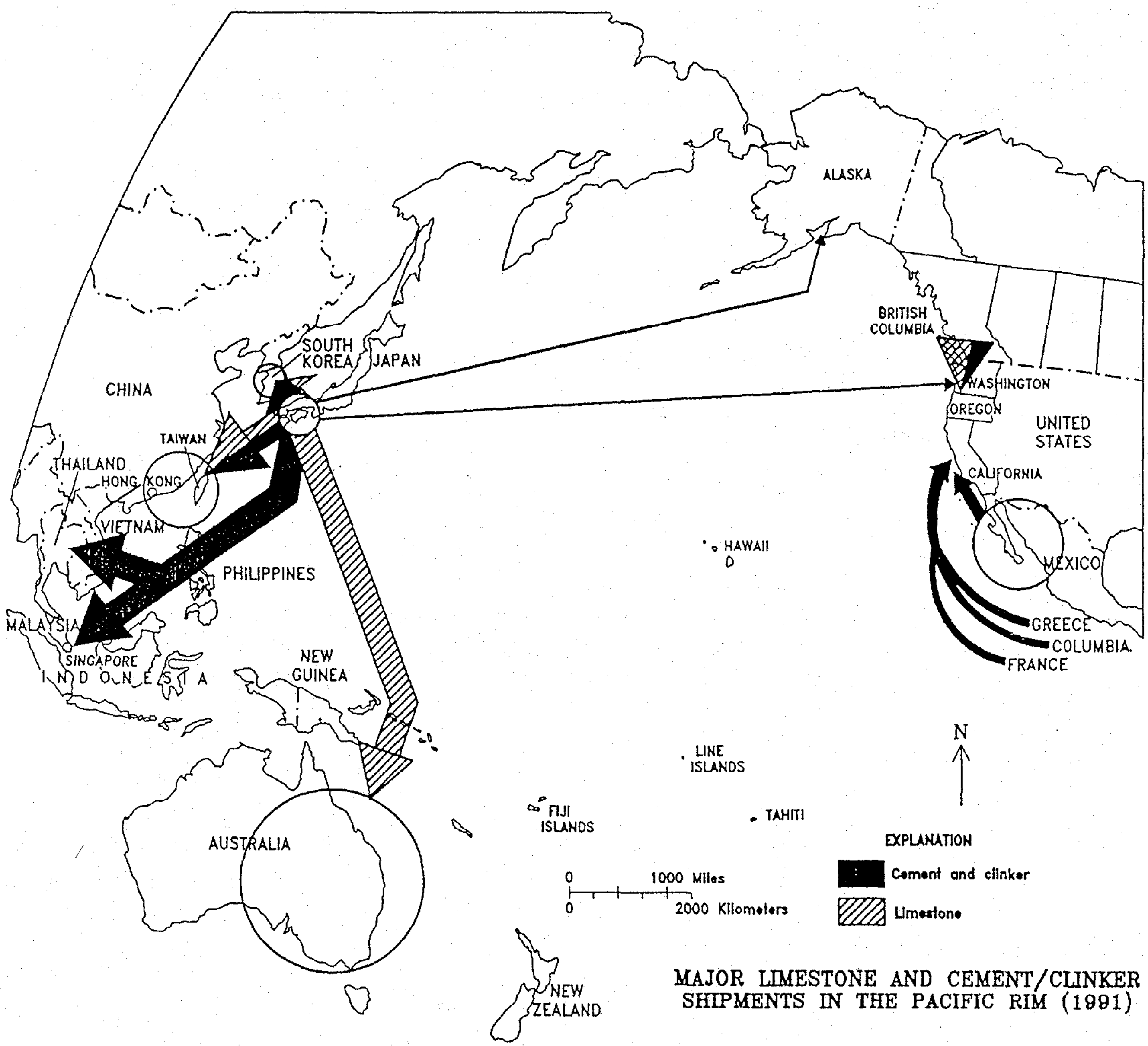


Figure 4 - Major shipments of limestone, clinker and cement in the Pacific Rim in 1991

In Japan, mining and processing has been cut back recently due to the recession in domestic industry and the consequent decrease in demand from both the steel and construction industry. Very little limestone has been imported to Japan in the past, and no markets for imported construction grade material are anticipated.

An analysis of a typical chemical grade limestone currently being exported to Australia is reproduced in Table 6. This specification exceeds the requirements for ultra-high calcium carbonate of 97% $CaCO_3$ (53.2% CaO).

Specialty carbonate pigments

There are specialty carbonate pigments which are highly refined pigments coated with various organic compounds or activated colloidal carbonates which are used in high quality rubber, high strength plastics, inks and paints. These pigments are predominantly PCC based but very finely ground GCC also may be used in some of these pigments. Exports are dominated by shipments to Korea and the U.S. for the rubber and automotive plastics markets. The current trend is for Japanese industry to invest and manufacture in other countries. When they manufacture overseas, the Japanese typically specify the same raw materials as used in Japan. In 1992 Japan exported over 70,000 mt of these specialty products to over 40 countries.

8. Asian market potential for GCC

There is a growing market for high brightness limestone for the production of fine particle size GCC in Japan, Korea, Taiwan and the U.S. (Parallax Inc., 1993; Temanex, 1993). The largest market is in paper but a growing market also exists in paint, plastics and other extender pigment and filler applications. At present a shortfall exists in this market in Japan, Taiwan and Korea (Figure 5) which is estimated to be between 175,000 and 250,000 mt/y. This market will increase because of the continued growth of the paper, paint and plastics industries in Asia. This growth cannot readily be identified from statistical data because GCC is not a specific item within import or export classification schedules. Estimates are therefore based on direct experience of marketing specialists servicing the region. The growth in GCC usage in the paper industry is due to several factors which include:

- the present trend toward alkaline paper making rather than acid processes. Alkaline processes permit the use of carbonates rather than kaolins as fillers, coating pigments or extenders.
- the growth in demand for high quality coated papers.
- the recognition that high brightness GCC has superior physical and optical performance over PCC and kaolin in certain applications.

Potential market tonnages are summarized in Table 8.

Table 8 - Usage and potential markets for GCC in Japan, S. Korea and Taiwan

(Metric tons)

Location	Estimated tonnage Used	Estimate of market tonnage undersupplied in 1993	Estimated Value CIF $/mt
Japan	1,200,000	135,000 to 180,000	50 to 60
Korea	250,000+	30,000 to 50,000	50 to 60
Taiwan	100,000+	10,000 to 20,000	50 to 60

Source: (Parallax, Inc., 1993)

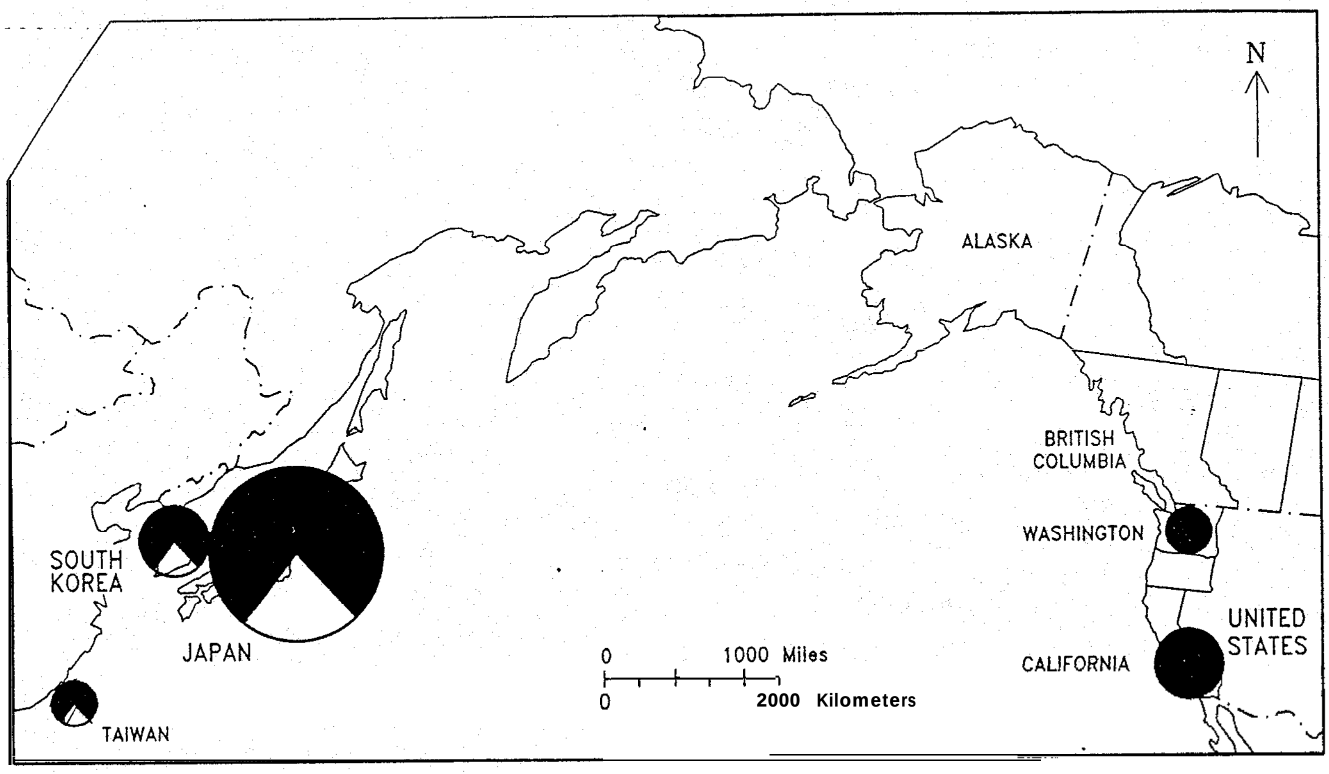


Figure 5 - Location and size of major GCC markets in the Pacific Rim

Note: Area of circle indicates relative market size. Proportion of undersupplied market is indicated by the open segment of circle. Market tonnages are detailed in the text.

The paper industry is projected to have the strongest growth potential where GCC will be used in conjunction with kaolin to improve both brightness and viscosity characteristics. The growth in GCC usage in the plastics and paint markets is due to the increasing production tonnages of these products particularly .in Asian markets.

If limestone/marble chips of suitable quality were to be supplied to Asia from the Pacific Northwest the projected delivered price (CIF Japan) is US$50 to $60/mt. The chip size is dependent on the hardness and resistance of the material. Softer materials tend to be shipped as larger lumps with up to a 15 cm diameter, while more resistant materials such as marble may be as fine as 2.5 cm diameter. If tonnages are sufficiently large to justify bulk shipments of 20,000 mt the FOB price is estimated to be within a range of $30.00/mt and $47.00/mt. This wide range in price reflects the $10 range in delivered CIF price and the volatility in bulk freight estimates which range from $13/mt to $20/mt .

9. Western U.S. markets

In the western U.S. the highly competitive GCC market is supplied by existing resources and no shortfall was identified . The market for GCC in Washington and California is projected to increase with the paper industry, having the strongest growth potential followed by paint and plastics. While the GCC resources in Washington and California are inland, in British Columbia they are located near deep water. This could offer a considerable freight advantage since the paper markets are predominantly coastal. Inland rail freight costs from the Washington GCC resources (in Okanagan County) to the Columbia River Carbonates plant in Woodland (approximately 300 km) are confidential to the operator. They are however conservatively estimated to be no less than $15/mt. In California, the coastal markets for CCC also are supplied by the inland resources of the Lucerne Valley in Southern California. The distance from these resources is approximately 160 km to Los Angeles and 640 km to San Francisco.

Although no comparative data has been obtained on the relative qualities of the high brightness marbles (in British Columbia, at Wauconda, Washington and the Lucerne Valley, California), the potential for supplying GCC chips to coastal situations in Washington or California justifies further study.

10. Prices by specific product and geographic area

10.1. Limestone

In British Columbia (Pilon and Associates, 1993), the 1993 prices for Texada Island limestones are:

Cement grade limestone:	$2.60/mt ($2.34/t)
High-calcium limestone:	$3.60/mt ($3.24/t)

Local prices of limestone are highly competitive with low profit margins (Pilon and Associates, 1993). Small quantities of white limestone sell for $7.93/mt.

10.2. Lime production costs and prices ,

Lime prices within the United States have remained very static for many years. The average selling price for lime moved from $55.22 in 1987 to $57.0/mt in 1991.

The average cement prices for general use and for all grades are presented in Table 9. In British Columbia statistical data are not available because the production is by few companies and the data are confidential.

Table 9 - Domestic cement prices in the U.S. aud British Columbia

	1988 $/mt	1989 $/mt	1990 $/mt	1991 $/mt
Alaska	54.28	59.57	68.86	58.25
British Columbia	C	C	C	C
Washington	54.29	C	C	C
Oregon	C	C	C	C
California (north)	63.68	65.04	67.40	65.57
California (south)	63.51	64.76	65.95	65.16
Portland cement	53.50	52.82	53.56	54.41
Hydraulic cement	54.40	54.76	55.32	55.79

Source: USBM Data
C = Data confidential because of limited number of producers.
* = Alaskan estimate is based on an average CIF price for imports

Table 10 - Imports of hydraulic cement and clinker to North American west coast (1991)

Region	Imports Mmt	Major Suppliers	Value CIF $/mt
Alaska	0.08	Japan, Canada	$51.70 $183.00
Washington & Oregon	0.81	Canada Japan	$54.34 $40.59
		Average Price	$45.96
California	2.57	France Mexico	$46.06 $45.59
		Average Price	$48.26*

Source: USBM Data
* This average exceeds the average price of the two major suppliers because of small imports of higher priced cement from other countries.

10.3. *Trends in clinker and cement prices in A sian countries of the Pacific Rim*

The trends in clinker and cement prices in Asian countries of the Pacific Rim have been assessed from five years of statistics from Japan and Taiwan. There has been a progressive increase in value for these commodities on an FOB port price as illustrated in Figure 6.

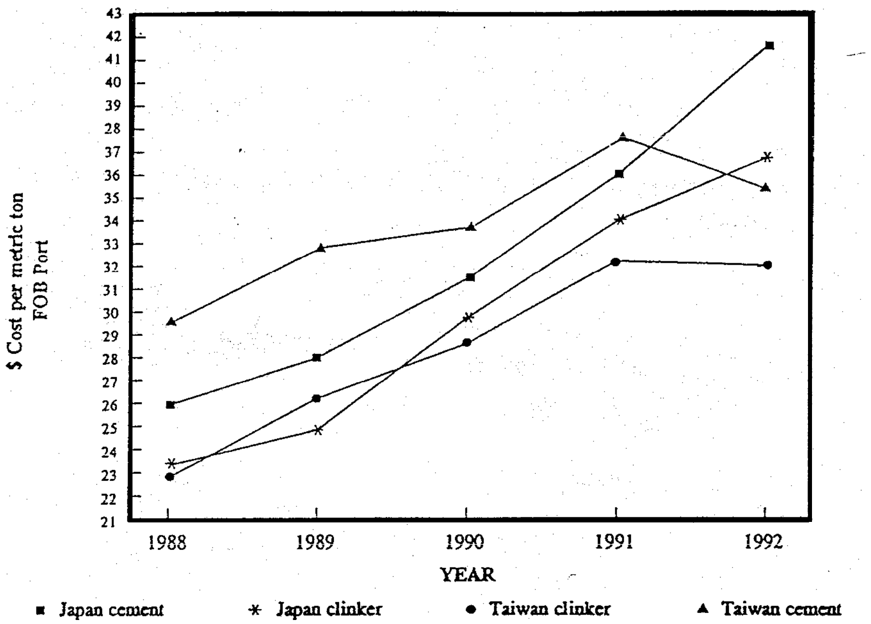


Figure 6 - Trends in FOB port prices for clinker and cement for Japan and Taiwan

10.4. Prices for marble or limestone chips

In California and Washington the resources of limestone and marble for the production of GCC are held by the processing companies and their cost data are confidential. In Asia, the CIF value for high grade ore suitable for GCC processing is $5O/mt to $60/mt (Parallax, Inc., 1993).

10.5. Prices for GCC products

After fine grinding, the prices range from $150 to $230/mt depending on the level of processing, and whether the materials are supplied in slurry, bulk or bagged. Pricing varies greatly depending upon the final application. The prices of GCC vary according to grade, contract type/size, and transport costs. For a large consumer with on site PCC and some CCC requirement, the price is on the order of $150 to $160/mt. Because of the highly competitive nature of the industry it is reported that base prices have not moved since 1987.

In Asia the pricing for high grade ore suitable for GCC processing is approximately $50/mt to $60/mt (Parallax, Inc., 1993). After fine grinding, the prices are around $150 to $250/mt depending on the level of material processing. Limited markets exist for decorative marble tile and block in the building industry. Pricing varies greatly depending upon the final application.

IO. 6. Specialty carbonate pigments

These carbonate pigments are highly refined pigments coated with various organic compounds or activated colloidal carbonates which are used in high quality rubber, high strength plastics, inks and paints. They are predominantly PCC based and may sell for over $400/mt on an FOB plant basis. Although such refined products are considered to be beyond the objectives of this study, the high prices illustrate the complexities to which carbonate processing may extend.

11. Shipping costs

Barge transportation is a logical option for transportation to a number of markets, particularly those delivery points that are located on the U.S. west coast. Barges of 5,000 mt (5,500 t) capacity are typically used to transport Texada Island limestones along the coast (Transmode Consultants Inc., 1990). The barge size is constrained by the depths in the inland waterways and the size of docking facilities. A quotation was obtained in May 1993 from the Rivertow Company in Vancouver for destinations from Texada Island. The costs to Vancouver, Seattle and Portland are presented in Table 11. For Californian ports the costs would be higher.

