ASBESTOS OCCURRENCES IN BRITISH COLUMBIA

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PURPOSE AND SCOPE OF REPORT

This Open File report consists of a systematic review of the asbestos resources of British Columbia. A detailed geological summary accompanies each showing description. The regional geology of each area has been used to categorize the 97 known occurrences of asbestos, particular attention has been paid to the relationship to host rocks, adjacent lithologies, tectonic setting, and proximity of intrusions. This information, in conjunction with exploration and mining records, can be used to assess the economic potential of each occurrence. This is reflected by the status applied to each occurrence, whether it be showing, prospect, developed prospect or past producer. There are no asbestos mines in production in British Columbia at present.

The deposit descriptions are subdivided by both host terrane and physiographic area: northern, central and southern British Columbia. Asbestos mineralization, where possible, is identified by mineral type, either asbestiform serpentine (chrysotile) or asbestiform amphibole (actinolite, tremolite, anthophyllite or crocidolite).

All known asbestos showings are compiled using the MINFILE database as the initial data set. Each occurrence is referenced by its MINFILE number, and a number specific to this report. Several lists showing the MINFILE numbers, geographical coordinates, mineralization and host lithologies are located within the appendices to this report.

SOURCES OF INFORMATION

This report is based on research of as much information as time permitted; no field examinations of the mineral occurrences were made. When possible, geologists with appropriate expertise were consulted with respect to specific occurrences or regional geology. Printed material researched included British Columbia Ministry of Energy, Mines and Petroleum Resources publications and mineral industry assessment reports; Geological Survey of Canada Memoirs, Papers, Bulletins, Open Files and maps; unpublished M.Sc. and Ph.D. theses; mining company reports and information releases; mining industry publications and newspapers; and, professional and academic journals. All information sources are included in the reference list at the end of the report.

Within the deposit description section of this report references have been abbreviated according to the MINFILE bibliographical style guide, chapter 8 of the 1992 MINFILE Coding Manual (MRD/GSB, 1992).

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BRITISH COLUMBIA ASBESTOS - A CURRENT PERSPECTIVE

DISTRIBUTION AND GENERAL CHARACTERISTICS OF ASBESTOS DEPOSITS IN BRITISH COLUMBIA

A preliminary inventory of British Columbian asbestos deposits was published in 1932 by Richmond. It discusses the valuable qualities, uses, grades, specifications and prices and markets for asbestos, but from a 1932 perspective. It is interesting to note that after six decades a consensus of the true definition still does not exist.

In British Columbia asbestiform minerals are found in fibrous form of varying commercial value. The most abundant source of fibre is the asbestiform serpentine mineral chrysotile. The commercial value of chrysotile is determined by the following characteristics: fineness of fibre, flexibility, silkiness, tensile strength, and resistance to acid, water & fire.

EXPLORATION FOR ASBESTOS IN BRITISH COLUMBIA

Over the years, Cassiar mine operators have explored numerous asbestos occurrences throughout the province of British Columbia. Their efforts were focussed within the Liard Mining Division where both the Cassiar and McDame chrysotile asbestos deposits are located.

The McDame orebody, located approximately 1 kilometre from the Cassiar deposit, has economic potential. High quality asbestos underground reserves in the McDame deposit have been estimated at 16 million tonnes (The Financial Post Survey of Mines and Energy Resources, 1989). Proven reserves at McDame are characterized by a 6.21 % mill yield of asbestos.

The most important undeveloped asbestos deposit in British Columbia is the Kutcho Creek Deposit. It is a medium size, medium grade orebody estimated at 15.7 million tonnes, with an average grade of 4.7 % and a cut-off grade of 3 % fibre.

BRITISH COLUMBIA ASBESTOS PRODUCTION

The bulk of Canadian asbestos production occurs in Quebec. Before its closure, the British Columbia asbestos industry accounted for about 20 % of the national fibre output and employed over 400 people. The majority of British Columbia's exports were in the long fibre grade, with minimal export of manufactured asbestos products.

British Columbia exports were much more diversified in market destination than other Canadian producers. Its major asbestos export markets were roughly equally divided between the advanced industrial markets of the United Kingdom, West Germany, France and Australia, and the less developed countries like India, Thailand, Malaysia and Mexico. The United States was also an export market, but considerably smaller than the others.

In British Columbia the Cassiar Mining Corporation (a wholly owned subsidiary of the Princeton Mining Corporation) dominated the asbestos mining industry. The closure of the operations at Cassiar was due to a combination of circumstances: Cassiar Mining Corporation's financial difficulties reflected higher-than-estimated capital costs required to develop the McDame underground deposit: a variety of operating problems were encountered during the changeover from the open pit mining of the Cassiar orebody to the underground development of the adjacent McDame orebody: production was affected by both labour disputes, and ground support failures within the extraction drifts.

TABLE 1: CASSIAR MINING CORPORATION CHRYSOTILE ASBESTOS PRODUCTION
(Princeton Mining Corporation Annual Reports; Morel-a-l'Huissier, 1992)

Production	1991	1990	1989	1988	1987
Chrysotile Asbestos (tonnes)	43163	86568	106090	106085	96014

TABLE 2: GLOBAL DISTRIBUTION OF CASSIAR MINING CORPORATION ASBESTOS SALES
(Princeton Mining Corporation Annual Reports)

WORLD REGION	1980	1990
ASIA	28 %	45 %
EUROPE	27 %	38 %
NORTH AMERICA	22 %	3 %
AUSTRALIA	16 %	0 %
SOUTH AMERICA	6 %	9 %
MIDDLE EAST	1 %	5 %

In 1993 Black Hills Minerals, Minpro and Cliff Resources jointly acquired a 6 month option to treat chrysotile asbestos tailings dumps and rehabilitate the old Cassiar Mining Site. They also acquired rights to several assets and properties of the Cassiar Mining Corporation. The price was $184,040 and a usage depletion fee, based on the amount of chrysotile recovered per tonne (The Northern Miner, February 14, 1993). Construction of a chrysotile recovery plant is projected for 1995. Cliff's patented wet process technology will be used to produce asbestos from tailings.

CANADA'S ASBESTOS INDUSTRY - BACKGROUND

Despite wining a major victory in obtaining the overturn of the Asbestos Ban Rule issued in 1989 by the Environmental Protection Agency (EPA), the Canadian and world asbestos industries are still feeling the consequences of a negative image associated with their product.

A result of these pressures is that 1994 Canadian production and export of asbestos is 40 % that of the previous decade. In the early 1980s an increase in the production from the former Soviet Union compensated for the drop observed in the Western World. Since its dismantling, the Russian and Kazakhstan asbestos producers have been experiencing financial problems which have resulted in a slight decrease in world production (Morel-a-l'Huissier, 1994).

The closure of the British Columbia operations at Cassiar was not the result of this negative image. It was due rather to production delays due to technical problems with underground mining which resulted in cash-flow problems and a lack of funds for higher than expected development costs.

CURRENT SITUATION OF CANADA'S ASBESTOS INDUSTRY

In 1993, Canadian asbestos production decreased 12.7 % from 1992 levels. Average prices increased by about 3.5 to 4.0 %. A 13.3 % decrease in shipments is explained by the general softening of the markets as a consequence of world recession.

TABLE 3: CANADIAN ASBESTOS PRODUCTION AND EXPORT FIGURES (Morel-a-l'Huissier, 1994)

YEAR	PRODUCTION (tonnes)	VALUE	EXPORTS (tonnes)	VALUE ($ million)
1992	586 994 t	$231 million	600 577 t	$ 354 million
1993	509 341 t	$215 million	510 386 t	$ 302 million

Ninety eight % of Canada's current asbestos production comes from asbestos mining operations located in the province of Quebec where two producers, LAB Chrysotile and JM Asbestos, are exploiting five sites: one underground and four open-pit. In 1993 these mines were operating at 90 % of their capacity .

In addition to this, a small tailings reprocessing operation is located at Baie Verte, Newfoundland and it was operating at 78 % of capacity.

Despite the decrease over the last decade in Canada's asbestos production and export, it is still the world's number one asbestos-exporting country. It is not within the scope of this report to delve into the state of Canada's asbestos industry over the past two decades. The author recommends two, of the many, summary papers which cover this topic: *Prospects for Canada's Asbestos Industry* (Ignatow, 1985); *Asbestos: The Challenge Ahead* (Houston, 1985); and the chapter on asbestos in the annual publication The Canadian Mineral Yearbook.

CANADA'S ASBESTOS INDUSTRY - OUTLOOK

The demand forecast for chrysotile asbestos varies significantly. Developed countries are expected to continue to reduce their demand while developing countries will remain the largest users of chrysotile asbestos.

More than 90 % of Canada's asbestos production is exported to about 70 countries. The United States is still Canada's major market, even though current exports are a mere 4 % of what they were two decades ago. Canadian exports to Europe continue to fall sharply (by 60 % since 1991). Current strong markets for asbestos are located in Asia and Latin America (Morel-a-l'Huissier, 1994).

Key factors that will affect the supply and demand of Canadian asbestos are: the growing concern over substitutes; the confirmation of the lower risk of chrysotile with respect to other asbestiform minerals; world economic growth; instability in the other major asbestos producing regions of the world; the development of the Chinese asbestos industry; and responsible re-use policies (Houston, 1985; Ignatow, 1985; Morel-a-l'Huissier, 1994).

The international environment for continued asbestos use has overcome the uncertainties that it experienced in the 1980s. Unfortunately regulatory bodies have taken longer to respond to the new information regarding the safe use of chrysotile asbestos. The general public must be educated to distinguish between the apparent and real risks of asbestos and its use.

USES

The first recorded use of the word asbestos is by Pliny the Elder in the 1st century ad, although the substance itself was known as early as the 2d century bc. The Romans made cremation cloths and wicks from it, and centuries later Marco Polo noted its usefulness as cloth.

Chrysotile fibres are very fine, flexible and highly resistant to heat, whereas other types of asbestos are more brittle and have a harsher texture. Both crocidolite and amosite are highly acid resistant, making their use particularly important in the manufacture of chemically resistant products.

Although asbestos has been used in approximately 3000 different products, its major applications now are limited to asbestos-cement (pipes, roofing tiles, sheets), friction materials (brake linings), gaskets, and specialty papers (diaphragms). Asbestos-cement accounts for approximately 85 % of chrysotile fibre consumption (Hoskin, 1993).

Asbestos fibers can be molded or woven into various fabrics. Because it is nonflammable and a poor heat conductor, asbestos has been widely used to make fireproof products such as safety clothing for fire fighters and insulation products such as hot-water piping. Its insulating qualities have been utilized as asbestos-covered gloves worn by workers in steel mills.