Table 11 - Barge Costs from Texada Island to Pacific Northwest ports

Destination	Freight Cost $/mt	Freight Cost $/t
Vancouver	2.40	2.16
Seattle	4.80	4.32
Portland	10.80	9.72

Source: Pilon and Associates (1993)

Estimates of 1993 freight rates from the Pacific Northwest to Asian Markets are detailed in Table 12.

Table 12 - Freight costs from Pacific Northwest to Asian markets

Vessel Size	Ocean freight estimate May 1993	Ocean freight estimate November 1993
60,000 to 70,000 mt capacity	$14 to $1 5/mt	$8 to $9/mt
25,000 to 30,000 mt capacity	$16 to $20/mt	$13 to $14/mt

Source: Transmode Consultants (1993)

12. Conclusions

12.1. Limestone, cement and clinker

In British Columbia, Washington and Oregon the Texada Island resources will continue to dominate the market for lime, clinker and cement in the foreseeable future. Their resource base is reported to be strong in all grades of limestone, while their production costs and distribution costs are low. The markets for cement and lime are currently either static or depressed. The cement industry is reportedly undergoing hard times, while lime prices have progressively decreased over the past 10 years:

Trends in CIF prices in Seattle and California are summarized in Table 13. There has been a significant increase in the CIF price since 1990. However, this has been caused by a higher proportion of cement rather than clinker within this category and the imposition of dumping duties on some imports.

Table 13 - Trends in imported hydraulic cement and clinker prices to U.S west coast ports

	1988 CIF/mt	1989 CIF/mt	1990 CIF/mt	1991 CIF/mt
Seattle	$40.78	$42.25	$45.89	$45.96
California	$36.77	$36.30	$39.16	$48.26

Source: USBM Data

With the recent establishment of NAFTA and the very large productive capacity in the Mexican cement industry, Mexico is poised to take a major role in the supply of cement to the Southwestern U.S.

12.2. GCC

In the Pacific Northwest the demand for GCC will continue to increase with the focus of the growth being the paper industry. No information has been obtained on the resources held by IMASCO in British Columbia. Resources of the high brightness Wauconda marbles in northern Washington held by Columbia River Carbonates are reported to be 20 Mmt (22 Mt) (O'Driscoll, 1989).

These resources are inland while the paper markets are predominantly coastal. Inland rail freight costs from the resources (in Okanagan County) to the Columbia River Carbonates plant in Woodland (approximately 300 km (200 miles)) are confidential to the operator but they are conservatively estimated to be not less than $l5/mt ($13.57/t). In California the coastal markets for GCC also are supplied by the inland resources of the Lucerne Valley in Southern California. The distance to Los Angeles is approximately 160 km (100 miles) while to San Francisco it is 640 km (400 miles). Although no comparative data has been compiled on the relative qualities of the Alaskan high brightness marbles versus the Wauconda marble and the Californian high brightness limestones, the potential for supplying GCC chips to coastal plants in Washington or California may justify further study.

12.3. Asia

The Asian area is a region of both tremendous market growth and resource development in industrial minerals. Japan, Korea and Taiwan have dominated the growth for many years; more recently, Thailand, Indonesia, the Philippines, Malaysia and other nations have shown very rapid rates of development. With the normalization of China's diplomatic relations with many countries, Chinese industrial mineral resources are now beginning to influence the patterns of supply in Asian markets. Japan has made significant investments in limestone resource development in China in the past two years, with several large cement plants under construction in southeast China. Mitsubishi Materials Corp. is investigating a 900,000 mt/y cement plant in Yantai Province, while Nippon Cement is considering a 7.3 Mmt/y plant near Nanjing.

Acknowledgements

Some of the statistical data for this study was compiled for the U.S. Bureau of Mines Alaska by the author. The U.S. Bureau of Mines generously consented to the inclusion of these data in this presentation.

References

Bleeck, J. A., R. L. Sherar, and C. W. Gulick. The Geology of Papermaking. Washington Geology, v. 21, No. 3, 1993, pp. 3-8.

British Columbia Ministry of Energy, Mines and Petroleum Resources. Mineral Market Update, v. 5, No.1, 1993, 31pp.

Brown, H. J. Geology, Genesis and Mining of High Brightness, High Purity Limestone Deposits at Pluess-Staufer (California) Inc. Lucerne Valley Operation. AIME Preprint No. 94-13, 1994, 11 pp.

Griffths, J. Mexico's Industrial Minerals Meeting Manana's Challenge. Industrial Minerals, No. 250, 1988, pp 19-41.

Maas, K. M., Private communication, 1993; available on request from K. M. Maas, BuMines AFOC-Juneau, AK.

Maas, K. M., J. C. Still, A. H. Clough, and L. K. Oliver. Mineral Investigations in the Ketchikan Mining District, Alaska, 1990: Southern Prince of Wales Island and Vicinity. U.S. Bureau of Mines OFR 33-91, 1991, 138 pp., and 12 plates.

Maas, K. M., J. C. Still, and P. E. Bittenbender. Mineral Investigations in the Ketchikan Mining District, Alaska, 1991: Prince of Wales Island and Vicinity. U.S. Bureau of Mines OFR 81-92, 1992, 69 pp.

Minarik, R. J. The Mineral Industry of Oregon. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 429-439.

Minarik, R. J., T. K. Bundtzen, R. C. Swainbank, J. E. Wood, and A. H. Clough. The Mineral Industry of Alaska. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 59-70.

Minarik, R. J., R. E. Derkey, and C. W. Gulick. The Mineral Industry of Washington. Ch. in BuMines Minerals Yearbook, v. II, 1991, pp. 543-553.

O'Driscoll, M. U.S. Pacific Northwest - An Outpost of Industrial Mineral Wealth. Industrial Minerals, No. 259, 1989, pp. 19-55.

_____ Fine Carbonate Fillers - PCC Breaks Ground in Paper. Industrial Minerals, No. 276, 1990, pp. 21-34.

_____ Industrial Minerals in Japan - Bowing to Recession Reality. Industrial Minerals, No. 295, 1992, pp. 19-45.

_____ South Korea's Minerals Industry - Imports Prove Seoul-Destroying. Industrial Minerals, No. 312, 1993, pp. 19-37.

Parallax Inc. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Pilon and Associates. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Saito, H. Limestone and Argillaceous Resources for Cement and Lime Production in Japan. AIME Preprint No. 82-371, 1982, 5 pp.

Stitt, P.H. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Stokowski, S., Jr., A. Shapiro, and A. Pincomb. Industrial Minerals for Lime Neutralization. Industrial Minerals, No. 302, 1992, pp. 67-73.

Temanex. Private communication, 1993; available on request from C.C. Harvey, H.H. Murray and Assoc., Bloomington, IN.

Tepordei, V. Crushed Stone. Ch. in BuMines Minerals Yearbook, v. I, 1991, pp. 1469-1511.

Transmode Consultants Inc. Transportation Costs for Industrial Minerals in B.C. A Report Prepared for the Province of B.C. under the Canada-British Columbia Mineral Development Agreement 1990, 50 pp.

Market Development and Business Growth Strategy for Light Weight Zeolite Concrete

by

L.E.W. Hogg,

President,

Polar Powders and Technology Inc.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

MARKET DEVELOPMENT STRATEGY FOR LIGHTWEIGHT ZEOLITE CONCRETE

PREPARED FOR

FOCUS ON BRITISH COLUMBIA INDUSTRIAL MINERALS
VANCOUVER, BRITISH COLUMBIA

OCTOBER 19, 1995

By

LuVerne E.W. Hogg

TABLE OF CONTENTS

INTRODUCTION

Polar Powders & Technologies Inc. (PPT) acknowledges a financial contribution by the Canada-Alberta Partnership on Minerals through the Alberta Department of Energy and the National Research Council (NRC). The research and development work was conducted by the Institute for Research and Construction (IRC) of the NRC.

Lightweight zeolite concrete (LZC) is a new product developed by technologies resulting from research and development. There is an increased demand by society, for new materials to replace traditional building materials. These demands are a result of society's changing values and recognition that our natural resources are finite. The development of lightweight zeolite concrete is a response to this growing demand for new materials and sustainable exploitation of our natural resources.

The research and development program resulted in a new technology, for which a U.S. patent was granted in October 1995. I will not deal with details of the processes or methodologies except to state that the LZC formulations are, for the most part, 80% natural zeolite,' which are subsequently cured in a conventional manner. The resulting material has the following desirable characteristics.

1. The material can be cast and is dimensionally accurate as well as machineable, which facilitates reduced construction time and costs.
2. The material can be made with compressive strengths in a range of 5-30 MPa, which meets a broad spectrum of needs in the construction industry.
3. The dry density can be made in the range of 500-1500 kg/m^3 (lightweight).
4. Excellent thermal properties and acoustical properties.
5. Fire resistant, impervious to rot and insects.
6. Flexibility, which allows for production of various size blocks, panels and reinforced members for walls, floors and roofs.
7. Good to excellent engineering properties of density,. pore structure, permeability, efflorescence, specific heat, thermal conductivity and elastic modulus.
8. Good to exceptional durabilities which are sulphate resistant, acid resistant, carbonation resistant and frost resistant.

THE OPPORTUNITY

Changing Traditions

The building industry is changing. Today's generation of builders is increasingly more sophisticated and relies heavily on cost benefit analysis of completed construction systems. These builders are more likely to change to new materials and techniques if they provide greater in place value over traditional systems.

Wood products are the traditional dimensional material for building purposes. Wood products use, as a depleting natural resource, has resulted in dramatically increased costs; a trend which is unlikely to change.

The consistent increases in energy costs, have created a requirement for energy conservation in new construction.

The above factors have created an opportunity for LZC to become an effective alternative to traditional systems by focusing on the production of high quality, value added materials for market niches.

THE CHALLENGE

Successful introduction of LZC will have to overcome the inhibiting factors of:

1. A facility for the production of LZC in commercial quantities.
2. Acquiring the necessary construction and inspection code approvals.
3. The consumer must be educated on the advantages of LZC systems and request its use. The consumer of today is more demanding, more sophisticated and smarter than ever about their options. They want better value and they have the muscle to insist on it.
4. Whereas building tradition is changing, the industry is highly fragmented with decision makers from architects, builders, developers, contractors, construction managers, unions and suppliers, all of whom must be educated to the opportunities of utilizing LZC.
5. LZC must meet the consumers' demands by satisfying the underlying requirement for a cost effective system.

THE STRATEGY

The strategy is to establish initial market share by concentrating on niche market products. This introduction stage commits all the key functions of research, development, engineering and production to the establishment of early adopters of LZC in the niche markets.

LZC is a differential product. A differential product is a product which can replace other products in the marketplace. In this instance LZC can replace both concrete and wood products. The potential customers must be shown a sufficient differential advantage to motivate the shift to LZC.

The strategy for LZC introduction, utilizing the differential advantage, will be adjusted into a developing strategy for the growth stage of LZC, beyond the niche markets. The strategy will continue to adjust and change as LZC reaches a maturity stage. it is important to recognize that the strategy must be flexible, adapting to the acceptance time for a differential product.

LZC is a high technology product. One of the key strategic implications is to be first in the marketplace and to be fast. Efficiency and economic production are important.

THE TACTICS

The tactic for the development of LZC is to overcome the challenges to fulfil the strategy.

PPT's tactic to overcome the challenge of initial production of commercial product is to have LZC produced under-license by a pre-cast concrete manufacturer with the required curing equipment. This method will allow PPT to achieve initial commercial production without the initial high capital cost of constructing a plant.

PPT will be able to begin acquiring the necessary construction and inspection code approvals for LZC. Priorities will be established for codes and approvals in the niche markets subsequently leading to additional approvals. Emphasis will be placed on utilization of LZC outside of urban areas to take advantage of faster approvals in the rural and remote industrial and agricultural sites.

The consumer, in the identified niche markets, can be provided with demonstration products from licensed production. All of the engineering properties and durabilities will be elucidated for the potential consumers, as well as the key function of costing. Architects, builders, developers, contractors and suppliers will be introduced to LZC and provided with details on utilization and construction techniques.

It is necessary to note the critical importance of marketing at this stage in the development of LZC. Up to the point of commercial production of LZC from a licensee, all of the financial resources have been allocated to. the research and engineering development of LZC. A preponderance of resources must be devoted to the marketing of the product in order to survive the introductory stage, otherwise, the product will fail. Sufficient resources for new product introduction is a must and planning must allocate sufficient financial resources for this.

The introduction of LZC systems is predicated on meeting consumer demands for a cost effective system. Initial production of LZC is planned at pre-cast concrete plants under license. In order to maintain low cost production, variables such as raw material costs for zeolite can be moderated by the location of the ore-cast plant and supply contracts for zeolite. Any zeolite raw material can be adapted with the technology to produce LZC.

A large scale plant dedicated to the production of LZC systems will cost several million dollars. The risk to the capital is too great to consider until market acceptance of the LZC has been demonstrated.

THE MARKETING

LZC is a differential product. Aggressive marketing of LZC products is acute to the success of the product and project. Significant missionary work introducing LZC to the consumer is going to be necessary. The LZC marketing plan allocates significant resources in money and personnel to achieve the goal of sustainable production.

The initial focus of the marketing effort will be to the niche markets with general market introductions of LZC made to potential customers. This initial introduction will be used to involve the potential customers in the development of LZC. The potential customers can provide valuable linkages in the development strategies. The object is to not only respond to the potential customers' expressed needs but to anticipate and supply their future needs.

LZC as a differential product requires elucidation of its advantages from a technical and engineering basis. Technical data sheets, physical demonstrations and price lists will be provided to potential consumers, as they form the cornerstones of the decision to purchase. No sales efforts can proceed until the two key questions can be answered and they are "How much will it cost?" and "When can you deliver?".

Product awareness is the result of an effective marketing program. The methods of creating awareness must produce an image for the consumer that the product is an alternative that they need. Acquiring the answer to that need provides satisfaction to the consumer: For example, if they live beside an airport and don't like noise, LZC acoustical panels will mitigate the noise.

The engineering properties and durabilities of LZC will be presented to the consumers as solutions to their needs for lightweight, strength, high R factors, sound attenuation, fire proof, dimensionally accurate, machineable building materials. A campaign of product awareness will utilize the format of trade shows and conferences. Technical papers will be published in trade journals.

The above methods are a normal approach to industrial marketing. Marketing of LZC must go beyond the conventional approach and create markets. The product has a very broad scope of uses which can be utilized in a myriad of new and replacement applications. In order to promote the LZC into these areas it is necessary to involve active participation by individuals in developing applications for LZC.

A more esoteric product awareness program is aimed at artists. LZC is machineable, it can be cut with a saw, drilled, etc. The plan is to sponsor a sculptors' competition with cash prizes for the winners. The competition will be adjudicated by the art colleges. Along the same lines, we plan to hold a design competition with cash awards for designers and architects for innovative and creative uses of LZC.

I have deliberately used the word “cash prizes” to emphasize the critical point that new or alternative product introduction requires a substantial investment in time and money in order to succeed.

The mass marketing media techniques of newspapers, television and radio will not be employed, except for special features i.e. who won the cash and why. The marketing plan for LZC targets specific consumers with specific messages and tailored products and promotion.

In the final analysis, regardless of any course of action, whether that be the adaption of the science and technology, public opinion or market research and development, only results matter.

B.C. Dimension Stone in 1995

by

Z. D. Hora,
Industrial Minerals Specialist,
B. C. Geological Survey

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

B.C. DIMENSION STONE IN 1995

BY Z.D. HORA

One hundred years ago, British Columbia had a flourishing dimension stone industry. Rapid urban growth in the western part of North America required permanent structures for banks, courthouses, legislative buildings, post offices and businesses. Quarried stone was the principle building material of choice; and production centres on the coast, in the Okanagan and the Kootenays provided a variety of dimension stone for both local and export markets. B.C. marble was used as far away as Winnipeg and Salt Lake City, sandstone went to San Francisco, and granite was used in Oregon, Hawaii, and Australia. With economic depression and new construction technology, stone production in B.C. gradually decreased and the last dimension stone quarries shut down during the 1950s. The recent increased worldwide popularity of stone for facing of high-rises, counters, wall and floor tile and other decorative purposes resulted in a gradual comeback for B.C.'s stone industry. Still small by world standards, British Columbia, in 1996, has three stone processing plants which not only supply the local market, but also export to foreign consumers. A major portion of the stone processed by these three plants is quarried from seven locations in the southwestern part of the province. While the historical production of B.C. stone included granite, marble and sandstone with minor volumes of slate, the present producers concentrate on a variety of types of granite, some marble, and two types of flagstone - quartzite and mica schist.

A wide range of intrusive rocks are produced under the generic name of "granite". Substantial tonnages are quarried for splitface ashlar products, as well as in blocks to be processed into slabs, tiles and cladding sheets. Fine and medium grained grey varieties of quartz monzonite, diorite and granodiorite are currently utilized for facing and masonry purposes by several companies and are marketed under names such as "Tsitika Grey", "Fox Island Grey", "Arctic White", "Glacier White", "Garibaldi Gold", Garibaldi Grey" and "Cascade Coral". These are established market varieties and the quarry sites are located on Vancouver Island; near Squamish; at the mouth of the Jervis Inlet; and near Beaverdell in the B.C. Interior. The stone is quarried by Garibaldi Granite Inc., Quadra Stone Company Ltd., Tsitika Stone Industries, and Granite Island Quarries. Four of the granite varieties - the "Glacier White", "Garibaldi Gold", "Garibaldi Grey", and "Fox Island Grey" are also used for custom work as polished slabs for counter tops in kitchens, bathrooms, etc.

Fine to coarse grained varieties of granite, mbnzonite and granodiorite are also produced in B.C., usually in approximately 15-tonne blocks, and are processed into polished tile by Margranite Industry Ltd. in Surrey, B.C. Pink varieties include two from the Skagit Valley - "Robson Rose" and "Valley Rose", and

“Cascade Coral” from Beaverdell. White granodiorite “Whistler White” comes from Elaho River near Squamish. Greenish to greenish-beige fine and medium grained “Aqua Mist”, “Alpine Summer”, “Whitewater” and “White water Classico” are quarried near Boston Bar east of the Fraser Canyon and all of the above stone is becoming very popular both in B.C. and abroad. Several other stone types are not yet commercially developed, but have very good market potential. Dark blue-grey “Majestic Blue” from Knight Inlet, and dark grey-almost black “Sable Black” from Princess Royal Island, black “Pedro Black” from Grand Forks and “Raven Black” from Harrison lake, mottled beige “Pacific Pearl” from Kelowna and pink “Pacific Rose” from McNulty Creek near Summerland are some examples.

On Vancouver Island, Matrix Marble Corp. processes two types of local marble into custom made products. Fine-grained black with white veining is called “Carmanah Black” and coarse crystalline white is marketed as “West Coast White”.

British Columbia is also a well established producer of flagstone. The Salmo area has been, for decades, a source of quartzite slabs with the Kootenay Stone Centre as the main producer. Mica schist is also a decades old product of the Revelstoke Flagstone Quarries in Revelstoke.

As a source of ornamental stone, B.C. has been the primary producer of nephrite jade and rhodonite for designers, sculptors and jewelers internationally. Jade West Resources Ltd. is marketing blocks, tiles, cut-to-size pieces and slabs to its customers worldwide in both rough and polished form.

This overview covers only the highlights of current dimension stone activity in British Columbia. There is a considerable degree of additional ongoing exploration and development activity and new discoveries are made every year

B.C.‘s vast, favourable geology, largely unexplored for dimension stone, provides unlimited scope for prospectors, producers and serious developers. With an excellent network of secondary and tertiary roads for access, one of the world’s largest and most efficient coastal barging systems, and several modern deep-sea port facilities, B.C. is well equipped to produce and deliver stone and stone products to anywhere in the world. Further, recent legislative changes have significantly streamlined the quarry land tenure acquisition process on Crown Land. Under Bill 13, dimension stone in B.C. is covered by mineral definition, which simplifies the development and start-up of quarry operations and reduces the time required to get the deposit to the production stage.

Proceedings

British Columbia Geological Survey

INFORMATION CIRCULAR 1997-4

Proceedings
Focus on British Columbia Industrial Minerals

Contents:

Mineral Development

Zeolite Potential in British Columbia	P. Read, Consultant
Holnam West Materials Ltd. Limestone Quarry, Texada Is. B.C.	P. M. Stiles, Vice President; Holnam West Materials Ltd.
Garnet Market Potential in Western Canada and United States	D. G. Lobdell, Consultant

Focus on British Columbia Industrial Minerals
Thursday, October 19, 1995

8:00am Registration

Chair: D. Hora and D. Gunning

8:30am *Welcome /Information*
Ministry of Energy, Mines and Petroleum Resources with B.C. Trade Development Corporation

8:40am *Demand Defines Exploration Targets for Industrial Minerals*
P. W. Harben, Consultant

9:00am *Industrial Mineral Opportunity for B. C. Custom Processing*
B. Ainsworth, Consultant

9:20 am *Industrial Kaolin and Market Growth on the Pacific Rim*
C. C. Harvey, Consultant

9:40am *Challenges for the Pacific Northwest Cement Manufacturer*
E. Cardey, President; I.M.P.A.C.T. Minerals Inc.

10:00 am Coffee Break and Posters

Chair: D. Gunning and G. Simandl

10: 30am *B. C. Dimension Stone in* 1995
Z. D. Hora, Industral Minerals Specialist; B. C . Geological Survey

11:00am *Market Development and Business Growth Strategy for Light Weight Zeolite Concrete*
L. E. W. Hogg, President; Polar Powders and Technology Inc.

11:20am *Hat Creek Property - A Source of Calcium Montmorillonite*
N. Skermer, President; Pacific Bentonite Ltd.

11:40am *Economics of Various Industrial Minerals in B. C. for the Pulp and Paper Industry*
B. A. Slim, President; MineStart Management Inc.

12:00pm Luncheon and Posters

Chair: G. Simandl and D. Lefebure

1:30pm *Industrial Minerals and Bill 13*
D. Lieutard, Director and R. Conte, Assistant Director; Mineral Titles, B.C. Ministry of Energy, Mines and Petroleum Resources

1:50pm *Clayburn Industries Ltd.*
D. Harris, President

2:10pm *Resources, Applications and Market Trends of Calcium Carbonates in the Northern Pacific Rim*
C. C. Harvey, Consultant

2:30pm *Update on Perlite*
D. F. Gunning, Consultant; B.C. Trade Development Corporation

2:50pm Coffee Break and Posters

Chair: D. Hora and D. Lefebure

3:30pm *Short His tory of an Industrial Mineral Development*
P. B. Aylen, President; Western Industrial Clay Products Ltd.

3:50pm *Zeoli te Potential in British Columbia*
P. Read, Consultant

4:10pm *Holnam West Materials Ltd. Limestone Quarry - Texada Island, B. C.*
P. M. Stiles, Vice President; Holnam West Materials Ltd.

4:30pm *Garnet Market Potential in Western Canada and United States*
D. G. Lobdell, Consultant

5:00pm Posters on Display

5:30pm Meeting Adjourns

6:30pm Field Trip B Departure from the Pan Pacific Hotel Entrance

Post Meeting Field Trip

Tour B

Southern British Columbia Industrial Minerals Deposits

October 19 to 22

A three and a half day post-meeting tour to visit industrial mineral deposits and operations in the southern interior of the province. Highlights of the trip will include visits to Baymag's Mt. Brussiloff magnesite mine, Mountain Minerals' Moberly silica operation, and Westroc's gypsum mine.

Field Trip Hosts

Baymag Mines Co. Limited

Canmark International Resources Inc.

Jade West Resources Ltd.

Margranite Industry Ltd.

Mountain Minerals Co. Ltd.

Okanagan Opal Inc.

Tilbury Cement Limited

West Coast Granite Manufacturing Inc.

Westrock Industries Limited

Organizing Agencies

BC Ministry of Energy, Mines and Petroleum Resources

BC Trade Development Corporation

Natural Resources Canada (Mineral Development Agreement)

BC Ministry of Employment and Investment

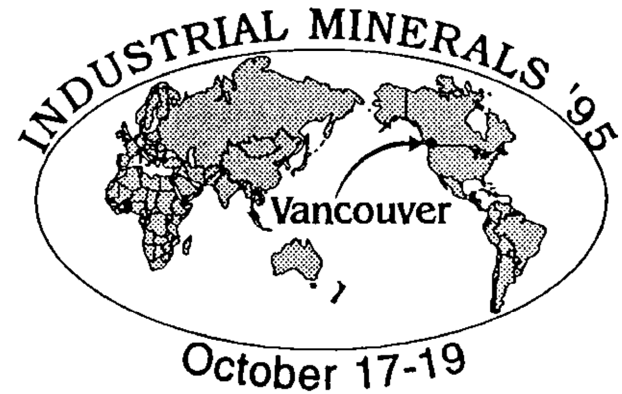
Reception Hosts

BC and Yukon Chamber of Mines

Mining Association of BC

Reception Sponsor

Tilbury Cement Limited



Focus on British Columbia Industrial Minerals

October 19, 1995
Pan Pacific Hotel
Vancouver, B.C.
Canada

Industrial Minerals and Bill 13

by

D. Lieutard, Director,
R. Conte, Assistant Director,
Mineral Titles,
B.C. Ministry of Energy, Mines and Petroleum Resources

presented at
Focus on British Columbia
Industrial Minerals

October 19,1995
Vancouver, Canada

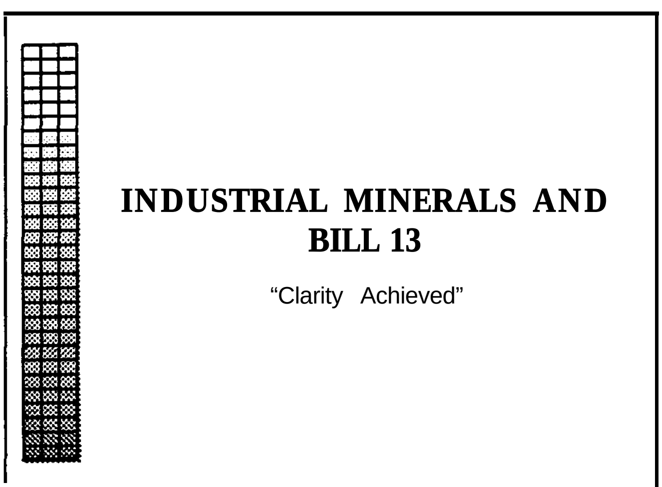
Speaker: Denis Lieutard, Director of Mineral Titles Branch and Chief Gold Commissioner

Denis was appointed Director in 1990, prior to that he was Deputy Director of the Branch for 7 years. During the 9 years previous to this, Denis, was a Mineral Titles Inspector working in Northern B.C. for 9 years. He holds a Bachelor of Science Degree in Geography and a Diploma in Public Administration from the University of Victoria.

INDUSTRIAL MINERALS AND BILL 13
"Clarity Achieved "

Slide Left and Right

INDUSTRIAL MINERALS AND BILL 13 'CLARITY ACHIEVED'



Thank You. I am very pleased to have the opportunity to present this short paper on industrial Minerals and Bill 13.

Bill 13 - is the Mineral Tenure Amendment Act which was passed by Legislature this summer.

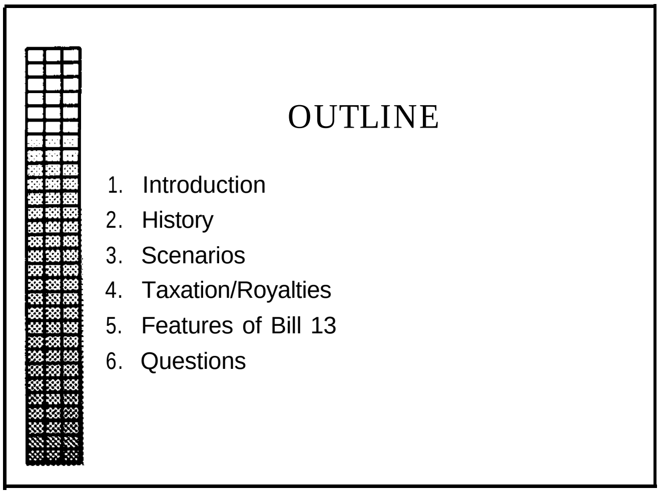
The implementation date for the Act is not set, but it will likely be in the coming months.

I've subtitled the paper, "Clarity Achieved" because I believe clarity as to the ownership of industrial minerals has been finally achieved after 30 years of trying.

History may ultimately prove us right or wrong, but for now, let's see if you agree with me at the end of this talk!

<u>Slide Left</u>

Outline



Here is the Outline of my presentation:

1. Introduction

2. History

A review of history often helps us understand a problem more clearly

3. Scenarios

These Scenarios will help you to know what to expect when Bill 13 is proclaimed

4. Taxation/Royalties

This will be a quick indication of what tax or royalty scheme you will be subject to.

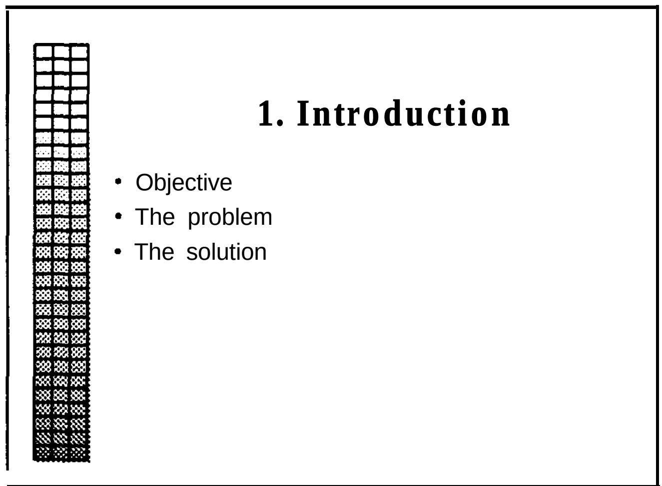
5. Features of Bill 13

We will look at some of the feature of Bill 13 designed to help in industrial minerals sector.

6. Questions

I will try and leave some time for questions.

Slide Right



1. Introduction

- ***Objective***

The objective of my presentation is to provide you with sufficient information to help you determine:

1. how to assess your industrial mineral tenure situation or

2. how to best acquire clear title to industrial mineral

- ***The problem***

There must be a clear definition of the rights granted in order for Government to issue clear title to a land lot or clear title to a sub-surface mineral claim, The definition of mineral and the corresponding definition of Land must be very clear, concise and stable in the Statutes.

The definition must not be subject to various interpretations and thus come into question after tenure is granted. It must not change when circumstances, such as end use or the production volumes change.

In reality the definition of mineral has changed several times in the past 100 years.

These changes related mainly to the inclusion or exclusion of construction materials and industrial minerals.

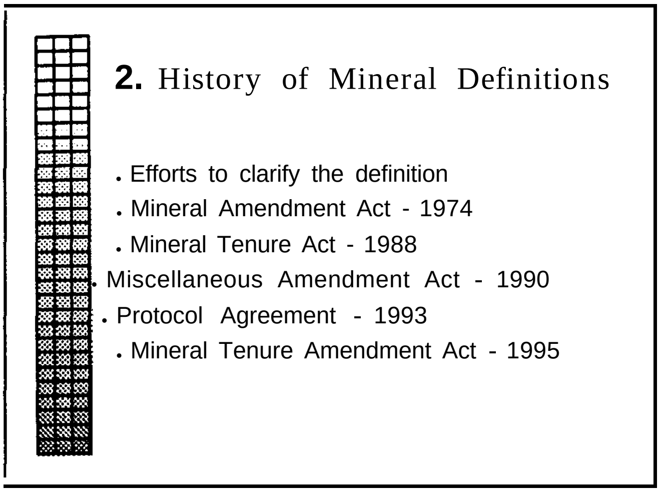
Some definitions relied upon the end use of the rock to determine if the rock was a mineral or a land tenure.

This condition has caused considerable uncertainty for the past 30 years.

. *The solution*

The solution of course lies in providing a clear definition, which allows perspective tenure holders to explore and develop industrial minerals. The challenge is making the appropriate changes to the legislation and implementing the changes successfully

Slide Right



2. History of Mineral Definitions

I'd like to spend a few minutes demonstrating the changes in the definition of mineral over time. As I mentioned earlier, a great deal can be learned from examining the history of change. (something about not repeating mistakes!)

- ***Efforts to clarify the definition***

In the past 10 years there have been several attempts to improve the definition of mineral

- ***Mineral Amendment Act - 1974***

A number industrial minerals were transferred to the Mineral Act but the system was never implemented and thus repealed in 1977

- ***Mineral Tenure Act - 1988***

The Mineral Tenure Act you will recall consolidated the Mining Placer Act and Mineral Act and simplified, streamlined and deregulated a number of things.

Unfortunately the new definition of mineral was not as clear as it could have been.

- ***Miscellaneous Amendment Act - 1990***

Here we attempted to correct the 1988 wording of the definition of mineral, but we could not reach a consensus with BCLands on how to implement this section. It was never implemented

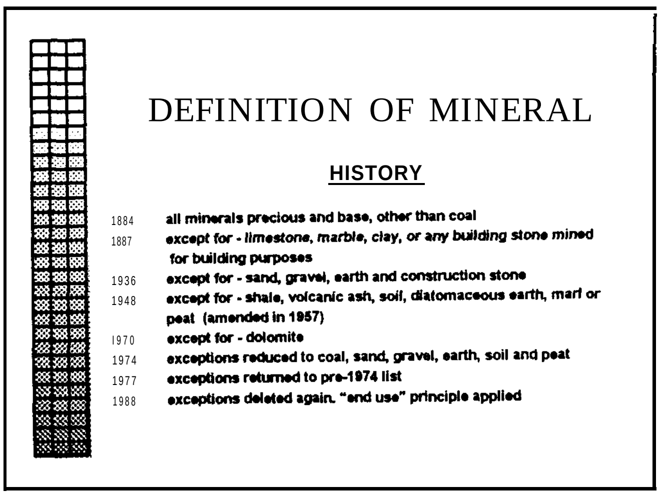
- ***Protocol Agreement - 1993***

As an interim step, an agreement was forged between Ministry of Energy, Mines and Petroleum Resources and BC Lands. This agreement set out the rules for dual tenure and guided both administrations in the issuance of tenures.

. ***Mineral Tenure Amendment Act - 1995***

This Act will simply ensure that dimension stone products are included in the definition of mineral and that rock used for construction purposes is clearly excluded. More on this later.

Slide Right



DEFINITION OF MINERAL - HISTORY

Here is a summary of the definition of mineral in the Mineral Act over the past 111 years.

1884 - all minerals precious and base, other than coal

Very simple and straight forward, worked fine in the 1880's

1897 - except for - limestone, marble, clay or any building stone mined for building purposes

This is where material typically used for construction purposes was excluded from the definition and administered by BCLANDS

1936 - except for - sand, gravel, earth and construction stone

Here again, more construction and land tenure type materials are excluded.