In the past it has been used in building-construction materials, textiles, missile and jet parts, asphalt and caulking compounds and paints. Tiles are sometimes made of acoustically absorbent material such as asbestos. Synthetic, resilient floorings once included vinyl asbestos tiles.

An exhaustive description of the uses for asbestos with respect to their different grades can be found in the 1994 paper on asbestos by R.L. Virta and E.L. Mann.

GRADES AND SPECIFICATIONS

Canadian asbestos, when subdivided by fibre grade, fits into 5 out of a potential seven groups. Group 3 is an essential fibre for textile manufacture: it is highly priced and is concentrated in British Columbian deposits. Group 4 is used primarily in asbestos cement pipe manufacture. Group 5 and 6 are used for asbestos building material (sheets, roofing, and friction products). Group 7 is used primarily as a low cost building additive in industrialized countries (vinyl flooring, molded friction materials and coatings and compounds).

The following agencies can be contacted for detailed information on Canadian asbestos grade shipping test specifications: The Asbestos Institute, and The Canadian Chapter of the National Asbestos Council (Appendix 3). Appendix 4 lists asbestos grades and their respective current market prices.

TABLE 4: CASSIAR ASBESTOS GRADES, NORTHERN BRITISH COLUMBIA (after Virta and Mann, 1994)

CASSIAR ASBESTOS GRADE	DESCRIPTION	GROUP
C-1	Crude. Cross-fibre veins having 3/4 inch staple and longer.	
AAA	Extra long spinning fibre	Canadian Group 3
AA	Spinning fibre	Canadian Group 3
A; AC; CC	Spinning fibre	Canadian Group 3
AK; CP; AS; CT	Asbestos-cement fibre	Canadian Group 4
AX; AY; CY	Asbestos-cement fibre	Canadian Group 5
AZ; CZ	Asbestos-cement fibre	Canadian Group 6

MINING AND EXTRACTION

It is not within the scope of this report to detail the aspects of asbestos mining and extraction. The author recommends the following papers pertaining to this subject. Virta and Mann in their 1994 summary paper on asbestos detail the exploration and exploitation of asbestos deposits. They have paid particular attention to the mining and milling of the commodity. J. Jakubec in a 1992 publication details the technical difficulties and provides some solutions to the underground mining of asbestos deposits. A summary of mine safety activities with respect to the exploitation of asbestos is provided by Goodwin and Kraft in the Society of Mining Engineers (AIME) 1981 summary volume on the geology of asbestos deposits.

MILLING AND PROCESSING

The fibers are separated from the waste rock by crushing, air suction, and vibrating screens, and in the process are sorted into different lengths, or grades. The most widely used method of grading, the Québec Standard Test Method, divides the fibers into seven groups, the longest in group one and the shortest, called milled asbestos, in group seven. The length of the fibers, as well as the chemical composition of the ore, determines the kind of product that can be made from the asbestos. The longer fibers have been used in fabrics, commonly with cotton or rayon, and the shorter ones for molded goods, such as pipes and gaskets.

WORLDWIDE DISTRIBUTION OF ASBESTOS DEPOSITS

Asbestos is of two principal classes, the amphiboles and the serpentines, the former of relatively minor importance. Chrysotile, in the serpentine class, constitutes about 95 percent of the world supply of asbestos, of which three-fourths is mined in Québec.

Of the six forms of asbestos, only three have been used to any significant extent in commerce. These are chrysotile, crocidolite, and amosite. Between 1870 and 1980, approximately 100 million tonnes of asbestos was mined worldwide, of which more than 90 million tonnes was the chrysotile variety, about 2.7 million the crocidolite variety, and about 2.2 million tonnes the amosite variety (Ross, 1987).

Other large deposits exist in former Soviet Union, Brazil and South Africa. In the United States, California, Vermont, and Arizona are the leading asbestos-producing states; however, the majority of United States deposits are of no commercial value. Detailed abstracts for and the global distribution of foreign asbestos deposits can be found in 1994 paper on asbestos by R.L. Virta and E.L. Mann.

TABLE 5: ASBESTOS WORLD PRODUCTION BY COUNTRY (from Morel-a-l'Huissier, 1993)

COUNTRY	PRODUCTION (tonnes)
Commonwealth of Independent States	1,700,00
Canada	510,000
Brazil	250,000
Zimbabwe	150,000
China	250,000
Republic of South Africa	130,000
United States	15,000
Greece	45,000
India	25,000
Swaziland	30,000
Columbia	5,000
Yugoslavia	1,000
Romania	3,000
TOTAL	**3,114,000**

ASBESTOS ENVIRONMENTAL AND HEALTH IMPLICATIONS

OCCUPATIONAL AND ENVIRONMENTAL HEALTH CONCERNS

Asbestos is a term used to refer to a number of inorganic minerals, specifically asbestiform serpentine and asbestiform amphiboles. When it was first used asbestos was thought to be chemically inert regarding its effects on the human body.

Three main diseases; asbestosis, lung cancer and mesothelioma are now associated with the long-term inhalation of excessive levels of asbestos. Excessive levels of asbestos are defined as levels in excess of 75-100 fibres per cubic centimetre of air (Hoskin, 1993). Chrysotile fibres, perhaps because of their instability in tissues and other characteristics, present a substantially lower risk of malignancies than amphibole fibres (HEI, 1991). Amphibole fibres pose a much greater risk of mesothelioma than exposure to chrysotile(asbestiform serpentine). The predominant type of asbestos used in North American building construction is chrysotile.

Researchers have suggested that chrysotile is the least hazardous of all the commercial asbestos minerals because the curly nature of the fibres makes them less likely to be inhaled into the alveoli of the lung (Rimstidt, 1991). Rather than remaining as an irritant, those fibres that are inhaled dissolve quickly because of the high solubility of chrysotile (Houston, 1985; Rimstidt, 1991).

Due to the fact that asbestos is the most studied industrial mineral in use, there exists an international scientific consensus on the health effects and safe use of the mineral. The Royal Commission on Matters of Health and Safety Arising from the Use of Asbestos in Ontario (ORCA) in 1984 released a report recommending the controlled-use approach for chrysotile asbestos. ORCA indicated the necessity to differentiate between fibre type (serpentine [chrysotile] and amphiboles [actinolite, tremolite, anthophyllite, amosite and crocidolite]) and fibre length.

Asbestos can be divided into three major groups based on fibre length. Short fibres are used as filler and binder in plastic materials; long fibres are used in the manufacture of asbestos-cement pipe and other construction materials; and extra-long fibres are used in some textile applications. Fibre length is of critical importance since the greatest environmental risk is associated with the short fibre group.

In 1988, a working group from the World Health Organization's International Program on Chemical Safety recommended that a distinction be made between the hazards posed by friable low-density asbestos products and high density products such as asbestos-cement. It also determined that the use of chrysotile-containing materials does not pose a risk to the general population; and that the legitimate needs of developing countries for asbestos-cement products should be recognized and their safe use encouraged.

In 1989 a World Health Organization consultation group was convened to establish permissible occupational exposure limit for chrysotile asbestos. The final report endorsed a maximum exposure limit of 2 fibres per cubic centimetre of air over an 8 hour time-weighted average, with further efforts to reduce this to 1 fibre per cubic centimetre of air.

In 1990, at the request of the US Congress, the Health Effect Institute (HEI) undertook a study of asbestos. Part I of the HEI's study, released in 1991, found that the mean exposure to asbestos fibre in public and commercial buildings was 0.00028 fibres per cubic centimetre. The Institute concluded that the presence of asbestos containing material within buildings in good repair, and a non-friable state, is unlikely to give rise to airborne asbestos fibre concentrations above the levels found outside those buildings. The focus of concern should be maintenance and utility service personnel whose occupations place them in close physical contact with asbestos containing material that may be disrupted. More scientific evidence indicates that the removal of asbestos, if improperly done, may actually increase health risk not only to the removal workers, but also to the building occupants.

There are times when removal of crocidolite is warranted. Crocidolite is a far more dangerous type of asbestos. It is mined in Australia and Africa and is used only rarely outside those countries. Chrysotile asbestos continues to be used fairly extensively in Europe, where regulatory bodies differentiate between the asbestiform serpentine and asbestiform amphiboles (crocidolite, amosite and tremolite).

It has been suggested that potential human risks must be evaluated using the concentration of air fibres, the asbestos type, and the fibre size (length and width). In many cases asbestos removal in non-occupational areas is a waste of time and money. Billions of dollars have been spent in BC alone to remove asbestos from buildings constructed before the late 1970s, when use of the material dwindled due to health concerns. The BC Buildings Corporation spent $10 million just to remove asbestos insulation from the provincial museum, archives and curatorial tower in Victoria, and tens of millions more to either remove or "manage" asbestos in its 3,500 other government buildings in the province. The Education Ministry has spent 42.5 million in the greater Victoria school district to remove asbestos from about half of the districts 55 schools. Similarly hefty bills have also been rung up in many of BC's 75 school districts.

Repeated attempts by asbestos experts to defend the use of chrysotile over the years were ignored by powerful regulatory bodies such as the US EPA and Canadian worker's compensation boards. Warnings that the risk of asbestos-related disease associated with the inhalation of high airborne asbestos levels was increased by cigarette smoking also fell by the wayside.

ASBESTOS IN WATER

Within the vicinity of some serpentinite hosted asbestos deposits, erosion can cause concentrations of asbestos to occur in the natural water supply. Extensive studies have revealed no consistent, convincing evidence that ingested asbestos is hazardous to human health (Hoskin, 1993). Hoskin (1993) states that chrysotile asbestos fibres likely dissolve in stomach acids.

In 1992, new EPA drinking water standards for 33 contaminants, including asbestos, became effective (Morel-a-l'Huissier, 1993).

Asbestos is not referenced in Canada's *Drinking Water Quality Guidelines*.

ASBESTOS SUBSTITUTES

At present no wholly satisfactory substitutes are available for asbestos in many of its applications (Ignatow, 1985). This is due to the fact that many of the substitute fibres are both respirable and bioresistent (Hoskins, 1993). Glass fibers and mineral wool are being promoted as asbestos substitutes. The Ontario Royal Commission on Asbestos cited a study by Enterline, Marsh and Esmann which found a high incidence of respiratory cancer among fiberglass and mineral wool workers, at levels of exposure much lower than those experienced by asbestos workers. It would therefore appear that the disease risk is linked not just to asbestos fibres, but indeed most other respirable fibres. In a 26 year study (Liddell, 1992) a research team found no incidences of asbestos-related disease among 11,00 chrysotile asbestos miners and mill-workers exposed to levels of airborne asbestos fibres exceeding the maximum OSHA standards. The highest asbestos levels ever found in an office building have been 0.001 fibers per millilitre of air.