1948 - except for - shale, volcanic ash, soil. diatomaceous earth, marl or peat (amended in 1957)

The 1948 Mineral Act was a long standing, but it too underwent changes in 1957 that removed certain material. This meant that shale could not be staked, even if it contained minerals.

1970 - except for - dolomite

Here is a last minute exclusion.

The trend reversed in the mid 1970s and industrial mineral products were returned to the definition of mineral

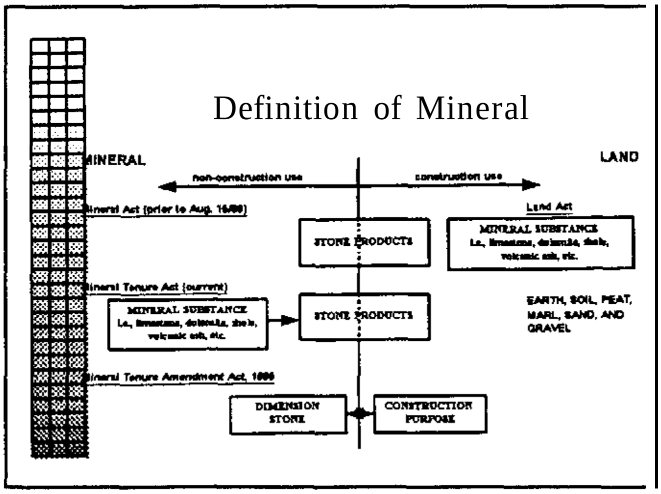
1974 - exceptions reduced to coal, sand, gravel, soil, and peat

This meant that limestone, shale, marble, dolomite and other materials were returned to the definition. Unfortunately this amendments was never activated and repealed in 1977.

1988 - exceptions deleted again "end use of stone products" principle applied

The next slide will give you a better appreciation of what happened in 1988.

Slide Right



Definition of Mineral

This slide is not as complex as it looks.

The world is divided into the Land Act and Mineral Act

Prior to 1988 the definition of mineral did not include what we collectively call MINERAL SUBSTANCES. That is limestone, shale, dolomite, marble, diatomaceous earth, volcanic rock etc.

The **stone products** box signifies:

- when you are on the land side - material used for construction purposes;

  such as roads, dams, berms levies, construction stone, tiles etc.

- when you are on the mineral side - material used for industrial purposes;

  such as ceramics, glass making, abrasives, refractory minerals, cement etc.

In 1988 the MINERAL SUBSTANCES were transferred to the definition of mineral. Notice that Stone products box did not change.

In reality we complicated the matter, in 1988 because before, limestone, shale, dolomite were clearly excluded from the definition of mineral. Now they became part of the stone products puzzle.

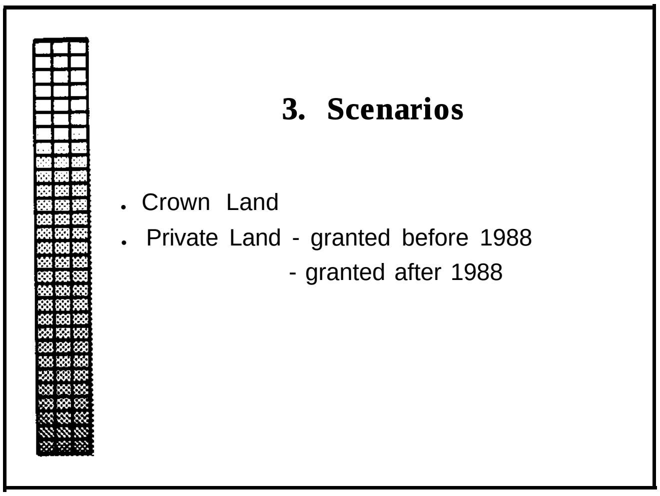
On the bottom of the slide is the Mineral Tenure Amendment Act - Bill 13

You will see that the Stone Product box has now been split into two distinct portions:

Dimension stone
Construction Purpose

More details on this definition later

Slide Right



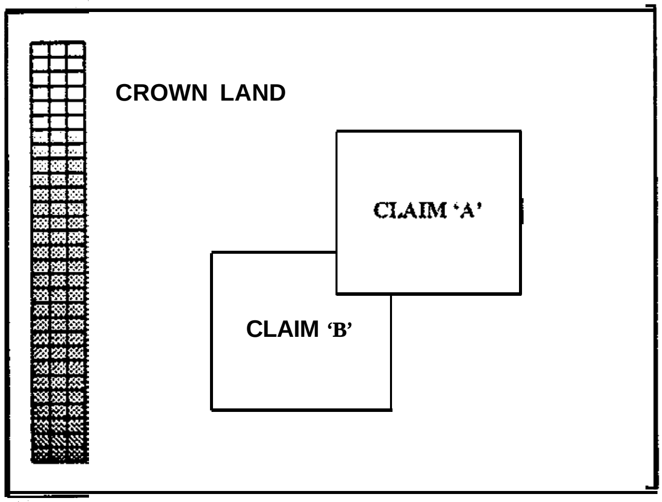
3. ***Scenarios***

The following two slides illustrates the three basic scenarios you should expect when Bill 13 is brought into force related to.

- ***Crown Land***
- ***Private Land - granted before 1988***
- ***Private land - granted after 1988***

First the Crown land

Slide Right

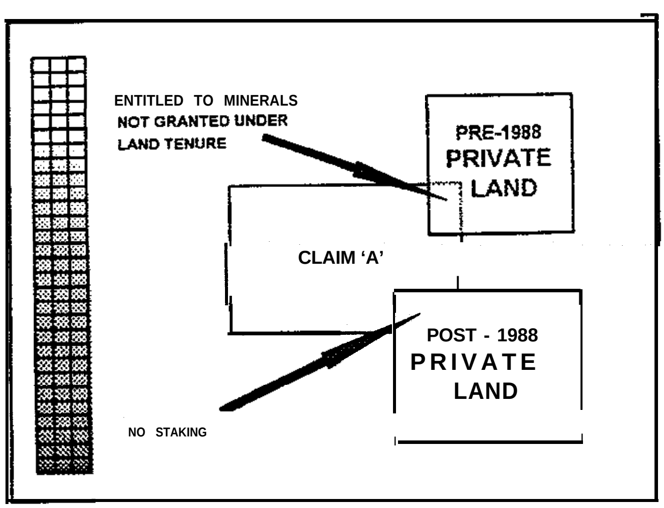


Crown Land

Mineral rights will continue to be determined by priority of claim location. Each claim will receive the benefit of the new definition for all areas of the claim not covered by private land or by a prior located mineral claim

Now the Claim staked over Private Land granted before 1988

Slide Right



Private Land - pre 1988

A Private Land owner may confirm mineral rights granted. by examining the granting indenture.

A land owners may also asked the court to rule on whether a substance such as limestone is held by the Land owner

The claim holder is entitled to all minerals as defined prior to 1988.

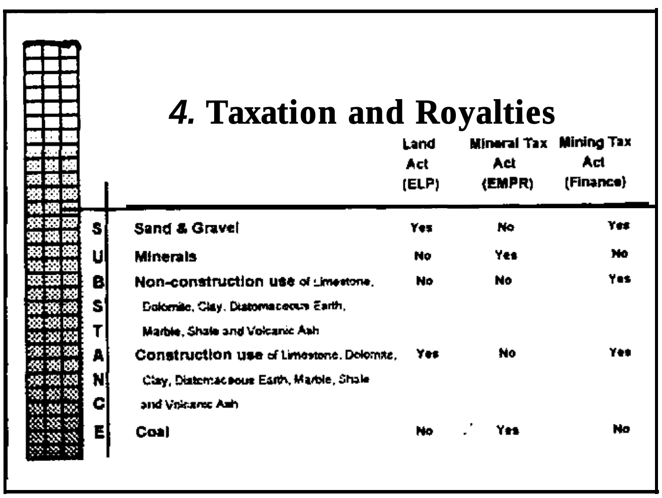
That means that limestone, dolomite, shale, marble etc. is likely to be excluded for the mineral rights acquired.

- ***Private Land - post 1988***

Few Private land lots have been issued since 1988.
Because of potential problems of mineral ownership, all lots issued after 1988 are not available for staking.

You can only stake on Land granted after 1988 when
the Minister of Mines,
the Minister responsible for Crown Lands and
the Land owner agree and
the appropriate Regulation has been passed.

Slide Right



4. Taxation and Royalties

SUBSTANCE	Land Act (ELP)	Mineral Tax Act (EMPR)	Mining Tax Act (Finance)
Sand & Gravel	Yes	No	Yes
Minerals	No	Yes	No
Non-construction use of Limestone, Dolomite, Clay, Diatomaceous Earth, Marble, Shale and Volcanic Ash	No	No	Yes
Construction use of Limestone, Dolomite, Clay, Diatomaceous Earth, Marble, Shale and Volcanic Ash	Yes	No	Yes
Coal	No	Yes	No

4. Taxation and Royalties

The right side indicates the various substances:

Sand & gravel

Minerals

Non - Construction Use **of limestone, dolomite, clay, diatomaceous earth, marble, shale and volcanic ash**

Construction Use **of limestone, dolomite, clay, diatomaceous earth, marble, shale and volcanic ash**

Coal

The construction material such as sand and gravel are subject to Land Act royalties

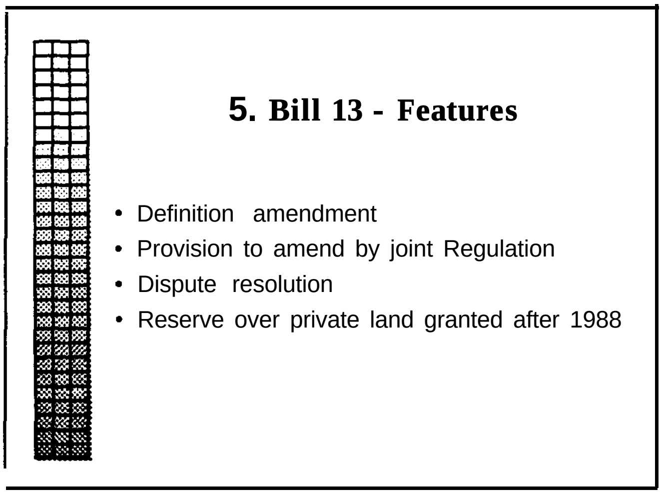
Minerals are covered by the Mineral Tax Act, Administered by the Ministry of Energy Mines and Petroleum Resources - which is an after period cost tax on profit

Non Construction - is taxed under the Mining Tax Act administered by the Ministry of Finance and Corporate Affairs - here to this is an after period cost profit based tax.

Construction Use - As you can see there are two potential tax acts to apply. There is agreement between the Land Act and Mining Tax Act that no duplicate taxes will be taken. The Land Act is a royalty and rent, whereas the Mining Tax is an after profit tax.

Coal is covered under Mining Tax administered by EMPR.

Slide Right



5. ***Bill 13 - Features***

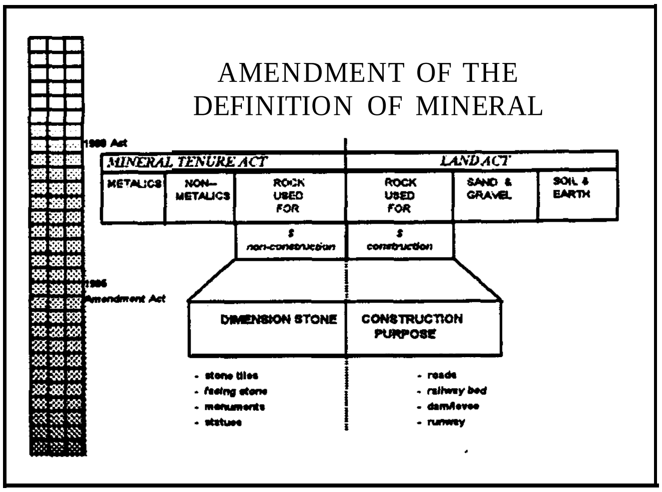
Here are a few of the features of Bill 13 which may affect industrial minerals

- Definition amendment

As indicated earlier, the moment Bill 13 comes into force, all existing claims and leases and all future claims and lease will enjoy the clarification of the definition of mineral.

The next slide illustrates this change.

Slide Right



AMENDMENT OF THE DEFINITION OF MINERAL

Here too the world is split between the Land Act and the Mineral Tenure Act.

Included in the Mineral Tenure Act side prior to Bill 13 are:

- metallic - gold, silver copper etc.
- non metallic - barite, fluorite, gypsum, jade etc.
- Rock used for non-construction - feldspar, phosphate, silica etc.

Included on the Land Act side are:

- Soils and earth
- Sand and Gravel
- Rock used for construction purposes - tiles, dimension stone, facings, fireplace stone

The 1995 Amendment Act - Bill 13 splits the rock used for non construction and construction and defines them as:

Dimension Stone:

means a rock or stone product that is cut or split on 2 or more sides, and includes, without limitation, tiles, facing stone, crushed rock, that is reconstituted into building stone, headstones, monuments, statues, ornamental furnishings and other similar components, but does not include crushed rock, cut or split rock that is used for construction purposes.

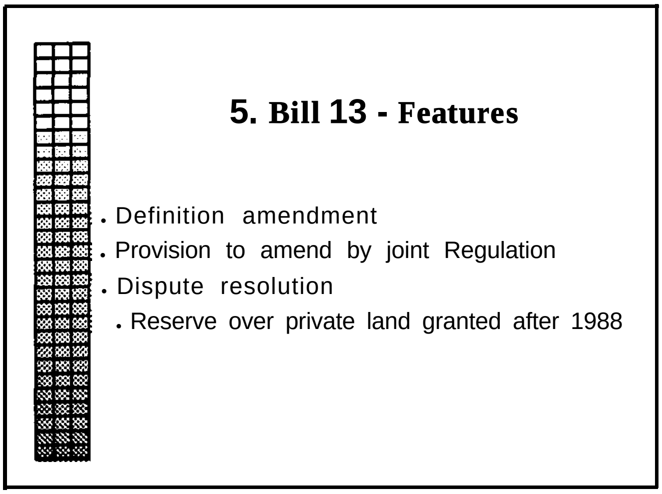
Construction Purpose:

includes without limitation:

(a) the building or maintenance of a road, railway bed, runway, berm, dam, impoundment, breakwater, dike, levee, foundation, rock wall and other similar thing and

(b) the providing of fill and riprap.

Slide Right



5 Bill 13 - Features

Here are few more features I'd like to describe

. ***Provision to amend by joint regulations***

The definition of mineral has a provision that allows the Minister of Mines and the Minister Responsible for Crown Lands to issue a joint regulations which clarifies the definition of mineral

This provision got a rough ride in the legislature, because of the mistaken belief that this power could be used to take existing mineral rights away without compensation.

. Dispute resolution

Bill 13 amends section 10 of the Mineral Tenure Act, which allows disputing parties to resolve conflicts between land tenure and mineral tenure.

The decision reached by the CGC may be appealed to the Supreme court.

- ***Reserve*** **over** ***private land granted after 1988***

I mentioned before that this provision was necessary to protect land owner rights issued between 1988 and 1995.

This provision was insisted upon by BC Lands as a protection of the surface rights owner.

The impact is small and there is a provision in the Act to lift the reserve where the three provisions are met.

IN REVIEW:

1. THE NEW DEFINITION OF MINERAL WILL BE IMPLEMENTED SHORTLY

2. THE CHANGE WILL ALLOW ALL MINERAL CLAIM HOLDERS TO ACQUIRE THE RIGHTS TO DIMENSION STONE.

3. TAXATION REMAINS ESSENTIALLY UNCHANGED, EXCEPT THE RELIEF FROM NOT HAVING TO HOLD DUAL TENURES

4. THE ACT HAS A NUMBER BUILT IN CORRECTION FEATURES AND DISPUTE RESOLUTION PROVISIONS HAVE BEEN ENHANCED.

SLIDE RIGHT AND LEFT

QUESTIONS?

6. Questions

Garnet Market Potential in Western Canada and United States

by

D. G. Lobdel,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Paper presented 19 October 1995 at:

Focus on British Columbia Industrial Minerals

Industrial Minerals '95

Vancouver, BC

Potential For Garnet Production in British Columbia

Introduction

It is a pleasure to give this paper today, for it gives me an opportunity to clear up a few common misconceptions about garnet, and to share with you new information and my sense of direction for the garnet industry. Garnet has historically been a small specialty minerals business in the hands of a few individuals, and most of the information about the commercial aspects have either come from promotional commercial literature, or the US Bureau of Mines.

One of the most irritating misconceptions long perpetrated by the US Bureau of Mines is that almandite commercially available from Barton Mines in New York is high-quality garnet, and that almandite from Emerald Creek is low-quality garnet. I will get back to these issues at the end of the paper, but for now I would like to present a general overview of the garnet business, both historically, and its current state. I will conclude with my assessment of the opportunities presented by garnet production worldwide, and specifically in British Columbia.

Let us Start out with a some background information, Garnet is not a mineral, but a group of minerals. Commercially, garnet is valued for its high hardness (6.5 to 8.0 on the Mohs scale), and its high density (with specific gravities ranging from 3.4 to 4.2). Table 1 below summarizes the properties of the six most common varieties of garnet:

Table 1: Properties of the Six Most Common Varieties of Garnet

Variety	Ideal Formula	Hardness	Specific Gravity
Almandite	$3FeO\text{-}Al_2O_3\text{-}3SiO_2$	7.5	3.9 -4.2
Grossularite	$3CaO\text{-}Al2O_3\text{-}3SiO_2$	7.0	3.5 - 3.7
Pyrope	$3MgO\text{-}Al2O_3\text{-}3SiO_2$	6.5 - 7.5	3.5 -3.8
Spessartite	$3MnO\text{-}Al_2O_3\text{-}3SiO_2$	7.0 - 7.5	4.1 -4.3
Andradite	$3CaO\text{-}Fe_2O_3\text{-}3SiO_2$	6.5 - 7.0	3.7 - 3.8
Uvarovite	$3CaO.Cr_2O_3\text{-}3SiO_2$	7.5	3.4 - 3.5

Of these varieties of garnet, almandite is at the high end of the ranges for hardness and density, and is one of the most common varieties. Thus it should not be surprising that it would be the garnet of greatest commercial significance.

Commercial almandite never consists entirely of almandite, but rather the almandite is to some extent in solid solution with the other garnet varieties, as well as being a dominant constituent in a mixture of minerals, especially with other garnet varieties, staurolite, and contaminating minerals that have not been totally removed during beneficiation. (Note- So long as staurolite is a relatively minor constituent, commercially there is no distinction between garnet and staurolite, since their physical and chemical properties are nearly identical.) The possibilities for trace amounts of non-garnet minerals (contaminants) are numerous, but the most Common are quartz, feldspar, mica, magnetite, ilmenite, and pyrite/pyrrhotite. These contaminants are present as both distinct grains, as well as 'inclusions within the garnet crystal.

Commercial almandite typically is produced from rocks resulting from high-grade regional metamorphism, possibly some unusual coarse-grained igneous rocks, and placer deposits derived from these parent materials. Another commercial garnet consisting of principally andradite with lessor amounts of grossularite and pyrope Is produced from skarns (metamorphic rock resulting contact metamorphism by siliceous intrusions into carbonate rock). Skarn garnets are inferior in terms of both hardness and density to almandite, but find utility in that they are relatively cheap to produce (deposits are often large, with relatively little waste, and the garnet often represents a by-product of some other mineral production, such as wollastonite or metals).

Potential for Garnet Production in British Columbia

The principal markets for garnet all capitalize on the relatively high density and hardness. In water filtration garnet is valued for its density in a multi-media filters, as well as its chemical inertness, insolubility, and its non-toxic nature. As an abrasive, garnet is valued for its moderately high hardness (intermediate to inexpensive silica sand and the expensive synthetic abrasives, its inherent grain toughness (allowing It to recycled up to six times), and its low silica content (less than 1%). As an interesting aside, all varieties of garnet find their way into gem markets (it is the birthstone for January).

Historical Review

Garnet has a long history of production in the United States, beginning in 1878 with Barton Mines in upstate New York, where it was first produced as an abrasive. The material from Barton is rather unique, even today, in that it fractures into sharp, chisel-shaped particles as it breaks down in use, in effect always presenting a fresh, highly abrasive surface throughout its use. Or so the story goes (Barton also has a long history of providing commercial lore to its customers about how unique their material is, sometimes without technical basis). The Barton operation can be classed as a high-cost, high-quality producer, especially of very specialized materials which command a selling price ranging from US$300 to $2,000/ton. The operation probably grosses about $10-million/year on sales of 15,000 to 25,000 tons annually. The operation Is also somewhat unusual in that it is an underground hardrock operation working with grades of up to 80% garnet, principally almandite.

The markets for Barton's garnet is quite distinct from those of commercial garnet *in* general, and relate largely to high-end abrasive markets such as coated abrasives, micro-abrasives in electronic applications, pioneer market development in water-jet Cutting, and small scale cleaning and de-burring.

in the late 1930's and early 1940's, garnet production commenced in Idaho, particularly from two operations in the Panhandle which merged in the 1960's to become the present day Emerald Creek Garnet Company. These -materials come from placer deposits in several small creeks near Fernwood which are derived from pelitic Belt Series sediments which have undergone high-grade metamorphism to garnetiferous, quartzo-feldspathic, mica schists on the margin of the Idaho Batholith. A hardrock almandite deposit operated briefly in the early 1980's in Maine, and there is historic production reported from California, Connecticut, Florida, New Hampshire, North Carolina, and Pennsylvania. And finally, there is byproduct andradite and grossularite from NYCO's New York wollastonite operation.

While the Barton material has been the world's premier material In terms of cost, the Emerald Creek material has been the premier material in terms of the world's largest producer in terms of tonnage. I do not have any inside information to support this figure, but my estimate is that Emerald Creek produces 40,000 to 50,000 tons annually, selling for an average price of $180/ton in bulk, FOB Fernwood, Idaho. This scale has not always been the case- Until the rnid-1960's, it is thought that total production from Idaho was never over 5,000 tons annually. Much of early production was probably as a sand blast media, and Boeing was probably a major regional customer.

The 1970's saw the beginnings of new markets related to the new "environmental consciousness" and developing new technologies, which resulted in an overall growth in sales of about 10% annually. The first was the development of the trimedia filter for industrial wastewater and municipal drinking water. Greatly simplified, the tri-media filter consists three sands varying in grain-size and density. The first layer (from the bottom up), consists of tine-grained garnet sand (s.g. ~ 4.0), a medium-grained silica sand (s.g. ~2.65), and finally, a coarse-grained hard coal (s.g. ~1.7). Often these lie upon a coarse "under-drain" material composed of coarse garnet. The objective of all this is for the coarse top layer to filter out the coarsest particulate, and the bottom most media, the finest particulate.

The benefit over a single-sized filter media is that the tri-media filter does not become clogged as readily, as sediment is trapped throughout the bed depth, whereas single media filters tend to clog quickly at the surface first encountering the particulate. Thus, the tri-media filter requires less frequent backwashing, and less water to complete a backwash, on the order of 1/10 in many cases. This results in greater economy of operation. As well, it becomes more practical to remove the finer particulate, as the garnet becomes a "polishing" layer removing all but the finest sediment and micro-organisms,

In the 1980's, concerns over the hazzards of silica reached fanatic levels, and legislation resulted in increased substitution of garnet for silica, especially in enclosed sand blast situations, such as ships and petroleum tank farms.

In the 1990's, new markets have resulted from a new technology, abrasive waterjet cutting. While this market is currently small, it is growing rapidly, and opens up higher-value markets. There are currently few substitute materials in significant use.

The acquisition of Emerald Creek Garnet Company by Hawkeye Resources, now Western Garnet Company, together with a 10% annual growth rate of garnet markets for several decades, spawned considerable interest in garnet by numerous US. and Canadian companies, and there promises to be garnet production from several new operations which have, or are about to, come into production,

Potential for Garnet Production in British Columbia

The world Situation is somewhat similar. Historically, the United States has dominated both world consumption and supply of garnet. As late as 1973 US consumption and production accounted for two-thirds of the world statistics. In the last two decades, new operations started up first in Australia, then India, followed by China, and recently Europe, Current US consumption and production of garnet is probably now reversed, and accounts for only one-third of the World figures.

A final word on quality. Barton Mines garnet has always been recognized as a superior quality material, and is somewhat unique in its markets and character. The US Bureau of Mines, and others, have often referred to "low quality garnet" coming from nearly all other sources, including garnet from Emerald Creek and other sources around the world. This is a great injustice, and is simply a gross error. Certainly Emerald Creek garnet, and the GMA garnet from Australia, and the material from a now operation in New York (Patterson Materials Corporation) also supply high quality garnet. The proof of this is that the tonnage sold from these sources greatly exceeds sales from Barton Mines, and is further born out by comparing the physical and chemical character of these materials. The ultimate argument is demonstrated by the relative inability of the world mining community to find comparable deposits after considerable effort. The situation 'is rooted in comparing materials which are for the most part similar, except that the Barton materials display a few very un-garnet-like characteristics. I argue that Barton's garnet is not a higher quality garnet, but rather is simply an unusual garnet.

In fact, there is a fair bit of variation in the properties of commercial garnet from garnet in general, as well as in the properties of garnet from operation to operation. Almandite in the textbooks is said to have hardness of 7.5 on the Mohs scale, while much of the commercial literature lists hardness as 7.5 to 8.0. There are reports in the literature of almandite displaying hardnesses exceeding 8. 1 have seen data on commercial almandite in which the Knoop hardness has varied 1470 to 1540 for garnet from various sources.

Current World Market Summary

In recent years there has been a major shift in the geographic scope of the garnet business, from one which was largely centered in the US in terms of both production and consumption, to one which is now worldwide. Table 2 below summarizes estimates of current world garnet capacity:

Table 2: Estimated World Garnet Production Capacity

United States	100,000	
North America		*100,000*
Norway	8,000	
Turkey	700	
Former USSR	2,000	
Europe		10,700
Australia	65,000	
China	20,000	
India	28,000	
Sri Lanka	100	
Australasia		113,100
Others	1200	1 200
Total	225,000	225,000

World production and consumption is thought to be rapidly approaching 200,000 tonnes annually.

It appears world garnet capacity (and probably consumption) has doubled in the last seven to ten years. The interest in garnet has more than double! in the same period of time, as can be seen by the large number of garnet projects either on the drawing board, or coming into production shortly.

Table 3 is a summary of some of the garnet projects;

Table 3: Partial Summary of Current Garnet Projects Worldwide

Bittsroot Resources Ltd	Arizona, USA	Almandite	30,000 tons/year	Seeking financing
Pittson Mineral Ventures Co.	Maine, USA	Almandite	not producing	Operation for sale
Cominco American	Montana, USA	Almandite	40,000 tons/year	Coming on stream 96
Royalstar Resources	New Mexico, USA	Andradite	70,000 tons/year	On hold for permitting problems
Hampton Creek Mines	Nevada, USA	Almandite		Under evaluation
Teledyne Wsh Chang	California, USA	Andradite		Under evaluation
imperial Mining Company	North Carolina, USA	Almandite		Review of by-product from gold dredging
Rare Earth Resources Ltd.	Oregon, USA	Almandite		Evaluation as HM by-product
Polestar Exploration inc.	BC, Canada	Andradite	60,000 tons/year	Permitting problems
Tiomin Resources inc.	PO, Canada	Almandite		Evaluation as HM by product
Stralak Resources Inc./Emerald Isle Resources Inc.	ON, Canada	Almandite		Production decision and funded
North American Garnet Inc.	Mexico	Almandite	35,000 tons/year	Under evaluation
Western Garnet Co.	India	Almandite		Major expansion purchased producer
Western Garnet	Italy	Almandite		Under evaluation
Ledmore Marble Ltd	United Kingdom	Melanite		Under evaluation
Garnet A/S	Norway	Almandite		Under evaluation

The Future for Garnet and Potential for New Production

Industrial garnet in its first hundred years has been a specialty mineral relying on niche markets. Operations have been typically family operations, with supply tightly controlled. The 1990's have seen a rapid transition toward garnet becoming a commodity type mineral, with sophisticated corporate entities purchasing family operations and developing new deposits. The full impact of this transition is yet to be felt. Most likely, garnet will come into over supply, and the price of garnet will fall.

This may negatively impact some producers, namely those which lack commercial sophistication, a quality product, or have high production costs relative to direct competitors. On the whole, however, it will probably be a positive period for the garnet industry in general. I believe garnet sales would have risen even faster than the phenomenal 10% growth, had supply and service been more In line with market requirements- large garnet accounts have lost out to substitute materials, which need not have been the case. It is expected falling prices will only fuel increased demand, garnet has some very useful properties which can make a significant contribution to a more efficient society. Total dollar sales may still continue to grow at historical rates.

A few years ago a window of opportunity existed in a wide open situation for now garnet production. That window is rapidly closing, due to the proliferation of garnet production coming on stream, and the emergence of entities such as Western Garnet. Opportunity still exists, but generally not for the type of deposits currently coming on stream or being evaluated. The real opportunities in the future are for the types of deposit which can be produced and delivered at low cost. The successful future deposit may have no comparable counterpart in today's garnet industry.

Tomorrow's garnet producer will likely have greatly increased responsibilities with respect to quality control, transportation, product development, recycling and disposal, and general operating efficiency.

The opportunities in British Columbia? The answer lies in the operating environment offered by the region (which historically has not been particularly good) and the potential to find superior deposits (geologically, the terrains exist that make BC a target on par with any location in the world). Looking at markets for garnet 'in the region, the existing situation is quite discouraging- success would for the time being be dependent upon successful export to California, Texas, and to other world consuming centers.

Conclusion

The garnet industry is becoming increasing more efficient, better managed, more sophisticated, well funded, and highly structured. The internal functions of the industry are still known largely by only those on the inside. The proformas (as well as the deposits) of many garnet projects on the drawing board may be abysmally lacking in the market environment of the future. Garnet is only following the realities of industry in general, namely:

- competition and markets are global
- business acumen is accelerating
- demand for quality is increasing
- forgiveness is disappearing

Success will not be found in following what is being done, but rather in achieving the limits of what can be done. In that respect, there is tremendous opportunity on a world scale.

GARNET, INDUSTRIAL [1]

(Data in metric tons of garnet unless noted)

Domestic Production and Use: Garnet was produced in 1995 by five firms, four in New York and one in Idaho. Output of refined material was valued at $11.2 million. The end uses for garnet were abrasives in the petroleum industry, 41 %; filtration media, 20%; transport manufacturing, 19%; finishing wood furniture, 10%; electronic components, 7%; and ceramics and glass, 3%.

Salient Statistics-United States:	**1991**	**1992**	**1993**	**1994**	**1995**
Production (crude)	50,900	54,100	44,000	51,000	53,300
Sold by producers (refined)	48,000	46,100	55,800	40,600	47,900
Imports for consumption*	5,000	6,000	12,200	6,000	5,000
Exports [e]	10,000	8,880	11,400	10,000	7,260
Consumption, apparent	44,000	45,700	56,600	37,500	44,900
Price, range of value, dollars per ton	60-2,000	100-2,000	100-2,000	100-2,000	85-1,500
Stocks, producer [e]	11,100	8,640	4,900	4,000	4,720
Employment, mine and mill	150	150	150	160	180
Net import reliance [2] as a percent of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (1 991-94): Australia, 85%; India, 11 %; and China 4%

Tariff: **Item**	**Number**	**Most favored nation (MFN) 12/31/95**	**Non-MFN[3] 12/31/95**
Emery, natural corundum, natural garnet and other natural abrasives, crude	2513.21.0000	Free	Free.
Emery, natural corundum, natural garnet and other natural abrasives, other than crude	2513.29.0000	$0.60/kg.	$2.20/kg.
Natural abrasives on woven textile	6805.10.0000	2.0% ad val.	20% ad val.
Natural abrasives on paper or paperboard	6805.20.0000	2.0% ad val.	20% ad val.
Natural abrasives sheets, strips, disks, belts, sleeves, or similar form	6805.30.0000	2.0% ad val.	20% ad val.

Depletion Allowance: 14% (Domestic), 14% (Foreign)

Government Stockpile: None

Prepared by **Industrial Garnet Specialist,** (703) 648-7721

GARNET, INDUSTRIAL

Events, Trends, and Issues: Imports from Australia continued to be used in the U.S. filtration and blasting media markets, but did not appear to affect domestic production negatively. The market appears to be large enough to absorb additional imports without harming U.S. producers. The garnet reclaim plant in Harvey, LA, was used intermittently as a distribution warehouse. Currently, evaluation and feasibility studies are underway on major garnet deposits in Arizona, California, Colorado, Montana, and New Mexico.

World Mine Production, Reserves, and Reserve Base:

	Mine production		Reserves4	Reserve base4
	1994	1995*		
United States	40,600	47,900	5,000,000	25,000,000
Australia	30,000	30,000	1,000,000	7,000,000
China	18,000	15,000	Moderate to Large	Moderate to Large
India	10,000	15,000	500,000	20,000,000
Other countries	2,000	2,000	6,500,000	20,000,000
World total (rounded)	101,000	110,000	Moderate	Large

World Resources: Garnets occur worldwide in a variety of rocks, particularly gneisses and schists. They also occur as contact-metamorphic deposits In crystalline limestones, pegmatites, and serpentinites, and in high-temperature intrusive contacts and vein deposits. Alluvial garnet also Is a coproduct with many heavy mineral sand and gravel deposits In the world. Large domestic resources of garnet are concentrated In coarsely crystalline gneiss near North Creek, NY. One of the world's largest known garnet deposits in Rangley County, ME, Is not currently being mined. The medium-grained ore from this deposit, has an unusually high garnet concentration of 50% to 60%. Significant resources of garnet also occur in Idaho, Montana, Now Hampshire, North Carolina, and Oregon. World resources of garnet are large.

Substitutes: Garnet is competitive in abrasive applications with natural and manufactured abrasives, such as diamond, cubic boron nitride, fused aluminum oxide, silicon carbide, and quartz sand; in filtration media with ilmenite, magnetite, and plastics; and in nonskid surfaces with emery.