U.S.A. ASBESTOS LEGISLATION

It is important to understand the history of asbestos legislation in the United States of America as it has had far reaching economic implications on the status of the asbestos industry in Canada.

In 1986 the United States Environmental Protection Agency (EPA) proposed a ban on the manufacture, importation and processing of asbestos products in the United States, and a complete ban on all asbestos products within the next decade. In that same year the OSHA revised its standards and redefined asbestos to include six non-asbestiform minerals, including actinolite, tremolite, and anthophyllite.

In October of 1991 a ruling was made by the 5th U.S. Circuit Court of Appeals on an appeal by the asbestos industry. The court overruled the EPA's ban on products containing asbestos. The court said that the EPA had failed to balance the estimated costs of regulation against the presumed benefits. The court cited estimates that a ban would cost $800 million in lost business and consumer replacements costs. The ban was implemented in 1989 and was expected to be fully implemented by 1996.

U.S. federal legislation dealing with asbestos does not specify the asbestos mineralogy, which is important for human health (Moody, 1991). In June of 1992 the Occupational Health Safety Administration (OSHA) rescinded provisions to regulate nonasbestiform actinolite, tremolite, and anthophyllite as asbestos. This 6 year battle was spear headed by the National Stone Industry at a cost of over $500,000.

By 1988, Canadian asbestos exports to the U.S. had fallen to 85000 tonnes from a high of 700000 tonnes in 1973. Only a handful of new North American products still contain asbestos, once prized for its unrivaled insulating qualities.

In 1994 a U.S. federal judge accepted a plan put forward by the Center for Claims Resolution under which future asbestos-related personal injury claims brought against 20 asbestos companies would be settled out of court under an agreed formula (*Industrial Minerals*, September 1994). This ruling will limit the extremely lengthy and costly litigation which has hampered the asbestos industry.

In the 1994 the U.S. permissible workplace asbestos exposure levels were halved, from 0.2 fibres per cubic centimetre of air to 0.1 fibres per cubic centimetre of air as an 8 hour time weighted average. The problem with the updated OSHA standard is that it has been formulated using a risk assessment model dating from 1984 which does not recognize that the risk to health from chrysotile is not as high as previously thought . The problem is that the new standard does not recognize the different health risks associated with amphibole and chrysotile asbestos. It is also way out of line with the conclusions of the World Health Organization group of experts, and the animal and epidemiological data upon which their recommendations of 1 fibre per cubic centimetre of air are based (*Industrial Minerals*, September 1994). In British Columbia, the Worker's Compensation Board has followed suit and changed their permissible workplace asbestos exposure limits accordingly.

BRITISH COLUMBIA ASBESTOS LEGISLATION AND REGULATION

In British Columbia asbestos is regulated by Section 35 of the Industrial Health and Safety Chapter of the Worker's Compensation Act. It states that workers should not be exposed to asbestos, or dusts containing asbestos, above the permissible concentration of 0.1 fibres per ml per 8 hour limit. The Act was amended in November of 1993 to delete the existing reference to Asbestos: Amosite, Chrysotile, Crocidolite, Tremolite and their permissible concentrations and substitutes, instead, one general classification and one permissible concentration for all forms of Asbestos (Table 6).

Other than Section 35.25 prohibiting the use of Crocidolite in places of employment and Section 35.07 prohibiting the spraying of asbestos or materials containing asbestos, no legislation has been drafted specifically prohibiting the use of asbestos (in the form of construction material) in British Columbia (re updated Act and Building Codes).

TABLE 6: WORKERS' COMPENSATION BOARD PERMISSIBLE CONCENTRATIONS OF AIRBORNE ASBESTOS FIBRES

SUBSTANCE	PRE 1993 8 hour limit (fibre per ml)	POST 1993 8 hour limit (fibre per ml)	PRE 1993 15 min limit (fibre per ml)	POST 1993 15 min limit (fibre per ml)
Asbestos	category not recognized	0.1	category not recognized	category not recognized
Chrysotile	2	category not recognized	5	category not recognized
Tremolite	0.5	category not recognized	5	category not recognized
Amosite	0.5	category not recognized	5	category not recognized
Crocidolite	0.2	category not recognized	category not recognized	category not recognized

The publication "Safe Handling of Asbestos: A Manual of Standard Practices", produced by the Worker's Compensation Board and revised in 1993, focuses on the handling of asbestos. This publication covers the following topics: a definition of terms, employer responsibilities, procedures for low, moderate and high-risk work activities; respiratory protection, procedures for bulk sample collection of materials suspected of containing asbestos, procedures for the removal of asbestos containing pipe insulation and pertinent emergency procedures.

It does not delineate the specific criteria that must exist to warrant the removal of asbestos. The definition of asbestos though accurate, presupposes a knowledge of mineralogy and crystallography on the part of the reader. It does not point out the inherent differences between the two asbestiform mineral groups (serpentine and amphiboles) or their significantly different toxicological effects on the human body. It also omits to point out that these minerals occur in non-asbestiform habits which are used for a variety of industrial purposes and pose none of the perceived health threats that the asbestiform do.

WASTE ASBESTOS IN BRITISH COLUMBIA

The Province of British Columbia's legislation for special waste management includes information on the disposal of waste asbestos material. The Waste Management Act, the Special Waste Regulation, the Federal Transportation of Dangerous Goods Act, and the Environment Management Act all address this issue. The information is summarized the 1993 BC Environment Publication "Special Waste Legislation Guide".

The BC Ministry of Environment defines special wastes as a group of wastes which are potentially hazardous to human health and the environment and which require special care during handling and disposal. Not all waste asbestos qualifies as a special waste.

The Special Waste Legislation Guide (BC Environment, 1993) defines "waste asbestos" as a waste containing more than 1% friable asbestos fibres. Release of asbestos fibres which may be inhaled, is the main concern with this waste type. The regulation is designed to eliminate this hazard during transport and disposal. Asbestos special waste management options are detailed on page 78 of the Special Waste Management Guide and under Part 6, Section 40 of the Waste Management Act, Special Waste Regulation (B.C. Reg. 63/88).

Friable asbestos is defined as asbestos material that can be crumbled, pulverized, or reduced to powder in the hand, readily releasing fibres with minimal mechanical disturbance. Typically, friable asbestos may have the following characteristics: fluffy or spongy appearance (always applied by spraying), irregular, soft surface (usually applied by spraying); or textured, dense, fairly firm surface (usually applied by trowelling).

Asbestos which is tightly bound within a solid matrix so that it is not easily crumbled by the hands is not a special waste. The Regulation is not directed at such asbestos materials as hardboard, brake linings, woven cloth, and asbestos reinforced cement, tile and plastics.

DEFINITION OF ASBESTOS AND ASBESTIFORM MINERALS

Asbestos (Greek a-, "not"; sbestos, "extinguishable"), the fibrous form of several minerals and hydrous silicates of magnesium. Many different definitions for asbestos appear in the abundant literature on the subject.

The AGI Glossary of Geology defines asbestos as: (a) A commercial term applied to a group of silicate minerals that readily separate into thin, strong, fibres that are flexible, heat resistant, chemically inert, and therefore are suitable for uses where incombustible, nonconducting, or chemically resistant material is required; (b) A mineral of the asbestos group, principally chrysotile and certain fibrous varieties of amphibole (esp. amosite, anthophyllite, and crocidolite); or (c) A term strictly applied to the fibrous variety of actinolite.

The most definitive was written by Ross, Kuntze and Clifton (1984), it is mineralogically correct and excludes all materials except that which has been used for commercial asbestos. They define asbestos as a term which is applied to the six naturally occurring minerals exploited commercially for their desirable physical properties, which are in part derived from their asbestiform habit. The six minerals are the serpentine mineral chrysotile and the amphibole minerals grunerite asbestos (also referred to as amosite), riebeckite asbestos (also referred to as crocidolite), anthophyllite asbestos, tremolite asbestos, and actinolite asbestos. Individual mineral particles, regardless of their mineral name, are not demonstrated to be asbestos if the length-to-width ratio is less than 20:1.

Asbestiform minerals occur as both amphiboles (double chain silicates) and as serpentine (a phyllosilicate). Classification of silicates is based on the number of shared oxygen ions per silica tetrahedron. The characteristics and behavior of silicates are largely dependent on the nature of the tetrahedral arrangements.

Phyllosilicates (serpentine) are formed when each tetrahedron shares three O^{-2} with other tetrahedra. The resulting giant negative ion extends indefinitely in two dimensions. The sheets consists of $(Si_20_5)^{-2}$ units held together in stacks by metal ions resulting in one direction of perfect cleavage. The sheet silicates cleave easily along this weakly bonded layer.

Although some of the serpentine minerals are fibrous, the structures of all of them are nevertheless of a layered type. the fibrous nature of chrysotile is explained by its consisting of layers curved cylindrically or spirally usually about the *x* axis.

Double chain silicates (amphiboles) are formed when double chains of composition $(Si_4O_{11})^{-6}$ are stacked together parallel to the *c* crystallographic axis. They are formed when half the tetrahedra share two O^{2-} and the other half share three O^{2-}. These chains are bonded together by cations such as Mg^{2+}, Fe^{2+}, Ca^{2+}, Na^{2+}, and K^+, with $(OH)^-$ anions also entering the structure. Double-chain minerals are prismatic and they possess two prismatic cleavages meeting at approximately 126° on the basal plane, these cleavages again representing the plane of weakness between the double chain units.

Understanding the fundamental differences between the two asbestos silicates will help explain why serpentine (chrysotile asbestos) does not pose the significant health risks that amphiboles do. When inhaled chrysotile fibres dissolve more readily in the lungs than asbestiform amphibole. In addition to this, when asbestos particles are broken down, chrysotile maintains a fibrous form, asbestiform amphiboles tend to form a fine powder which is more readily inhaled into the alveoli of the lungs.

PHYSICAL PROPERTIES OF SERPENTINE & AMPHIBOLE FIBRES

Asbestos fibres are characterized by high tensile strength, flexibility, resistance to chemical attack and thermal degradation, large surface area, and the ability to be woven. Each type of asbestos has different characteristics.