*Estimated E Net exporter

1. Excludes gem and synthetic garnet

2. Defined as imports - exports + adjustments for Government and Industry stock changes.

3. See Appendix B.

4. See Appendix C for definitions

Zeolite Potential in British Columbia

by

P. B. Read,
Consultant

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

INDUSTRIAL ZEOLITE POTENTIAL IN BRITISH COLUMBIA

Peter B. Read

Geotex Consultants Limited: # 1200 # 100 W. Pender St., Vancouver, B.C., V6B 1R8

INTRODUCTION

The Metamorphic Map of the Canadian Cordillera (Read et al., 1991) shows that zeolite-bearing rocks are widespread in British Columbia (Fig. 1). They form the least metamorphosed parts of the Insular, Intermontane and Foreland belts of the Canadian Cordillera with a total area of about 18% of the province, but economic and geologic factors to be discussed reduce the search area for potential deposits of industrial zeolites. Industrial zeolites are those minerals of the zeolite group which are commercially used in industry. At present they include heulandite-clinoptilolite, mordenite, erionite and chabazite. Of the economic factors, easy access to a cheap and efficient transportation network on land and sea restricts the area of search to southern British Columbia, an east-west highway and railway corridor in central British between Prince George and Prince Rupert, and the coast, particularly the Queen Charlotte Islands. Geologic parameters favouring the development of industrial zeolites are suitable: (a) host rock composition; (b) syndepositional conditions of the host; and (c) post-depositional conditions affecting the host.

a) Host Rock Composition

Industrial zeolite deposits result from massive zeolitization of felsic to intermediate, aphanitic to glass-rich tuff and ash. Because it is important that the host rock should be highly permeable, even vesicular to scoriaceous flows can be a suitable though atypical host.

b) Syn-depositional Conditions of the Host

If a suitable tuff or ash is waterlain under terrestrial, not marine conditions, in a warm temperate to subtropical climate it may come in contact with Na, K and/or Ca-rich alkaline groundwater. Such waters will selectively dissolve the unstable glass shards and aphanitic volcanic fragments, and enhance the permeability of the original rock. Depending upon the composition of the host rock and fluids, a range of zeolites may develop. For example, in the Upper Cretaceous tuffs of the Sustut Group (Fig. 1), heulandite-clinoptilolite selectively develops within and immediately adjacent to rhyolite crystal-vitric tuffs where the waters are silica-charged from the dissolution of the glass (Fig. 2). The formation of laumontite, a nonindustrial zeolite, does not depend upon a high silica activity and its development is not proximal to the vitric tuffs. Whether the fluids are Ca, Na or K-rich will control whether heulandite (Ca-Al-rich end member) or clinoptilolite (Na, K or Si-rich end-member) respectively, will form. Indeed, whether a zeolite will form or not is largely dependent upon the chemcial potential Of C02 in the fluid (Albee and Zen, 1969; Thompson, 1971). If it is CO2-rich, clay minerals plus calcite are favoured over the compositionally equivalent Cazeolite.

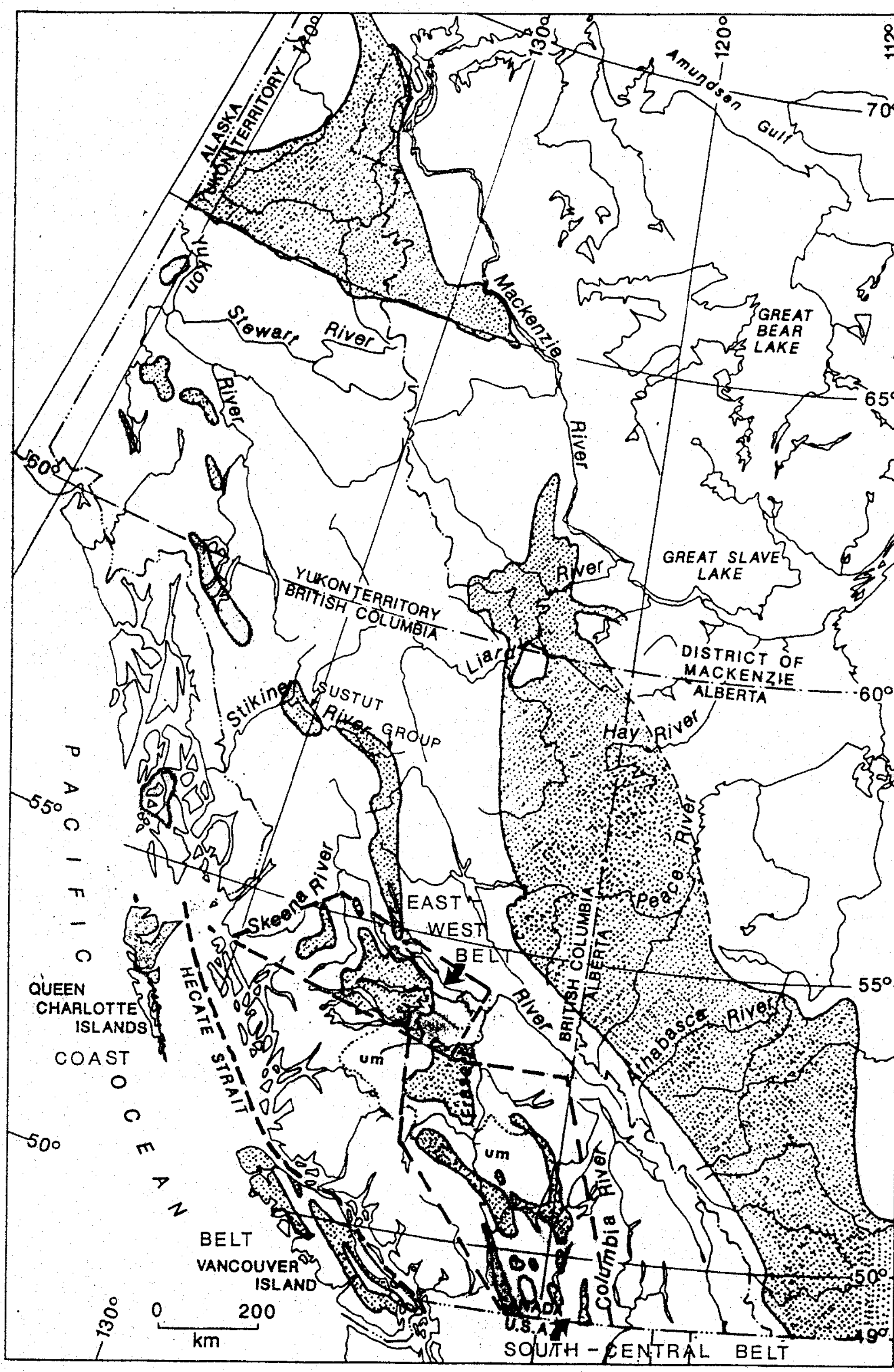


Figure 1: Distribution of zeolite facies rocks in British Columbia.

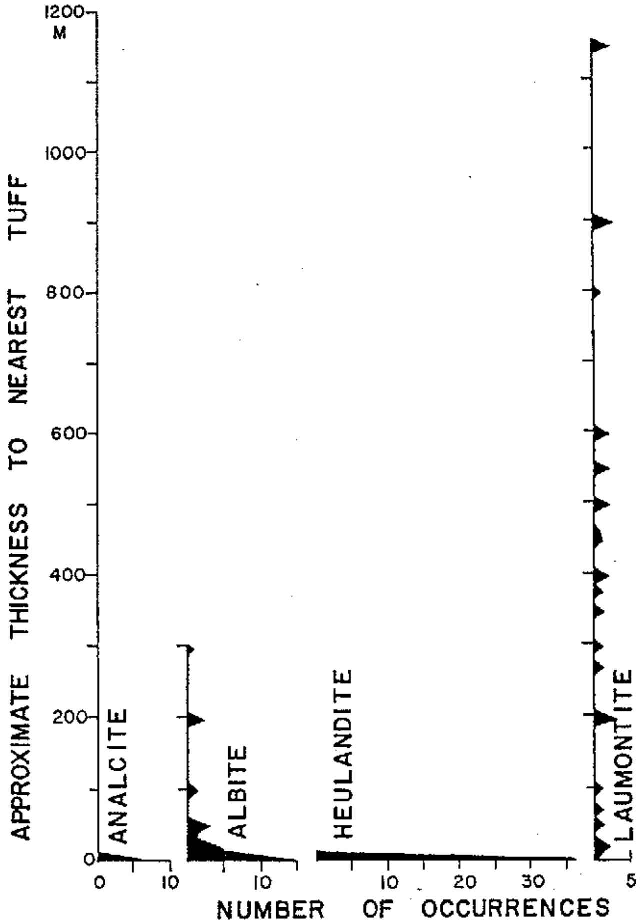


Figure 2: Distribution of analcime, albite, heulandite and laumontite relative to the nearest vitric tuff horizon in the Sustut Group (from Read and Eisbacher, 1974).

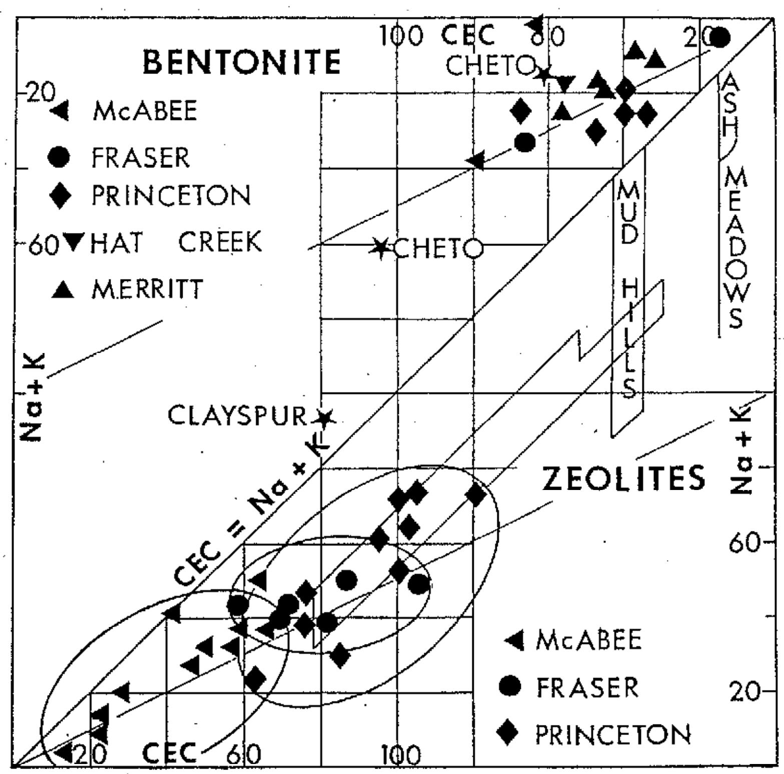


Figure 3: Na+K/CEC diagram of British Columbia zeolites and bentonites compared to some American producers (modified from Read, in press).

c) Post-depositional Conditions Affecting the Host

Industrial zeolites are highly hydrated with large diameter channels developed in their crystal structures. Zeolites with these characteristics are stable only in the low temperature and pressure portion of the zeolites facies. As judged by the organic maturity of interbedded coal in the sediments surrounding industrial zeolite showings, vitrinite reflectance values should be about 1.0 or less or the coal should have a rank of high volatile bituminous or less for industrial zeolites either to be formed or preserved (Read, in press). Although these conditions may not exist during or shortly after deposition of the host, as long as they are not exceeded after deposition, the potential for industrial zeolite deposits exists. For example, K-Ar whole-rock dating of the zeolitized vitric tuffs of the fossiliferous Brothers Peak Formation (Middle to Late Campanian to Early Maastrichtian or about 75-70 Ma) of the Upper Cretaceous Sustut Group yields mid-Eocene ages (55-50 Ma). The age difference implies that the formation of the massive heulanditeclinoptilolite occurred some 20-25 Ma after the deposition of the tuffs.

CHARACTERISTICS OF B.C. INDUSTRIAL ZEOLITE SHOWINGS

Taking into account the geographic and geologic factors outlined, the extensive Mesozoic and Paleogene volcanic and sedimentary rocks in British Columbia have the best industrial zeolite potential. The industrial zeolites consist of Cretaceous and Eocene showings in south-central British Columbia; a few occurrences in the east-west corridor, and the untested potential of the coast belt (Fig. 1). Showings of industrial zeolites in these rocks are dominantly heulandite-clinoptilolite with CEC values that range from less than 70 to 130 (Fig. 3). The typical host rocks are waterlain, rhyolite to dacite crystal-vitric tuff and ash in which the vitric portion is completely zeolitized. Although the presently known rocks with industrial zeolites range in age from Early Cretaceous (Albian) to Middle Eocene, the development of zeolites in rocks within a Late Triassic to Pliocene span may support extension of an industrial zeolite potential to rocks of the broader age range in restricted areas of the province. For example, in the Hecate Strait portion of the Queen Charlotte Basin, Galloway's report (1974) of laumontite in sedimentary rocks as young as Pliocene, in an area of presently high heat-flow, implies that a zeolite potential may exist in the Neogene as well as the Paleogene rocks of the Queen Charlotte Islands (Fig. 1); neither has been investigated properly for zeolites. However, many zeolites fill the amygdules of the Miocene and Pliocene Chilcotin plateau basalts, but the underlying and intercalated rhyolite vitric ashes and diatomaceous, lacustrine and paludal sediments are not zeolitized. The lack of zeolites indicates that the groundwater composition and/or the temperature-pressure conditions during later burial were inadequate for zeolite formation over a large area of southern and central British Columbia (area labelled um, Fig. 1).

INDUSTRIAL ZEOLITES AND THEIR POTENTIAL IN CRETACEOUS ROCKS

Although regionally developed, zeolitized rocks in British Columbia were known through the investigations of Surdam (1967a; 1967b; 1973), widespread industrial zeolites were unknown in the province until 1974 (Read and Eisbacher, 1974). In north-central British Columbia, the intercalation of waterlain, rhyolite vitric tuff and coarse conglomerate at the base of the Upper Cretaceous Brothers Peak Formation implies deposition in a high energy environment probably unsuited to the syngenetic development of zeolites. However, in the Middle Eocene, groundwater caused dissolution of the glass shards and their replacement by industrial zeolites at inferred temperature and pressure values not exceeding 65'C and 15-40 megapascals over an area of 4000 km' (Fig. 4). Nearby, a few vitrinite reflectance measurements (McKenzie, 1985) substantiate an elevated temperature.

Here and there in south-central British Columbia, Lower Cretaceous rocks, such as the Spences Bridge Group, contain industrial zeolites. In the volcanic rocks, zeolite amygdules, joint fillings and matrix replacements are widespread. Restricted to the lenses of waterlain felsic tuff and tuffaceous sediments, such as the Dot Member between Spences Bridge and Merritt (Fig. 1), massive zeolitization has produced industrial zeolites (Read, 1995). Cycles of crystal-lithic tuff grading up through several metres to zeolitized ash were deposited in a lacustrine environment (Plates I and 2). The assemblage of mordenite-analcime-quartz suggests that Na-rich waters, perhaps developed in a playa lake setting, were responsible for the zeolitization. Because most of the Lower Cretaceous rocks have undergone P-T conditions exceeding those suited to the development of industrial zeolites, the difficulty lies in defining felsic tuff-rich search areas that have undergone low P-T conditions. To date in south-central and coastal British Columbia, the sediment-rich stratigraphy of the Lower Cretaceous Jackass Mountain and Upper Cretaceous Nanaimo groups lacks both waterlain felsic tuff units and industrial zeolite showing.

INDUSTRIAL ZEOLITES AND THEIR POTENTIAL IN EOCENE ROCKS

The potential for industrial zeolite deposits is assessed best for the Eocene of south-central British Columbia. Here, several down-faulted blocks are the remnants of a formerly extensive sheet of Eocene sediments up to 2000 metres thick which stretched from the Princeton and Tulameen areas, through Merritt, Hat Creek, and Gang Ranch areas to the Quesnel area for a span of 450 kilometres (Figs. 5 and 6). Although waterlain crystal-vitric tephra occurs in the Princeton, Tulameen, Hat Creek and Gang Ranch blocks, only the Princeton block contains several clinoptilolite beds up to 20 metres thick and 4 kilometres long (Read, 1987; Plate3). The Tulameen block has a single zeolitized bed, and the fault blocks around Merritt have none (Read, 1988c). The two thick felsic tephra beds at Hat Creek lack zeolites, but instead contain montmorillonite + calcite (Read, 1990). Probably the C02-rich groundwaters derived from the thick limestone of the surrounding Marble Canyon Formation favoured the montmorillonite-calcite assemblage over a zeolite. Along the Fraser River, 100 kilometres to the northwest and distant from the Marble Canyon Formation heulandite-clinoptilolite reappears in the felsic tuffs south of Gang Ranch (Green, 1989; Read, 1988a; 1988d). North of Williams Lake, the Eocene has not been examined for industrial zeolites.