Chrysotile is a white, fibrous material. The fibres are extremely thin, and most are soft and flexible enough to be woven. Because of the fibre structure it has an extremely large surface area, and a tensile strength between 550 and 700 Mpa, making it one of the stronger asbestos types. It is extremely heat resistant and is used routinely in commercial products that are exposed to temperatures exceeding 700°C. The fusion temperature for chrysotile is 1521°C. Chrysotile fibres are readily degraded by exposure to acidic and alkaline solutions.

Amphibole asbestos fibres generally are harsher and more brittle than those of chrysotile. They are more resistant to chemical attack, have very good filtration rates and are comparatively long, ranging up to several centimetres. Tensile strengths range from 28 Mpa for anthophyllite asbestos to 2100 Mpa for crocidolite. All of the forms of amphibole asbestos withstand temperatures exceeding several hundreds of degrees without degradation. The fusion temperature for all of the asbestiform amphiboles exceeds 1093°C.

Due to the difference in the structural makeup of serpentine and amphibole a number of specific physical properties exist between the two. Simple techniques exist which can easily and inexpensively assist the researcher in distinguishing between the two mineral groups.

The moisture content of chrysotile is four times or more greater than that which is found in the amphibole asbestos minerals and is the chief chemical difference between the two groups. Commercial chrysotile ore always contains more than 13 % moisture whereas the harsh asbestos fibres such as tremolite and actinolite seldom contain more than 2 % moisture.

Serpentine exhibits a hardness of 3 to 3.5 and can be easily scratched with a knife. The specific gravity of serpentine is 2.2, less than that of either the amphiboles or quartz. Serpentine asbestos fibers have a greatest refractive index less than 1.58, when ground in a mortar the fibers form a matted aggregate which can be powdered only with great difficulty, and can become stained with a solution of iodine in glycerol.

The hardness of amphiboles is between 5 and 6. Amphibole asbestos have a greatest refractive index greater than 1.58, when ground in a mortar generally rub to a powder and are not stained by a solution of iodine in glycerol.

IDENTIFICATION TECHNIQUES FOR ASBESTIFORM MINERALS

In his 1981 paper (Lee, 1981) R.J. Lee outlines the techniques available, their limitations and the areas of applicability for the identification of asbestos, and the separation of the asbestos and nonasbestos amphiboles. Reviewed are the varying definitions of asbestos; bulk analysis (chemical differential thermal analysis, infrared spectroscopy and X-ray diffraction) of asbestos; and microscopic techniques for the identification of asbestos (optical microscopy, transmission electron microscopy and scanning electron microscopy).

XRD is not considered specific for asbestos because it does not distinguish minerals on the basis of morphology, but is an excellent technique for differentiating between serpentine and amphibole group minerals. The morphology and physical properties of asbestos form the basis for its usefulness and macroscopic identification. Microscopic procedures permit the direct classification of particles according to their morphology.

Complete mineralogical descriptions of asbestiform serpentine and asbestiform amphiboles may be found in a number of textbooks (Deer *et al.*, 1992;Gribble and Hall, 1993; Kerr, 1977). Rigorous and precise definitions of asbestos can be found in one of many articles written by Malcom Ross (Ross *et al.* 1984).

ASBESTIFORM SERPENTINE

MINERALOGY: SERPENTINE (CHRYSOTILE) $Mg_3Si_2O_5(OH)_4$

Serpentine, a hydrous magnesium silicate, includes a variety of colourless and pale to dark green minerals; one fibrous (chrysotile) and two tabular (lizardite and antigorite). Lizardite and antigorite are massive varieties which crystallize as flat, tabular crystals with basal cleavage. Picrolite (fibrous antigorite) can occur as a slip fibre in veins and on shear surfaces. Picrolite exhibits a splintery fracture and is not used commercially. It is tough, not easily separated into fibres and often brittle and harsh to the touch. The hardness of the serpentine ranges from 2 to 5, and the specific gravity ranges from 2.2 for chrysotile to 2.65 for antigorite.

Chrysotile, the primary asbestiform mineral, is distinguished from lizardite and antigorite on the basis of habit and cleavage (Gribble and Hall, 1993). Chrysotile exhibits both fibrous cleavage and a fibrous habit which is elongate to and parallel to the x crystallographic axis. It has a greasy, silky lustre and feel; is usually white or light green to dark green or brown in colour. Chrysotile can occur as both slip and cross fibres.

Research into the crystal chemistry of lizardite and the formation of magnetite has been done by D.M. Darby and D.S. O'Hanley (Dyar, 1991). A detailed examination of the chemistry of serpentine can be found in the 1992 version of "An Introduction To The Rock Forming Minerals" by Deer, Howie and Zussman.

PARAGENESIS: SERPENTINE (CHRYSOTILE) $Mg_3Si_2O_5(OH)_4$

Serpentine minerals form principally after retrograde hydrothermal alteration of ultramafic rocks (dunites, pyroxenites and peridotites) from the hydration of the ferromagnesian minerals (olivine, clinopyroxene, orthopyroxene and amphibole). Conditions favorable to this reaction include temperatures of generally less than 500°C, fluid pH's in excess of 10, and a low partial pressure of CO_2 (O'Hanley *et al.*, 1992).

Serpentine minerals can also form by prograde metamorphism of pre-existing serpentinite. The formation of asbestos results from low temperature prograde reactions where a mixture of chrysotile and lizardite mineralizes in massive serpentinite. In a typical asbestos deposit, e.g. at Cassiar, British Columbia, the varieties of serpentine occurring with increasing grade follow the sequence (O'Hanley *et al.*, 1989):

pseudomorphous retrograde lizardite → lizardite+chrysotile → chrysotile+antigorite→antigorite.

The intrusion of diabase sills into siliceous dolomite can also result in the formation of serpentine minerals. The siliceous dolomite is transformed to fosterite which is subsequently serpentinized. In these circumstances, veins of chrysotile, parallel to the contact, are free from magnetite and other impurities except for small amounts of talc.

Serpentinization processes in naturally occurring ultramafic rocks have been discussed at some length in the geological literature (O'Hanley, 1992; Malpas, 1992; Laurent and Herbert, 1979; Moody, 1976; Coleman and Keith, 1971; Komor *et al.*, 1985). Serpentinization, with the exception of water is essentially an isochemical reaction. Isotopic evidence suggests that serpentinization occurs as a result of rock interaction with various waters, including sea-water, meteoric water and hydrothermal water, according to the environment in which the alteration takes place. A byproduct of the serpentinization process is the formation of magnetite from the oxidation of iron (Coleman and Keith, 1971).

The invasion of water into the peridotite is primarily controlled by the presence of conjugate joint sets. Large volumetric increases accompany this process (Coleman, 1971). The accessibility of fluid to ferromagnesian mineral surfaces is facilitated by faulting and shearing which increases the available surface area and thus the rate of serpentinization (O'Hanley, 1991). In some circumstance, picrolite or chrysotile filled cross-fractures are radially distributed around the perimeter of the serpentinized peridotite (O'Hanely, 1992). Dunites that are completely serpentinized generally assume a mesh-texture. Harzburgites follow a similar process of replacement except for the resistance of the orthopyroxenes to replacement.

The three most common textures produced during serpentinization are: blocky or massive serpentinite, sheared serpentinite, and fibrous serpentinite (Malpas, 1992). Fibrous serpentinite develops in veins that vary from microscopic to macroscopic. Generally the veins follow a joint pattern inherited from the olivine.

Fibrous chrysotile forms as: cross-fibre veins, agglomerates of finely matted material, or, a combination of the two. The cross-fibre form consists of white to pale yellow-green fibres that have crystallized normal to the vein walls. Much of the matrix material containing veins of chrysotile is fine-grained, platy lizardite. If the veins are subsequently sheared, the fibres become platy and brittle and produce picrolite. Shearing and faulting produce slip-fibre seams. In most cross- or slip-fibre veining asbestos deposits only 5-10% of the ore is useable whereas in the tectonized serpentinized bodies there may be as high as 50% recoverable chrysotile, however in these high grade deposits only short fibre is produced (Coleman, 1977; Coleman and Keith, 1971).

The origin of alpine peridotite-hosted, cross-fibre chrysotile asbestos deposits (e.g. Cassiar) has been addressed by D.S. O'Hanley (1988). These deposits are syntectonic, the asbestos veins occur in tension fractures which have been induced by regional stress fields. The trend of these fields is moderated by local structural heterogeneity. The presence of fluid will greatly affect the magnitude of the deviational stress. Asbestos develops during the change in the orientation of the regional stress. At the Cassiar Mine in British Columbia, and other localities, this is a function of the transition from convergent (dip-slip) to strike-slip fault motion.

Several factors determine whether or not asbestos is developed. First, the serpentinite must have a nonfoliated texture. Massive serpentinite retains its ability to fracture, the presence of a schistose texture impedes this process. Second, it must be situated near a fault that is active during a change in the orientation of the stress field. Third, the serpentinite must be in the stability field of chrysotile when the change in orientation occurs. Last, there must be no subsequent deformation and no increase in temperature.

OCCURRENCES: SERPENTINE (CHRYSOTILE) $Mg_3Si_2O_5(OH)_4$

Ultramafic rocks occur in three major settings: ophiolite complexes; stratiform complexes; and concentrically zoned complexes (Alaskan-type). The most commonly recognized serpentine protoliths are those which form part of ophiolite complexes which have been tectonically emplaced into orogenic belts. Chrysotile is the main serpentine polymorph and where veins are several centimetres thick they form the main source of commercial asbestos.

Large deposits of chrysotile are located at Cassiar, British Columbia, Vermont, New York, and New Jersey. Economic deposits of chrysotile asbestos derived from peridotite occur in the Thetford area of Quebec, South Africa and in Kazakhstan. Chrysotile occurs in veinlets in serpentinite and also in masses, as at Coalinga, California. White chrysotile in fine white fibers up to 6 inches long is found along the contact zone between carbonate rocks and layered intrusives north of Globe, Arizona in the United States. Elsewhere (e.g. Transvaal) serpentinized dolomitic rocks host veins of chrysotile.

USES: SERPENTINE (CHRYSOTILE) $Mg_3Si_2O_5(OH)_4$

Chrysotile is the most important source of commercial asbestos. Chrysotile's white colour, spinnability, superior tensile strength combined with thermal stability and low thermal conductivity make it an extremely useful in a wide range of important products.

ASBESTIFORM AMPHIBOLE MINERALS

Asbestiform amphiboles are generally found in slips and fault planes as slip-fibre. The fibres are harsh, brittle, weak and poor conductors of heat. Generally speaking, the amphiboles are not suitable for spinning and weaving into yarns and textiles but their superior heat and acid-resisting qualities give them a limited market in the chemical industry for filter applications.

Ca-poor amphiboles

MINERALOGY: ANTHOPHYLLITE $(Mg,Fe^{2+})_7[Si_8O_{22}](OH,F)_2$

The anthophyllite minerals vary in habit from fibrous and asbestiform to bladed and prismatic, all with elongation parallel to the *c* axis. The fibers of the colourless, grey, brown or pale green (colour dependent on its iron content) anthophyllite asbestos do not have great tensile strength and are of less economic importance than those of amosite and crocidolite.

PARAGENESIS: ANTHOPHYLLITE $(Mg,Fe^{2+})_7[Si_8O_{22}](OH,F)_2$

Anthophyllite is a common product of the reaction zone between ultramafic bodies (e.g. serpentinized peridotites) and country rocks. in anthophyllite-talc schists, the anthophyllite may exhibit an asbestiform habit.

OCCURRENCES: ANTHOPHYLLITE $(Mg,Fe^{2+})_7[Si_8O_{22}](OH,F)_2$

Finland is the most important of past-producer of anthophyllite. In the United States smaller quantities have been mined in the states of North Carolina and Georgia.

USES: ANTHOPHYLLITE $(Mg,Fe^{2+})_7[Si_8O_{22}](OH,F)_2$

Unsuited for textiles but of some value for chemical uses because of its superior heat and acid-resisting qualities.

MINERALOGY: GRUNERITE (AMOSITE & MONTASITE) $(Mg,Fe,Mn)_7[Si_8O_{22}](OH)_2$

The characteristic habit of the cummingtonite-grunerite minerals is acicular or fibrous; asbestiform varieties are common, and amosite and montasite are names given respectively to the harsher, more iron-rich and softer, more magnesium rich, fibers of economic importance. Grunerite is the Fe-rich monoclinic equivalent of the Ca-poor amphibole Gedrite. Amosite (brown asbestos) is asbestiform grunerite. Montasite is the softer more magnesium rich variety of the mineral fiber.

Amosite occurs as a grey-green, tough, strong cross-fibre which can attain lengths of 1.5 to 3 cm in length.

PARAGENESIS: GRUNERITE (AMOSITE)

Grunerite occurs in metamorphosed iron-rich sediments, where it is associated with either magnetite and quartz or with almandine garnet and fayalitic olivine, the latter minerals being common constituents of eulysite bands.

USES: GRUNERITE (AMOSITE & MONTASITE) $(Mg,Fe,Mn)_7[Si_8O_{22}](OH)_2$

Amosite is used to a limited extent as a textile fibre.

Ca-rich amphiboles

MINERALOGY: TREMOLITE-ACTINOLITE $Ca_2(Mg,Fe)_5[Si_8O_{22}](OH,F)_2$

Tremolite, compact, acicular mineral, transparent to translucent, is composed of hydrated calcium magnesium silicate. Fibrous tremolites are a minor source of asbestos. The mineral crystallizes in the monoclinic system in fibrous or columnar form. It has a hardness of 5 to 6 and a specific gravity of 2.9 to 3.2, exhibits perfect prismatic cleavage and a vitreous lustre. The colour ranges from light green to white; excess amounts of iron sometimes replace the magnesium in part, causing a slightly darker colour. A hard, compact variety of tremolite, known as nephrite, yields the mineral jade. Some varieties of jade exhibit a microfibrous habit, but due to the low ratio of length to width of the fibre it is excluded from being classified as an asbestiform.

Actinolite forms a solid solution with tremolite and is distinguished from it by having greater than 2 percent of iron.

PARAGENESIS: TREMOLITE-ACTINOLITE $Ca_2(Mg,Fe)_5[Si_8O_{22}](OH,F)_2$

Tremolite occurs in various talc schists and and contact skarns. It is often found in impure, crystalline varieties of medium to low grade metamorphosed dolomitic. Actinolite is widespread in contact skarns, greenschists, and talc schists. It is also found as a replacement of pyroxene in igneous rocks.

OCCURRENCES: TREMOLITE-ACTINOLITE $Ca_2(Mg,Fe)_5[Si_8O_{22}](OH,F)_2$

In the past tremolite was mined extensively in several areas of upper New York State, U.S.A.. Other deposits occur in the Italian, Swiss, and Austrian Alps and throughout the mountain areas of Turkestan.

Alkali amphiboles

MINERALOGY: RIEBECKITE (CROCIDOLITE) $Na_2(Fe_3^{2+}Fe_2^{3+})[Si_8O_{22}](OH)_2$

Crocidolite (blue asbestos) is the highly fibrous asbestiform of riebeckite (Deer *et al.*, 1992). Riebeckite is one end member of a solid-solution series of alkali amphiboles which include, glaucophane, magnesioriebeckite, and ferroglaucophane. Crocidolite occurs as a cross-fibre up to 5 cm in length.

PARAGENESIS: RIEBECKITE (CROCIDOLITE) $Na_2(Fe_3^{2+}Fe_2^{3+})[Si_8O_{22}](OH)_2$

Crocidolite is formed from the metamorphism at moderate temperature and pressure of massive iron formations. The best known occurrences are in South Africa and Western Australia where it occurs as seams conformable with the bedding of the iron-rich sedimentary rock. The composition of the crocidolite is closely comparable to that of the host rock. The crystallization of the amphibole , initially in the form of massive riebeckite, occurred with little or no addition of material and under conditions of moderate temperature and pressure consequent on the burial of the iron-rich sedimentary rock to moderate depths. The transformation of the riebeckite to the fibrous crocidolite may result from the instability of the massive riebeckite during a period when the host rocks were subject to shearing stress (Deer *et al.*, 1992).

USES: RIEBECKITE (CROCIDOLITE) $Na_2(Fe_3^{2+}Fe_2^{3+})[Si_8O_{22}](OH)_2$

The fibers of crocidolite have a greater tensile strength but a lower heat resistance than chrysotile. In some countries the industrial use of crocidolite asbestos has been banned because the inhalation of its finely fibrous particles has been associated with the diseases asbestosis and mesothelioma.

OCCURRENCES: RIEBECKITE (CROCIDOLITE) $Na_2(Fe_3^{2+}Fe_2^{3+})[Si_8O_{22}](OH)_2$

Crocidolite is found over a large area of Cape Province, South Africa. Deposits are also found in India, Western Australia and Bolivia.

GEOLOGICAL OCCURRENCE OF COMMERCIAL ASBESTOS

Deposits of commercial asbestos are found in four types of rocks: the depleted mantle portion of ophiolitic ultramafic rocks, characterized by variable proportions of harzburgite, lherzolite and dunite; stratiform ultramafic intrusions; serpentinized limestone; and banded iron formations (Ross, 1987).

Table 7 summarizes the three major categories of chrysotile asbestos deposits and differentiates between them with respect to protolith, lithology and fibre type. The largest chrysotile asbestos deposits are located in Quebec, Canada and the Ural Mountains of the Former Soviet Union (Lamarche and Riordon, 1981; Malpas and Talkington, 1977). In South Africa, Swaziland, and Zimbabwe, tremolite and predominantly chrysotile mineralization occurs within stratiform ultramafic intrusions.

The third type of deposits are small and are characterized by chrysotile mineralization within serpentinized carbonate rocks. The most notable of these are located near Globe, Arizona and in the Carolina Area of South Africa.

Amosite and crocidolite deposits are found in Precambrian banded iron formations located in the Transvaal and Cape Provinces of South Africa, and in Western Australia (Butt, 1981; Dreyer and Robinson, 1981). Only the South African deposits are still in production.

TABLE 7: CLASSIFICATION OF CHRYSOTILE ASBESTOS DEPOSITS (from O'Hanley, 1988)

EXTENDED CLASSIFICATION	LITHOLOGY	FIBRE TYPE	EXAMPLE
Ophiolitic Ultramafic Rocks	Tectonized Peridotites (Harzburgite & Dunite)	Cross-fibre Slip-fibre Massive-fibre	Cassiar, British Columbia Coalinga, California Asbestos, Quebec
Differentiated Sills	Sills Komatiitic flows	Cross-fibre Cross-fibre	Great Dike, Zimbabwe Abitibi belt, Ontario
Serpentinized Limestones		Cross-fibre	Globe, Arizona district

Eighty-five % of the world's mined serpentinite-hosted asbestos occurs in ophiolitic ultramafic rocks. The ultramafic constituents originate as oceanic lithosphere formed by magmatic processes at oceanic ridges. After spreading and cooling, slabs of the oceanic lithosphere are detached and emplaced at orogenic plate margins (Coleman, 1977; Malpas and Stevens, 1977; Gass, 1987; Edelman, 1988; van de Beukel, 1990; Canwood and Suhr, 1992; Van der Wal and Vissers, 1993). Isolated tectonic lenses of ophiolite result from subsequent deformation. Serpentinization occurs throughout the process.

ASBESTOS OCCURRENCES IN BRITISH COLUMBIA

Out of the five asbestiform minerals used commercially more than 90 % of the fibre consumed by world markets is the serpentine asbestiform chrysotile; the remainder is crocidolite or amosite. Chrysotile is the most abundant asbestiform mineral found in British Columbia and holds the most potential for economic exploitation.

Most British Columbian occurrences of asbestiform serpentine occur along a median belt of major faults and serpentinites trending northwesterly from the International border near Hope to the Yukon border north of Dease Lake. The deposits lie mainly between the Coast Mountains on the west and the Rocky Mountains on the east. The belt is not strictly parallel with the structural grain of the Cordillera. In the south it lies along the eastern margin of the Coast Mountains, farther north the deposits lie in the Omineca Mountains, and in the north they are largely in the Cassiar Mountains or along the adjacent margin of the Stikine Plateau. The association of asbestiform serpentine with faults, serpentinites, and mainly Permo-Triassic rocks implies a genetic relationship influenced by post-Jurassic dextral-transcurrent faults that have dismembered the accreted terranes.