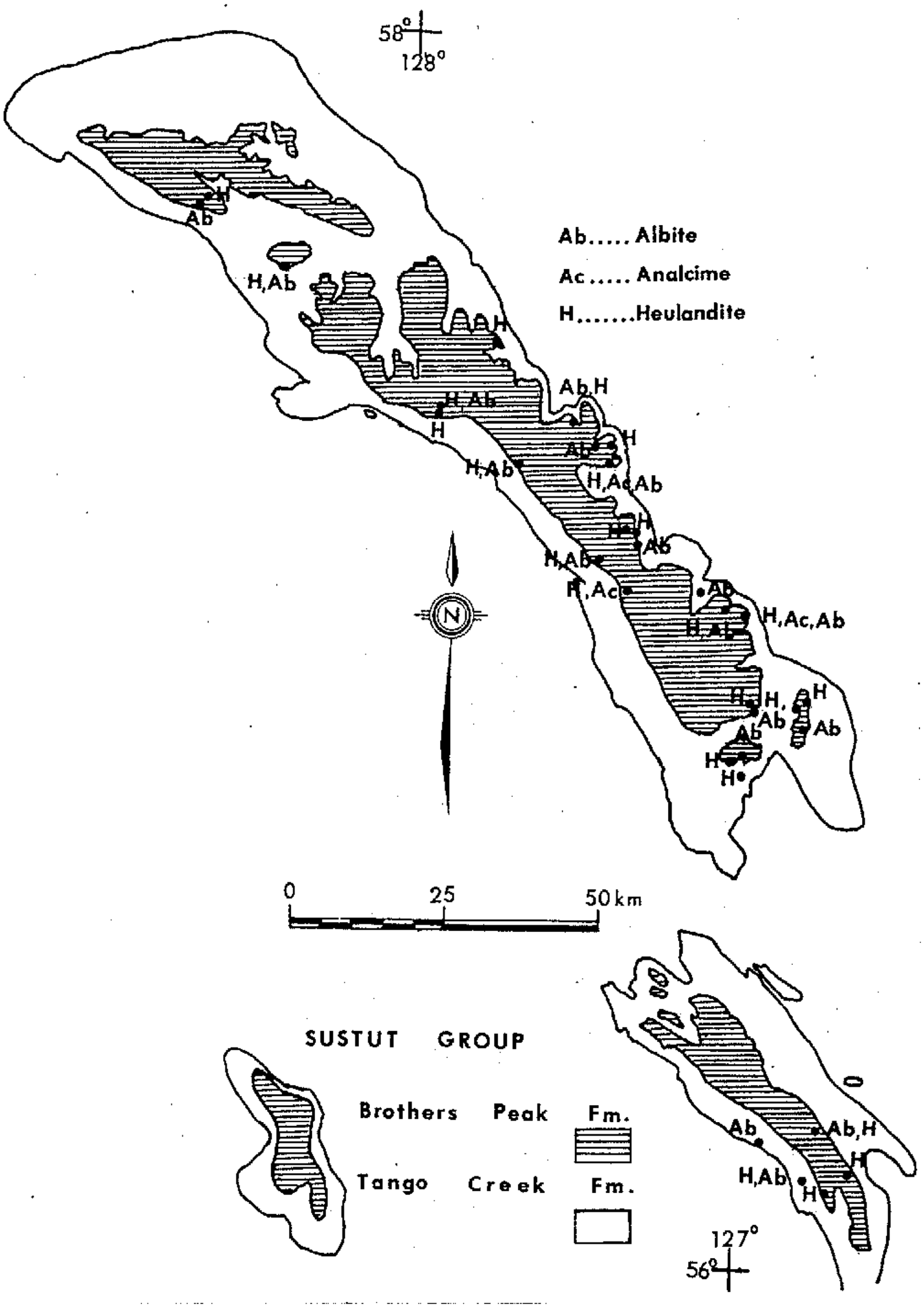


Figure 4: Regional distribution of heulandite, analcime and albite in the Sustut Group and the restriction of the industrial zeolite potential to the Brothers Peak Formation (modified from Read and Eisbacher, 1974).

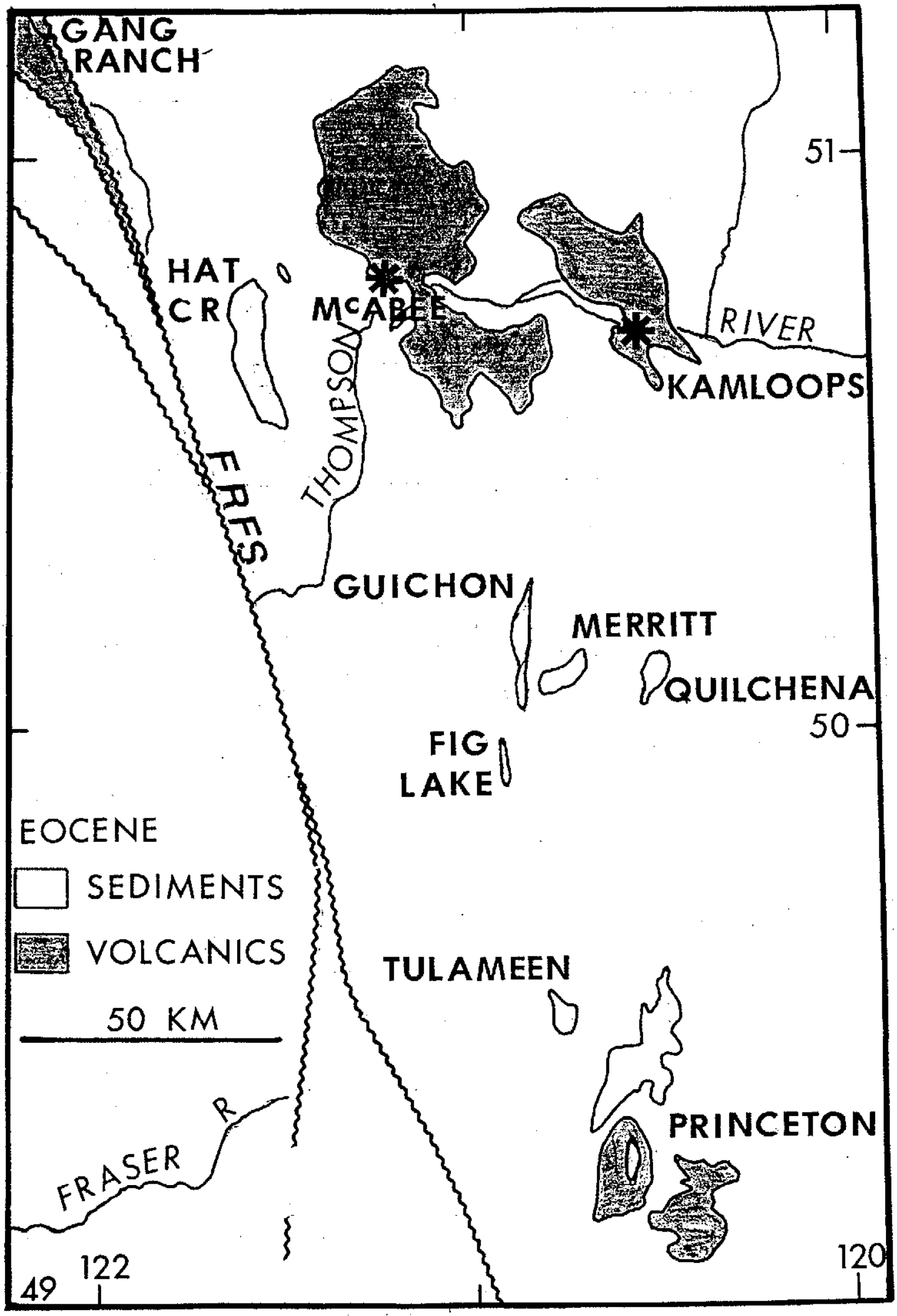


Figure 5: Regional geological map of south-central British Columbia showing the distribution of Eocene sediments and volcanic rocks.

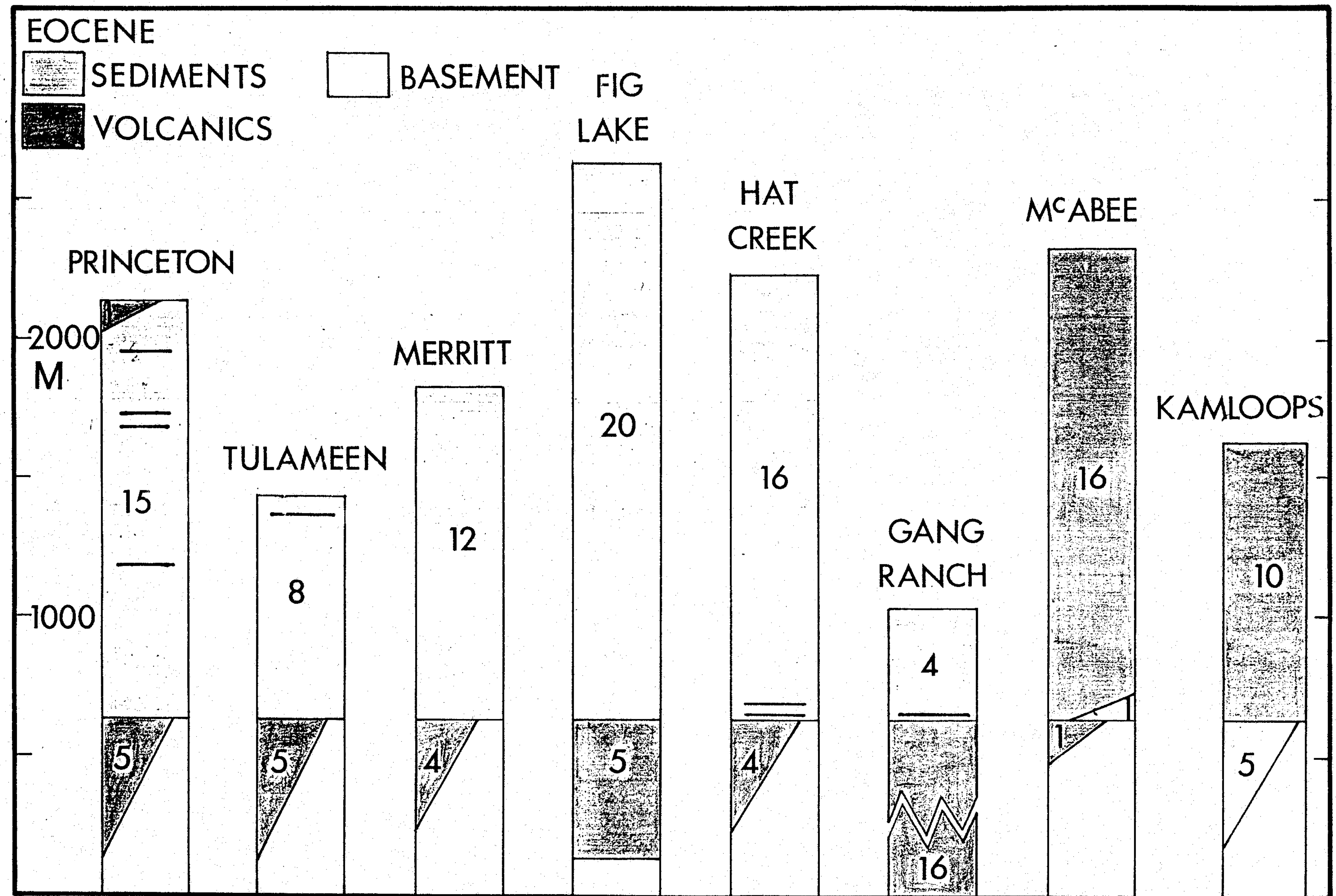


Figure 6: Stratigraphic columns of the Eocene blocks of southern British Columbia showing the thicknesses (in hundreds of metres) of the sediments, waterlain ash (black lines) and volcanics.

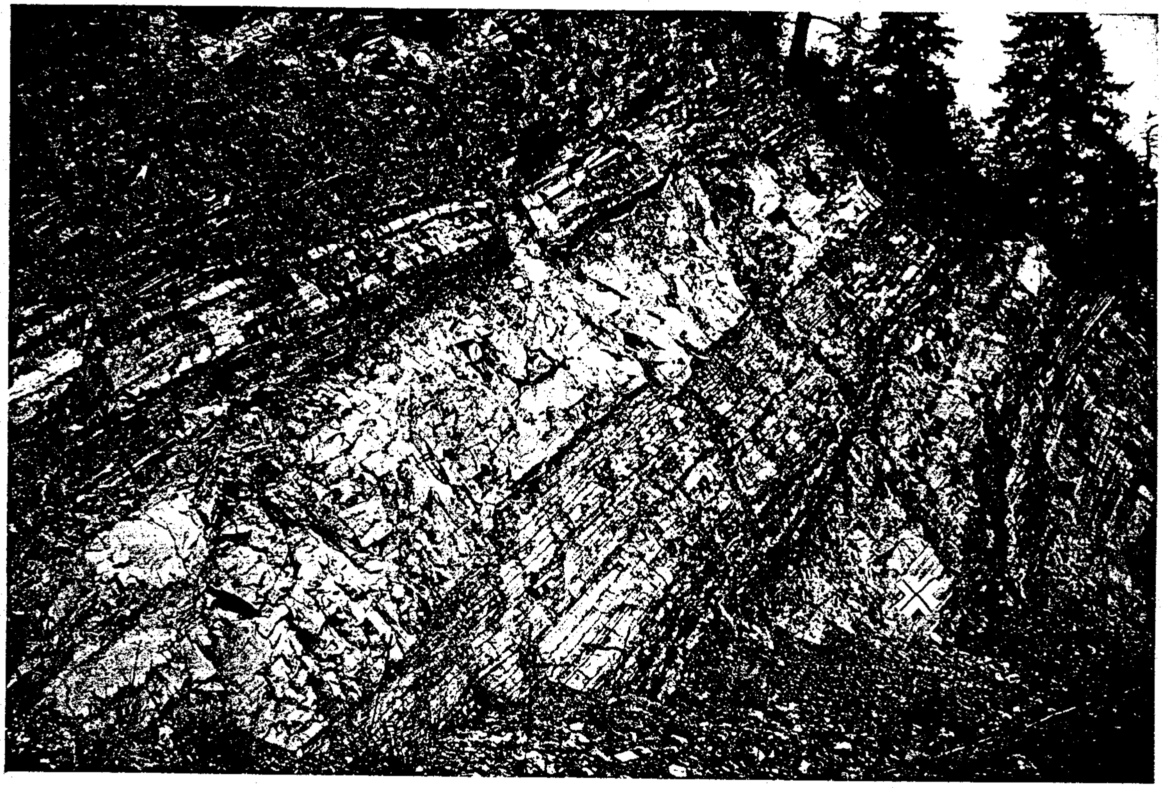


Plate 1: Exposure of the Dot Member showing four cycles of crudely layered lapilli tuff grading up to well bedded mordenite ash of the Lower Cretaceous Spences Bridge Group.

Plate 2: Detailed view of the mordenite-analcime-quartz ash from the X in Plate 1.

Plate 3: On the southern Trans-Provincial Highway 5.0 kilometres southwest of Princeton, a roadcut exposes a 13 metre thickness of the clinoptilolite-rich Tailings Ash of the Eocene Princeton Group.

Plate 4: At McAbee, on the Trans-Canada Highway 8.5 kilometres east of Cache Creek, is a white-weathering lens of heulandite-clinoptilolite altered tuff near the base of the Eocene Kamloops Group.

Lying east of the sediment-rich fault blocks is a thick Eocene volcanic succession containing thin lenses of tuffaceous sediments within 500 metres of the base. At McAbee (Fig. 5), lacustrine-deposited, felsic tephra lenses are variably altered to heulandite-clinoptilolite (Read, 1988b; 1988e; 1989; Plate 4). Because waterlain vitric tuffs lenses are few and thin in the sedimentary lenses farther east near Kamloops and Chu Chua, south of McGlashan Lake and northwest of Falkland, the heulandite-clinoptilolite showings are small. In the Okanagan Lake area southeast of Kamloops, Hora and Church (1986) substantiated the well-known occurrences of zeolites in the fractures and amygdules of the Eocene flows and noted the preferential development of clinoptilolite in volcaniclastic rocks, but did not discover any industrial zeolite occurrences. The waterlain felsic tuffs, widespread in the Eocene Kettle River Formation, were not tested in this x-ray diffraction study of 25 samples. X-ray diffractograms of porcelaneous ash-tuffs, from the Kettle River Formation exposed in the Phoenix open pit, indicate massive mordenite (Read, unpublished data). Northwest of Kamloops, exposures of a zeolitized felsic tuff east of Horsefly on Black Creek road (Lay, 1930) show that an industrial zeolite potential may exist in the Eocene felsic tuffs in the east-west corridor (Prince George to Prince Rupert) at places such as Cheslatta. Falls and Nazko where waterlain felsic tuffs are found (Rouse and Mathews, 1988). The corridor has not been investigated.

In the Queen Charlotte Islands of the coast belt, zeolitized tuffs have not been reported from the Tertiary in spite of the suitable bulk composition of the rocks and range in organic maturity. Although I made a petrographic and x-ray diffraction examination of hundreds of volcanic rocks collected by Sutherland Brown (1968) during his study of the islands, zeolitized rocks were absent. Because the collected samples were as fresh as possible, his collections probably selectively excluded zeolitized rocks and this area, so close to tidewater, requires further investigation of its industrial zeolite potential.

EPILOGUE

Today, 22 years after the first report of widespread industrial zeolites in northern British Columbia, all the industrial zeolite showings defined during and after the First Canada/British Columbia Mineral Development Agreement (1985-1990) are staked. Several properties in the Princeton and McAbee areas have been bulk sampled with test shipments exceeding 100 tonnes each. By the turn of the millenium in British Columbia, a producing, industrial zeolite deposit is possible, even probable, and more deposits await discovery.

REFERENCES

Albee, A.L. and Zen, E-An (1969): Dependence of the Zeolitic Facies on the Chemical Potentials of CO, and H20; *in* Zharikov, V.A., editor, *Contributions to Physico-Chemical Petrology* (Korzhinskii volume), pages 249-260.

Galloway, W.E. (1974): Deposition and Diagenetic Alteration of Sandstone in Northeast Pacific Arc-Related Basins: Implications for Greywacke Genesis; *Geological Society of America,* Bulletin, volume 85, pages 379-390.

Green, K.C. (1989): Geology and Industrial Minerals in the Gang Ranch Area; unpublished M.Sc. thesis, *The University of British Columbia,* Vancouver, B.C., 107 pages.

Hora, Z.D. and Church, B.N. (1986): Zeolites in Eocene Rocks of the Penticton Group, Okanagan-Boundary Region South-Central British Columbia (82E); *in* Geological Fieldwork 1985, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1986-1, pages 50-55.

Lay, D. (1930): Volcanic Ash; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Minister of Mines Annual Report 1929, page C195.

McKenzie, K.L. (1985): Sedimentology and Stratigraphy of the Southern Sustut Basin, North Central British Columbia; unpublished M.Sc. thesis, *The University of British Columbia,* Vancouver, B.C., 120 pages.