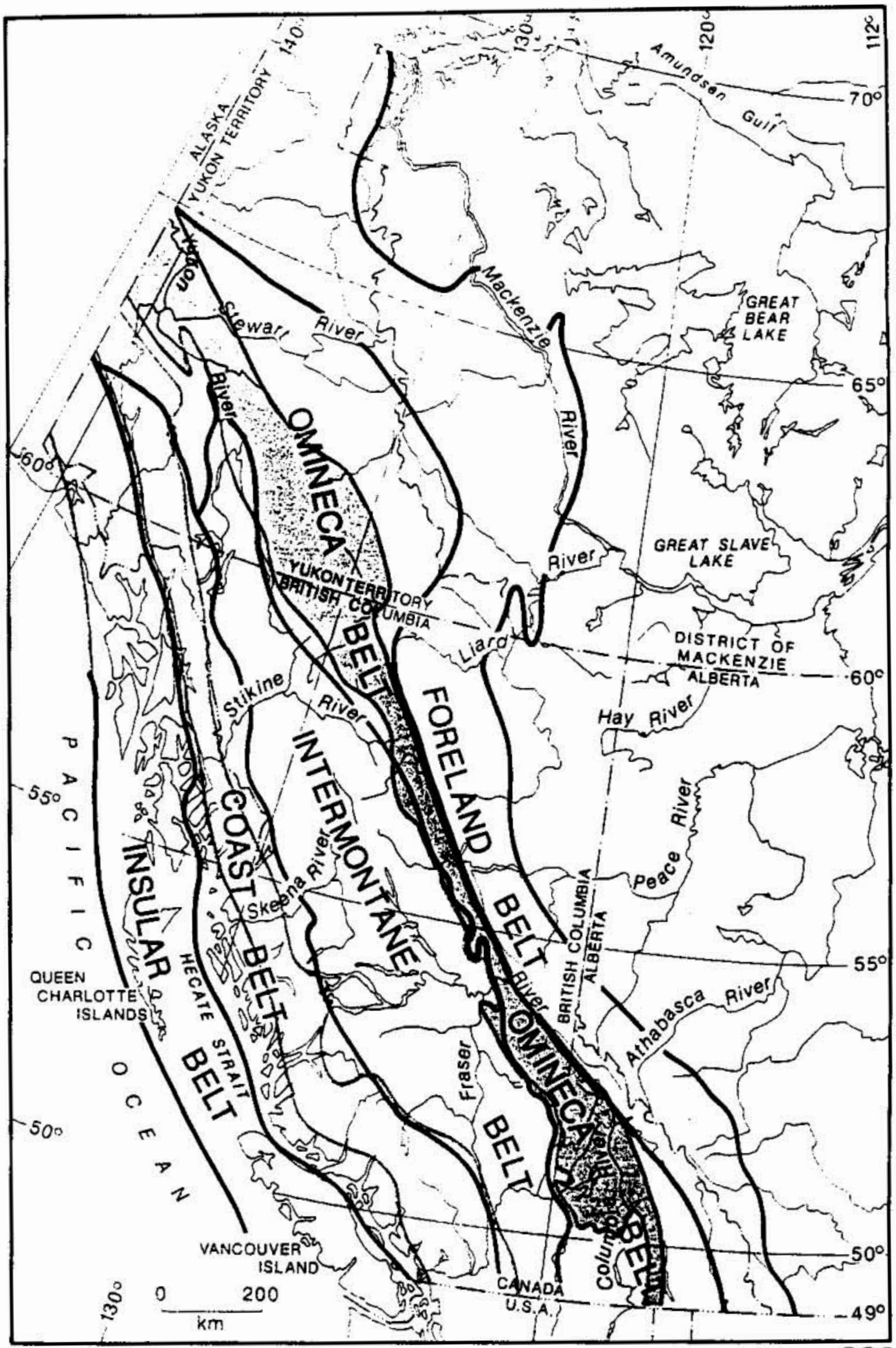
The deposits are all associated with middle Paleozoic to Triassic rocks which are thought to have been part of the oceanic crust but which are now large allochthonous slabs thrust over continental rocks. Deposits are also found in highly serpentinized ultramafic bodies i.e. dikes whose spatial, genetic, and chronological links with the ophiolite masses proper have not as yet been adequately resolved.

ASBESTOS METALLOGENY OF THE CRATON AND DISPLACED PERICRATONIC AND ACCRETED TERRANES

The distribution of asbestos deposits in British Columbia is clearly not random. Asbestos showings have been documented in a variety of terranes, geologic and physiographic subdivisions of the Canadian Cordillera. These are summarized below in Table 8 and Table 9. The terranes comprising the accreted collage of the western Cordillera possess unique lithotectonic characteristics. Each Cordilleran terrane preserves a stratigraphic record different from those neighboring terranes (Dawson *et al.*, 1991).

TABLE 8: CHARACTERISTICS OF THE MAJOR BELTS OF THE CORDILLERA (after Monger *et al.*, 1982)

BELT	DESCRIPTION
Foreland	Northeasterly tapering wedge of Mid-Proterozoic to Upper Jurassic (1500-150 My) miogeoclinal and platformal carbonates and craton derived clastics, and overlying Upper Jurassic to Paleogene exogenoclinal, Cordillera-derived clastics; horizontally compressed and displaced up to 200 km northeastward on craton in Late Jurassic to Paleogene time
Omineca	Mid-Proterozoic to miogeoclinal rock, Paleozoic and lower Mesozoic volcanogenic and pelitic rock, local Precambrian crystalline basement, highly deformed and variably metamorphosed up to higher-grades in mid-Mesozoic to early Tertiary time, and intruded by Jurassic and Cretaceous plutons
Intermontane	Upper Paleozoic to mid-Mesozoic marine volcanic and sedimentaray rock, mid-Mesozoic to upper Tertiary marine and nonmarine sedimentary and volcanic rock; granitic intrusions comagmatic with the volcanics; deformed at varous times from early Mesozoic to Neogene
Coast	Mainly Cretaceous and Tertiary plutonic granitic rock with sedimentary and volcanic strata of known late Paleozoic to Tertiary age and probable early Paleozoic and Precambrian age, variably metamorphosed up to higher grades.
Insular	Upper Cambrain to Neogene volcanics and sedimentary strata, granitic rocks in part comagmatic with the volcanics; deformed at various times from Paleozoic to Neogene



EXPLANATION

Accreted superterranes

Pericratonic and displaced terranes

FIGURE 1: MORPHOGEOLOGICAL BELTS OF THE CORDILLERA

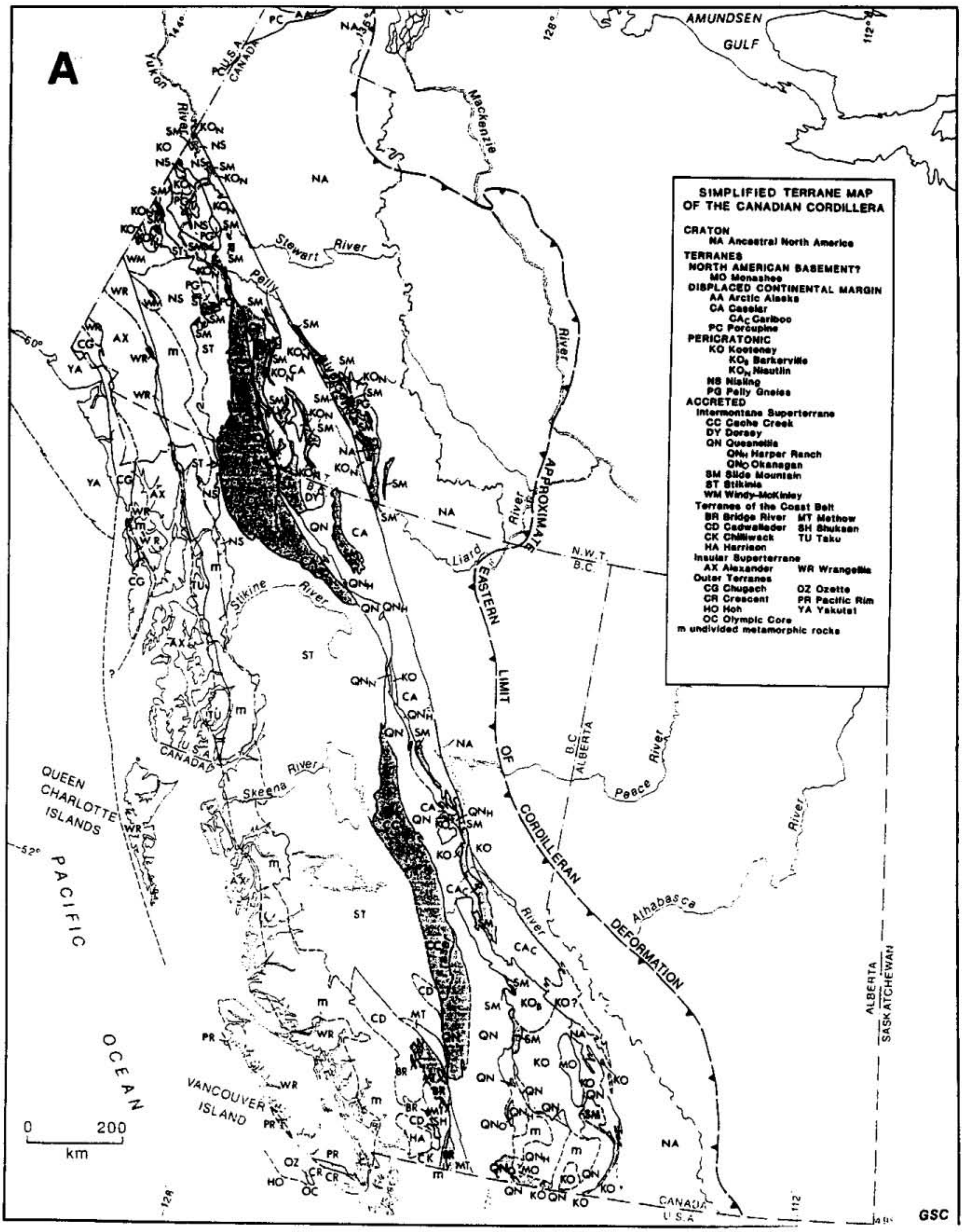


FIGURE 2: SIMPLIFIED TERRANE MAP OF THE CANADIAN CORDILLERA

TABLE 9: NATURE OF ALLOCHTHONOUS OR SUSPECT TERRANES WHCH HOST B.C. ASBESTOS DEPOSITS (terrane descriptions from Wheeler *et al.*, 1991)

TERRANE	DESCRIPTION
Kootenay (Pericratonic)	Intensely defomerd **variably metamorphosed** and poorly dated Proterozoic to Triassic, siliceous clastic sediments, **subordinate volcanics, and limestone**, locally intruded by Ordovician, Devonian and Mississippian granitoid plutons. Some of the deformed lowest Paleozoic rocks appear to be stratigraphically related to ancestral North America whereas the younger, less deformed rocks do not.
Slide Mountain (Accreted Terrane)	Oceanic and marginal basin volcanics and sediments of Devonian to Late Triassic age (are basement to Quesnellia in southern B.C.). Included are chert, argillite, sandstone, conglomerate, mafic intrusions, basalt, **alpine-type ultramafic rocks**, carbonate rocks and local occurrences of blueschist and eclogite. Fossil evidence suggests terrane movement from the south.
Quesnellia (Accreted Terrane)	Upper Triassic and Lower Jurassic arc volcanics, volcaniclastics and comagmatic intrusive rocks **(alaskan-type ultramafic complexes)** overlain by Jurassic arc-derived clastics. Faunas differ from those in coeval, co-latitudinal cratonal rocks.
Cache Creek (Accreted Terrane)	Mississippian to Lower Jurassic oceanic volcanics and sediments, Upper Triassic island-arc volcanics and local accretionary prism melange. Included are radiolarian chert, argillite and basalt, shallow water carbonate and **alpine-type ultramafics**. The Terrane is bounded on the east by the Teslin and Pinchi Faults.
Stikinia (Accreted Terrane)	Devonian to Permian arc volcanics and platform carbonates form the basement to Stikinia. They are overlain by Triasic and Lower Jurassic **arc volcanics**, volcaniclastics, chert and arc-derived clastics which are intruded by comagmatic plutonic rocks. Differing faunas from co-latitudinal cratonal rocks indicate northward terrane displacement.
Bridge River (Accreted Terrane)	Accretionary prism and oceanic crust of Permian to Middle Jurassic age disrupted and variably metamorphosed radiolarian chert, argillite, basalt, **alpine-type peridotite ultramafics** and minor carbonate and diorite.
Chilliwack (Accreted Terrane)	Devonian to Permian **arc volcanics** and clastics overlain by Upper Triassic to Lower Jurassic arc clastics. Permian fusulinid faunas resemble those in Quesnellia and Stikinia.
Shuksan (Accreted Terrane)	Upper Triassic and Lower Jurassic **oceanic crust** and sediments metamorphosed to greenschist and blueschist facies and Jurassic near-arc oceanic marginal basin crust and sediments.
Alexander (Accreted Terrane)	Upper Proterozoic to Triassic **volcanic** and sedimentary rocks in a variety of depositional settings (ocean arc, back arc, platform, rift, trough, offshelf) and **comagmatic intrusions**.

Similar types of mineral deposits of displaced (Cassiar) and/or deformed (Kootenay, Nisling) continental margin terranes support their cratonal linkage. Cross-fibre chrysotile asbestos deposits, such as the ones at Cassiar (104P 005) and McDame (104P 084), developed in alpine peridotites at a specific stage in the evolution of a convergent margin.

Stikinia and Quesnellia, which together constitute the bulk of the Intermontane Superterrane are characterized by their predominantly calcalkalic volcanic arc composition. The ophiolitic Cache Creek and Slide Mountain terranes display distinctive kinds of mineral deposits typical of their oceanic origin. The Coast Belt is characterized by diverse terrane of dominantly volcanic arc character. The lithologies of both Wrangellia and the Alexander Terrane of the Insular Super terrane represent several depositional settings: ocean arc volcanics, oceanic rift volcanics, carbonate strata and platformal sediments.

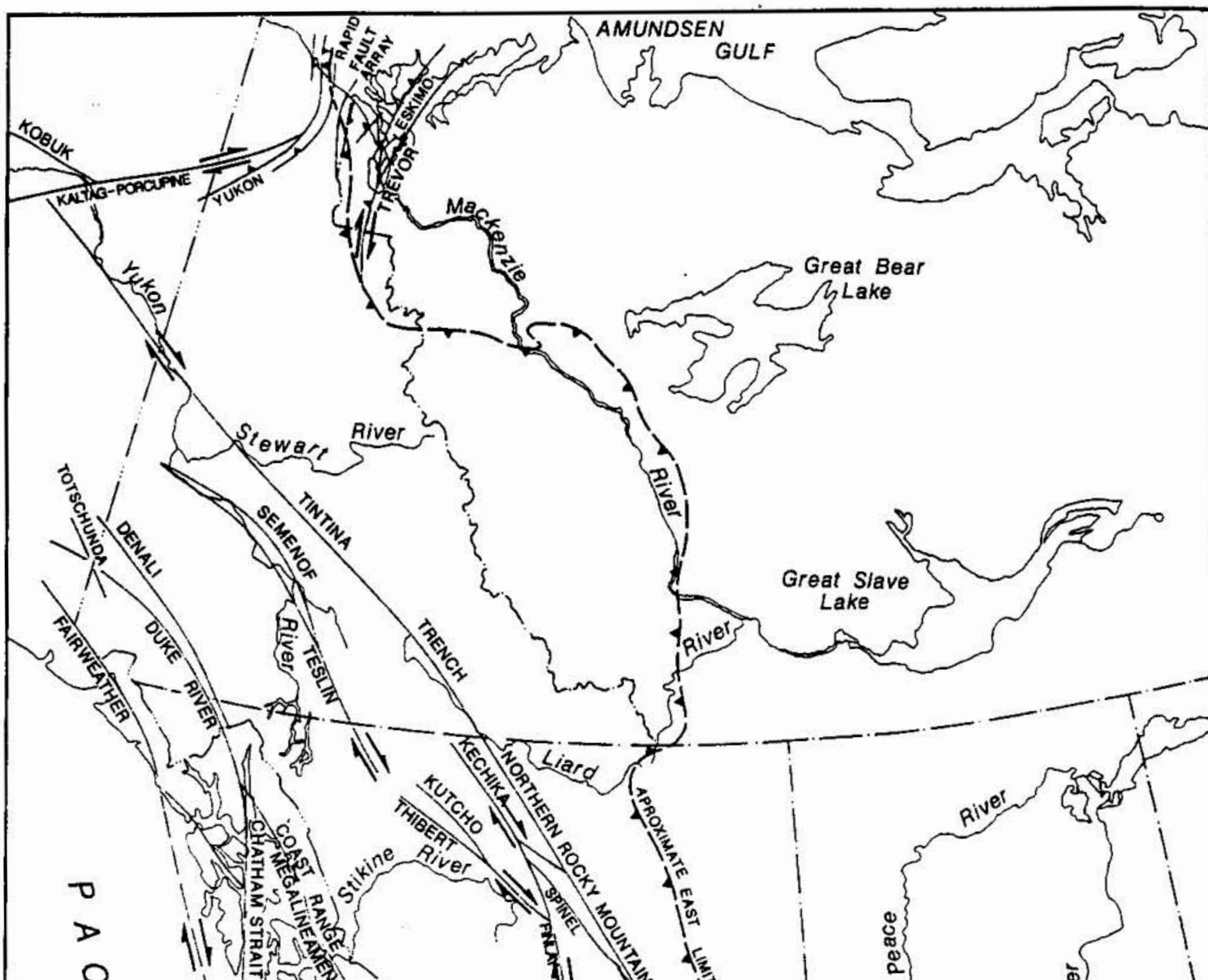


FIGURE 3: MAIN TRANSCURRENT FAULTS OF THE CANADIAN CORDILLERA

The distribution of asbestos occurrences in British Columbia is equally as important as the emplacement history of those allochtonous segments of serpentinized ultramafic crust which predominantly host them. This can be considered in relation to the time of terrane accretion as pre-accretionary, accretionary, and post-accretionary. Deposits formed prior to subsequent accretion to the North American craton may have undergone significant modification and redistribution due to the accretionary metamorphic, pultonic and hydrothermal processes.

CHRYSOTILE ASBESTOS IN BRITISH COLUMBIA

Documented chrysotile showings or deposits make up 55 % of all known British Columbian asbestos occurrences. Due to the significant volume of chrysotile the commodity accounts for over 90 % of all the asbestos known to exist in the province. Unidentified asbestos showings account for 23 %.

Most asbestiform serpentine (chrysotile) occurrences share a common form, host rock, and paragenesis. In British Columbia economically viable chrysotile deposits are invariably found within fault bounded slices of ophiolitic ultramafic rocks (i.e. Cassiar and McDame). Chrysotile showings, of little or no economic value also occur in both contact metamorphosed siliceous dolomites and in serpentinized portions of Alaskan-type ultramafic bodies.

Associated mineralogy is serpentine. Paragenesis is by: (1) retrograde hydrothermal alteration of ultramafic rocks (dunites, pyroxenites, peridotites - rocks of igneous origin low in silica and high in iron and magnesia content); or (2) in metamorphosed crystalline limestone adjacent to intrusive contacts of basic igneous sills and dikes.

Associated or concurrent commodities are: serpentine, chromite, magnetite, talc and magnesite. These do not necessarily exist in every asbestos occurrence.

Chrysotile usually occurs as a network of scarce, widely separated, narrow veinlets within serpentinized ultramafic rock. Veins vary in thickness from 1.6 millimetres and less to as much as 7.5 centimetres or more, though seldom exceed 19 millimetres. Chrysotile occurs mostly as cross-fibre (the fibres are arranged perpendicular to the plane of the vein). Fibres are usually shorter than 3.2 millimetre.

AMPHIBOLE ASBESTOS IN BRITISH COLUMBIA

Amphibole asbestos occurrences in British Columbia are relatively scarce when compared to those of chrysotile. Out of all of the asbestiform amphibole minerals only actinolite, tremolite, anthophyllite and one occurrence of crocidolite have been reported to date in the province. Two amphibole deposits, an anthophyllite occurrence at Shuttleworth Creek and an actinolite occurrence at Waleach (Jones) Creek, have had exploration work done on them.

Geological environments which favour the development of amphibole asbestos mineralization are: reaction zones between serpentinized peridotites and anthophyllite-talc schists, metamorphosed dolomitic limestones, and metamorphosed iron rich sediments. Of these three, only the first two are found in British Columbia. The amphibole asbestos minerals are generally found as slip-fibre aggregates in metamorphosed crystalline schists of high magnesia content.

Within the Canadian Cordillera asbestiform amphibole also occurs in variably metamorphosed metavolcanics of the Stikinia Terrane. The age of mineralization may be influenced by the Cretaceous-Tertiary intrusive events of the Coast Belt.

There has been no commercial production of amphibole asbestos in British Columbia. The potential for commercial deposits seems to be low.

EXPLORATION GUIDLINES FOR ASBESTOS DEPOSITS

To date, the occurrence of economically viable asbestos deposits in British Columbia occurs almost exclusively in the fault-bounded alpine-type serpentinite bodies of the Canadian Cordillera.

Lamarche and Riordan in their 1981 paper on The Geology and Genesis of the Chrysotile Asbestos Deposits of Northern Appalachia set out a number of exploration guidelines for the exploration of new chrysotile asbestos deposits. The guidelines below have been modified to suit asbestos exploration in British Columbia. Not all of the following geological conditions are necessary for the development of asbestos deposits.