Read, P.B. (1987): Tertiary Stratigraphy & Industrial Minerals, Princeton & Tulameen Basins, British Columbia; B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 1987-19.

Read, P.B. (1988a): Industrial Minerals in Tertiary Rocks, Lytton to Gang Ranch, Southern British Columbia; *in* Geological Fieldwork 1987, B.C. *Ministry of Energy Mines and Petroleum Resources,* Paper 88-1, pages 411415.

Read, P.B. (1988b): Industrial Minerals in the Tertiary of Bonaparte to Deadman River Area, Southern British Columbia; *in* Geological Fieldwork 1987, B.C. *Ministry of Energy, Mines and Petroleum Resources,* Paper 88-1, pages 417-419.

Read, P.B. (1988c): Tertiary Stratigraphy & Industrial Minerals, Merritt Basin, British Columbia; B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 88-15.

Read, P.B. (1988d): Cenozoic Stratigraphy and Industrial Minerals: Fraser River, Lytton to Gang Ranch, Southwestern British Columbia; B.C. *Ministry Energy, Mines and Petroleum Resources,* Open File 88-29.

Read, P.B. (1988e): Tertiary Stratigraphy & Industrial Minerals, Cache Creek, British Columbia: B.C. *Ministry of Energy, Mines and Petroleum Resources,* Open File 88-30.

Read, P.B. (1989): Tertiary Stratigraphy & Industrial Minerals, Bonaparte to Deadman Rivers, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Open File 1989-2 1.

Read, P.B. (1990): Tertiary Stratigraphy & Industrial Minerals, Hat Creek, British Columbia; *B. C Ministry of Energy, Mines and Petroleum Resources,* Open File 1990-23.

Read, P.B. (1995): Geological Mapping and X-ray Diffraction Analysis, MAN Claim and Surroundings, Nicola Valley, Kamloops Mining Division; private report, *Geotex Consultants Limited,* 19 pages, 2 appendices.

Read, P.B. *(in press):* Geology and Industrial Minerals of the Tertiary Basins, South-Central British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin.

Read, P.B. and Eisbacher, G.H. (1974): Regional Zeolite Alteration of the Sustut Group, North-Central British Columbia; *Canadian Mineralogist,* volume 12, pages 527-541.

Read, P.B., Woodsworth, G.J., Greenwood, H.J., Ghent, E.D. and Evenchick, C.A. (1991): Metamorphic Map of the Canadian Cordillera; *Geological Survey of Canada,* Map 1714A, Scale 1:2 000 000.

Rouse, G.E. and Mathews, W.H. (1988): Palynology and Geochronology of Eocene Beds from Cheslatta Falls and Nazko Areas, Central British Columbia; *Canadian Journal ofEarth Sciences,* volume 25, pages 1268-1276.

Surdarn, R.C. (1967a): Low-Grade Metamorphism of the Karmutsen Group, Buttle Lake area, Vancouver Island, British Columbia; *University of California,* Los Angeles, 313 pages.

Surdam, R.C. (1967b): Low-Grade Metamorphism of Tuffaceous Rocks in the Karmutsen Group, Vancouver Island, British Columbia; *Geological Society of A merica,* Bulletin, volume 84, pages 1911-1922.

Sutherland Brown, A. (1968): Geology of the Queen Charlotte Islands British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 54, 226 pages.

Thompson, A.B. (1971): PC02 in Low-Grade Metamorphism; Zeolite, Carbonate, Clay Mineral, Prehnite Relations in the System CaO-AI203-SiO2-CO2-H20; *Contributions to Mineralogy and Petrology,* volume 33, pages 145-161.

Economics of Various Industrial Minerals in B.C. for the Pulp and Paper Industry

by

B.A. Slim,

President,

MineStart Managment Inc.

presented at

Focus on British Columbia

Industrial Minerals

October 19, 1995

Vancouver, Canada

ECONOMICS OF VARIOUS INDUSTRIAL MINERALS IN B.C. FOR THE PULP AND PAPER INDUSTRY

Bryan A. Slim

MineStart Management Inc, 1763 Scott Road, North Vancouver, B.C. V7J 3J4
Telephone: +1604 986-7014, Fax: +1604 986-7017

1 INTRODUCTION

All white industrial minerals have the potential to be used either as a filler or coater in the pulp and paper industry. Their potential lies in meeting the *Economic Foundation* - Figure 3 - which requires that the mineral or supply characteristics must be in balance with the demand requirements.

The accompanying figures were developed for slide presentation and are half tone prints from the slides

2 MARKET STATUS AND MILL NEEDS

Of initial importance is determining if the market is supply or demand driven. - Figure 4 From the producers view-point the supply is looking for the market to sell into for a profit whereas the paper mill is looking for a demand which will be of economic benefit to the mill. We believe that there is a regional demand looking for an economic supply of minerals filler and coater.

The terminology of marketing and sales must be understood. *Selling* is supplying what you have and for which there is a ready buyer. However, *marketing* is determining what the buyer needs and ensuring that the production matches this demand - as per Figure 5. This implies, correctly, that the onus is on the potential supplier to investigate the market. For many of the white industrial minerals the emphasis will have to be on the marketing when the mineral company is wishing to sell a mineral which is new to the paper mill.

There are an estimated 119 pulp and paper mills in the west coast region comprising Alaska, British Columbia, Alberta, Washington, Oregon and California - Figure 6. The product outputs range from newsprint to some printing and writing grades, to liner board, building papers and market pulp. However, the paper mills are constrained by a similar range of problems as shown in Figure 7. The emphasis should be seen as on the lack of a regional supplier of a good filler and coater.

The high freight charges for the traditional kaolin supply from the south-east USA eliminates the economic benefits stressed in Figure 4. This restricts the region to the lower selling priced unfilled or uncoated newsprint, limited directory grades or market pulp - Figure 7.

3 ROLE OF INDUSTRIAL MINERALS IN PAPER MILLS

Typically unfilled or uncoated paper has a rough surface and low opaqueness. To improve this paper for printing and writing demands white industrial minerals are needed to either fill or coat the surface - Figure 8. The mineral can also substitute for some of the pulp which offers a further saving for paper manufacture. Figure 9 presents the alternatives for mitigating the Westcoast mill needs named in Figure 7.

In Figure 10 we describe some of the typical loadings - percentage of mineral used - in various paper grades.

4 WHICH INDUSTRIAL MINERALS

Clearly with the fundamental requirements established, including the application for the paper, it is then possible to describe which minerals are suitable. Figure I I presents a summary of the more common minerals and some of their typical specifications.

Selection of a minerals is dependent on the mill operating system, ultimate market for the paper and the delivered selling price. This can be summarized as "...capable of delivering an economic benefit".

5 MINE FEASIBILITY

We turn now to the economics of the mine-site. In Figure 12 we give a nominal flowchart setting out the critical stages of investigations for economic feasibility. Specific to this paper is the need to understand the beneficiation testing which allows for the initial description of possible market type products by providing characterization - a reflection back to the *economic foundation* presented in Figure 3. By matching the mineral characteristics to the preliminary market opportunity analysis the preferred products can be established and this in turn allows for estimating the possible demand tonnages and revenues and costs. Where and when profits are indicated then possible reserves can be estimated for the various products.

This stage is followed by a trial market entry which, when it leads to a sales contract, allows the reserves to be classified as *proven and probable.*

6 SOME COMPETITIVE FORCES

Competitive forces are an inevitable part of the marketing and selling. In Figure 13 we present some of the more typical forces of three categories.

The *entry barriers* are totally controllable by the mining company and rest on the previous section of this paper. *Other industry substitutes* require an adequate understanding of other mineral fillers, and their economic benefits, which could be offered to the mills.

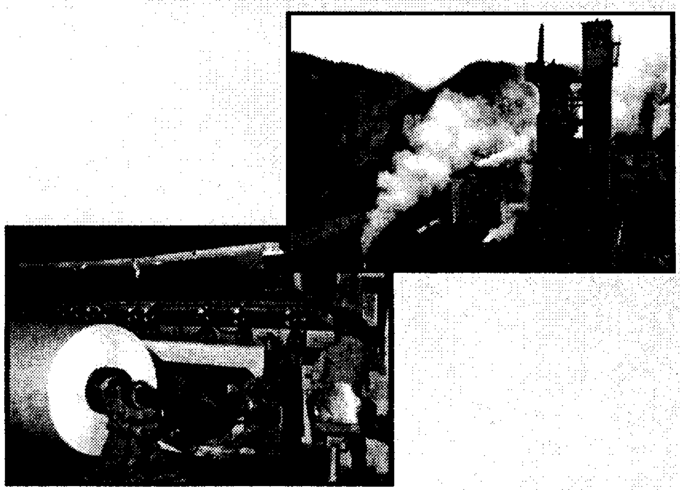
Buyer power leverage is the seller losing control, in this case to the paper or pulp mill. This which must not be allowed to happen and the components listed here identify some areas in which the seller can lose control.

7 CONCLUSIONS AND INITIAL DEMAND ESTIMATE

The initial demand shown here for 100 000 to 200 000 t/a is for the existing 1995 potential. If a mining company can demonstrate that it can *deliver the second load* then it is possible to contemplate the market demand could increase to 700 000 to 800 000 t/a as some paper mills could switch to printing and writing production lines.

> The ... *second load* apart from the economics is the overall key. In summary it means that there has been sufficient property investigations coupled with beneficiation trials that all shipments will be consistent with the first load and meet the buyers requirements.

Economics of various industrial minerals in B.C. for the pulp and paper industry



Bryan A. Slim

MineStart Management Inc
North Vancouver

Highlights

- economic foundation
- market status & mill needs
- role of industrial minerals in paper mills
- which industrial minerals
- mine feasibility
- competitive forces
- conclusions and the demand estimate

Economic Foundation

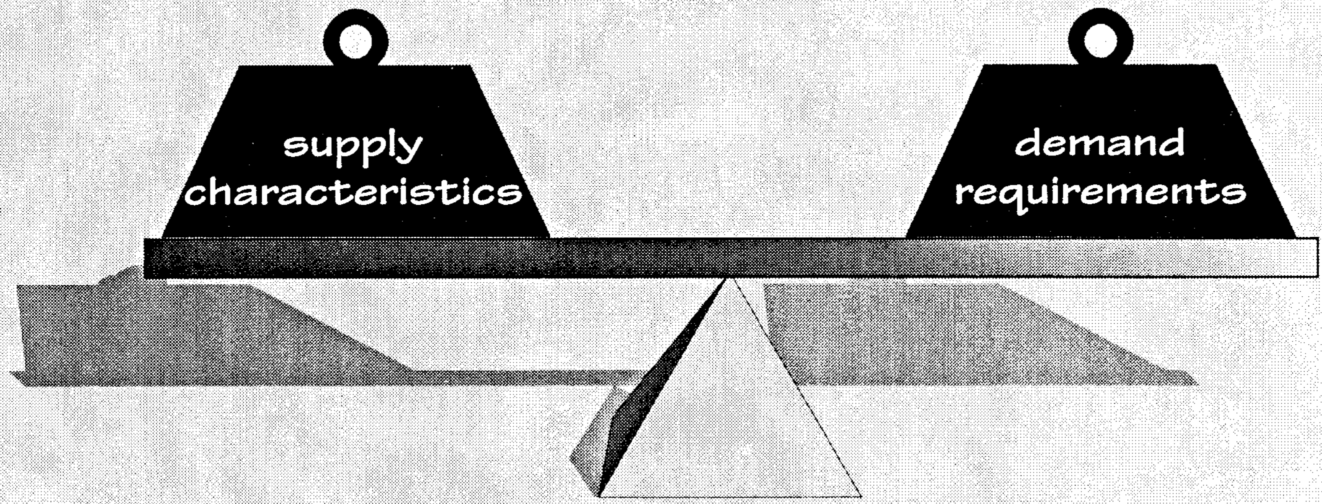


Figure 3

Holnam West Materials Ltd. Limestone Quarry- Texada Island

by

P M Stiles,
Vice-President,
Holnam West Materials Ltd.

presented at
Focus on British Columbia
Industrial Minerals

October 19, 1995
Vancouver, Canada

Holnam West Materials Ltd.

Limestone has many uses and is an essential raw material in any developed society. The production of basic building materials, such as steel, base metals, pulp, glass, portland cement, and lime, consume large quantities of limestone providing the primary components of any community's physical growth and development.

Pulverized or precipitated white limestone has become an increasingly important industrial mineral filler for many manufactured products such as paint and other coatings, joint cement, drilling muds, plastic pipe, and fine paper.

Other growing markets that are adding to the demand for limestone include waste gas desulphurization, soil conditioning, and acid rock drainage neutralization. The almost galloping pace of environmental regulation and control is doubtless going to provide everincreasing demands for limestone and lime across a broad range of specifications.

Thus it is common to find limestone mining operations within relatively small economic zones, as it was a century ago when marbleized stone was such an important building material. Then, as now, transportation costs played a very strong role in the location of these operations. unlike deposits of precious and base metals, many high grade limestone properties remain unexploited because of distance from viable markets. It is interesting to see how this relationship has played out in the Pacific Northwest.

Holnam West Materials, and it's predecessor, Ideal Cement Company Ltd., has quarried limestone on Texada island since 1956.

Texada Island is located some sixty miles north of Vancouver, B. C. in the Georgia Strait between Vancouver Island and mainland British Columbia. It is thirty miles long in a northwest, southeast direction and is four to five miles across.

The majority of the limestone is found in the northern third of the island. The portion of this limestone being quarried by Holnam is described as the lower member and possibly part of the middle member of the Triassic marble Bay formation. The strata dip 10 to 12 degrees northeasterly and strike northwesterly. Several faults trending North 10 degrees West have fractured and offset the formation. Dykes trending in the same direction have been intruded during at least two separate periods.

Within the quarry area, dykes appear to occupy nearly vertical fracture zones, particularly those which are 10 to 15 feet thick. These dykes trend North 15 degrees West and are commonly resistant to erosion. Smaller dykes ranging from I to 3 feet, either crosscut the larger dykes at about North 45 degrees West or run parallel to them. These dykes erode slightly below the limestone surface and show no indication of past intrusive faulting.

The limestone can be described as medium to dark grey, even textured and cryptocrystalline. Minute irregular veinlets containing minor amount of silica and pyrite are present but are not readily apparent to the eye. This high quality chemical grade limestone is being used by pulp mills, smelters and in the manufacture of cement and high purity chemical grade lime.

Limestone quarries have been a facet of Texada living since the early 1890's, initially for flux for a local copper smelter, subsequently, and still early on, for other shoreline smelters on Vancouver Island pulp and paper mills up and down the Coast. Lime kilns were constructed on Texada Island - originally vertical kilns fired with wood then a rotary kiln fired with oil. Burning of lime locally halted in the mid 50's. Raw, sized stone was then shipped to lime plants in Tacoma and Portland from the Blubber Bay Quarry, now operated by Ash Grove Cement.

B. C. Cement (now Tilbury Cement) supplied their small cement plant on Vancouver Island at Bamberton from a quarry on the north end of Texada near Blubber Bay during the 1930's, 40's and 50's. A new quarry was opened at Cobble Hill and the Texada quarry operation was closed down.

Cement-grade limestone production began on Texada in earnest in 1956 when Lafarge began shipping limestone to a new cement plant in Richmond from the quarry south of Van Anda. Nearby, Imperial Limestone has continued operations since the early 50's, supplying specialty limestone markets. Ideal began shipments to the Grotto Cement plant in Washington State in 1966 and then to it's Seattle cement plant which made it's first cement in March 1967. This amount of cement-grade limestone, some 500,000 tonnes/year, gave the quarry the opportunity to expand.

Increase in demand for rip rap (over 200,000 tonnes in 1968) and other limestone products gave the Company a new credibility in the eyes of senior management. In 1972, a new crushing, screening, conveying, stockpiling, reclaiming, and barge loading facility was approved and commissioned in 1973. It is still operating today.

The present quarry covers an area of approximately 100 acres with a limestone depth potential of over 700 feet where it lies on the Karmutsen volcanic basement. The volcanics have a similar dip and strike generally to the limestone.

Down-the-hole drilling provides the 8-inch boreholes for blasting with ANFO or high explosive. A smaller track-type hydraulic drill is used for pioneering work. Bench heights average 33 feet. Front-end loaders and trucks feed an impact crusher in closed screening circuit at a capacity rate of 800 tonnes per hour to produce a minus three-inch product. This product is stockpiled and shipped to cement plants or to aggregate users in the Lower Mainland. Chemical grade limestone is crushed in the same system with a twoinch minus product being processed further on two 8'x2O' double decked screens.

Four crushing plants area used to reduce the blasted rock to customer specifications. Four loading facilities on the west side of Texada Island put the quarry production on the customer's barge. One of these is capable of loading deep sea vessels and is currently used to load coal from the Quinsam Mine near Campbell River. Panamax sized vessels are now being loaded and the capability is there to load Cape sized. Another facility, a ramp, allows the loading of rip rap and the unloading of coal directly by truck to or from barge. Coal is stockpiled on site for shipment overseas.

The million tonne shipping threshold was crossed in 1972, the 2,000,000 in 1987 and the 3,000,000 in 1992.

Current limestone shipments amount to some 2,700,000 tonnes per year, rip rap and construction materials 600,000 tonnes per year, and coal 480,000 tonnes per year. For the last five years, Holnam is also producing white limestone for the Huber's plant in Seattle. Ground product is used for a variety of filler applications. The property has reserves for many years to come and it's strategic location on tide water assures it's future as a raw material supplier and handler of basic commodities.