1. Where ultramafic rocks consist of partly or totally serpentinized peridotite (harzburgite), or exceptional dunite.

2. Where the ultramafic rock shows an unusually high magnetic background.

3. Where signs of tectonic movements such as faults, shear zones, fracture zones, brecciation, or serpentine veins are visible.

4. In those parts of ultramafic units that rest close to their cratonward contact.

5. A short distance away from major irregularities in this contact or in the thickness of the ultramafic unit.

6. Where the cratonward contact is vertical, dips steeply away from the craton, or dips towards the craton.

7. Where abundant granitic masses intrude the ultramafic rocks.

8. Where the mineral assemblages in the serpentinized ultramafites consist of associations such as nonpseudomorphic interpenetrating textures of chrysotile ± brucite, or antigorite ± brucite.

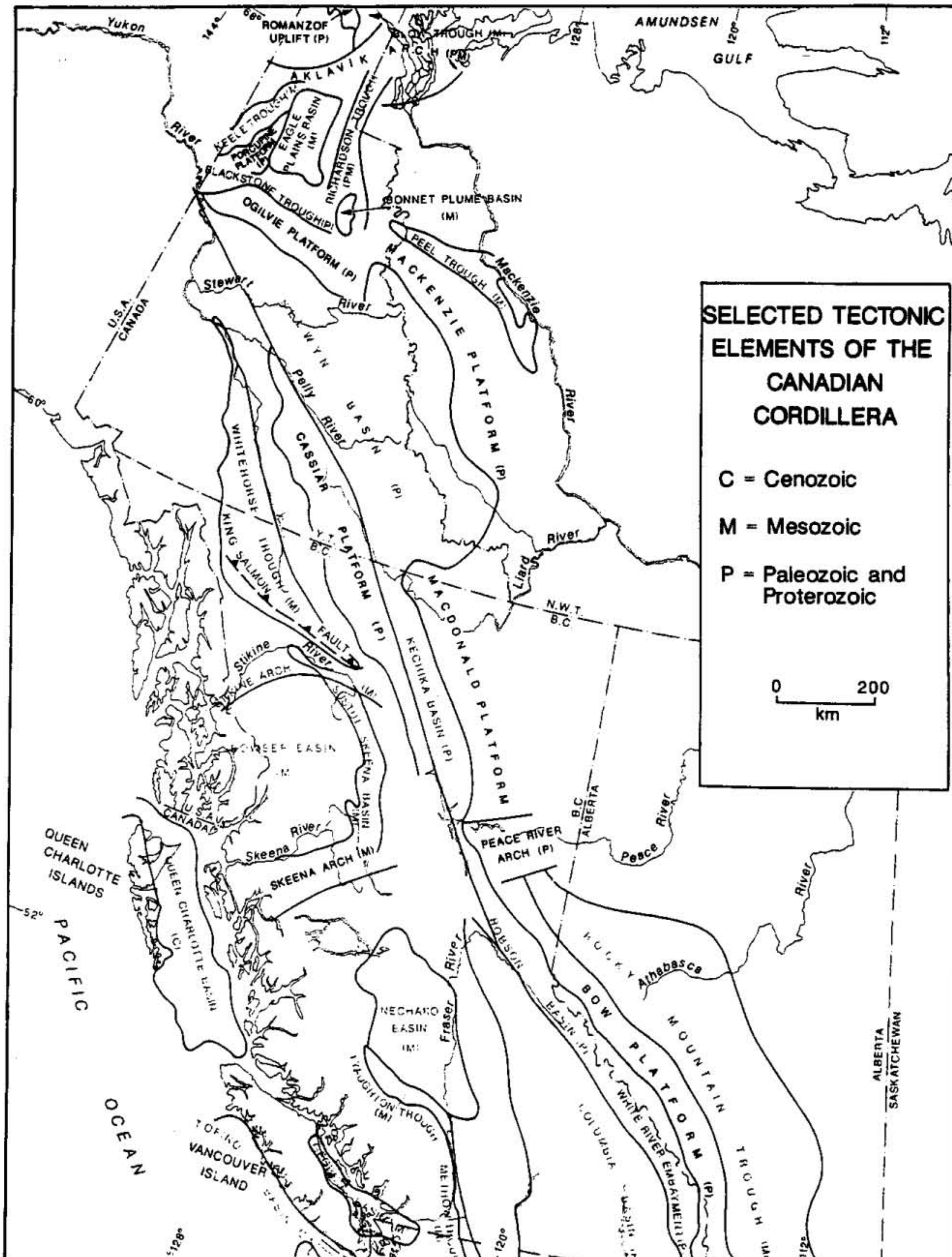


FIGURE 4: PHYSIOGRAPHIC FEATURES OF THE CANADIAN CORDILLERA

INSULAR SUPERTERRANE

Alsek Ranges

Within the Alsek Ranges two asbestos fibre showings occur along a contact between serpentinized peridotite and Upper Paleozoic carbonates.

NO. 1

NTS MAP: 114P14E

NAME: SQUAW VALLEY (1)
MINFILE NUMBER: 114P 060

LAT/LONG: 59° 57' 40" / 137° 01' 15"
ELEVATION: data not available

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Alexander
TECTONIC BELT: Insular

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

At the Squaw Valley showing a good grade asbestos fibre was reported to occur in narrow veinlets, within the serpentine, along a limestone-serpentine contact near the headwaters of Squaw Creek. The limestone may be Upper Paleozoic or Upper Triassic in age. (**EMPR AR** 1962; **GSC OF** 926; **EMPR ASS RPT** 13521, 14742)

NO. 2

NTS MAP: 114P10E

NAME: NADAHINI MOUNTAIN (2)
MINFILE NUMBER: 114P 028

LAT/LONG: 59° 40' 15" / 136° 42' 45"
ELEVATION: data not available

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Alexander
TECTONIC BELT: Insular

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

Two elongate, tabular ultramafic bodies, 15 and 30 metres thick, are in contact with Upper Paleozoic carbonates on the southwest slope of Nadahini Mountain. The ultramafic bodies strike southeast and dip about 60 degrees northeast. In a zone of serpentinizartion veinlets of poor quality cross-fibre chysotile up to 2.5 centimetres in length have been documented. (**EMPR BULL** *25; **GSC OF** 926)

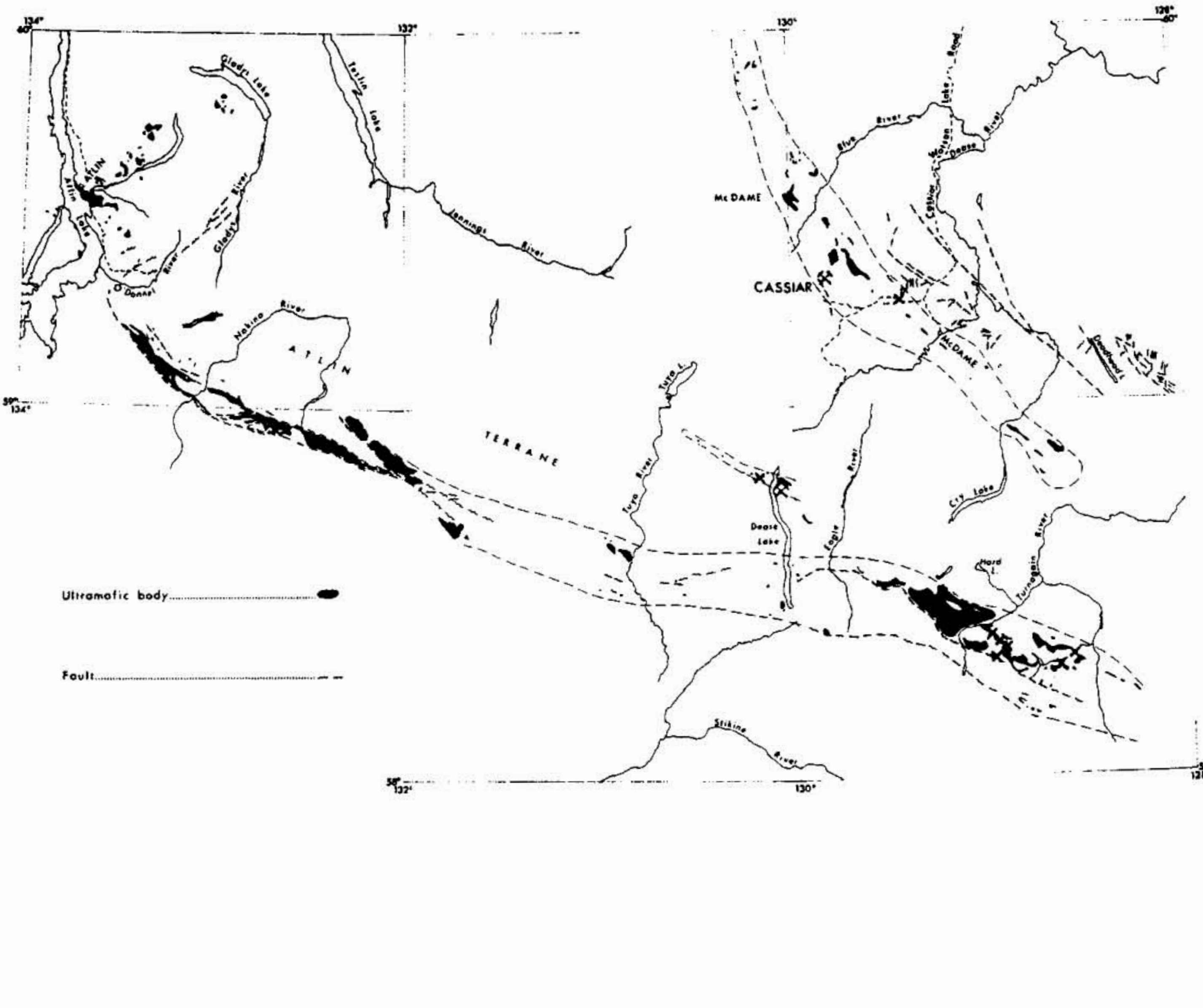


FIGURE 5: DISTRIBUTION OF ULTRAMAFICS, NORTHERN B.C., ATLIN AND CASSIAR AREAS
(modified from Leaming, 1978)

INTERMONTANE SUPERTERRANE

Atlin Ultramafic Allochthon

The origin and tectonic setting of the ophiolitic ultramafic rocks in and around the Atlin area of British Columbia has been summarized by Ash (1994). Both asbestiform amphibole and serpentine showings and prospects occur within the Atlin Ultramafic Belt. The following excerpts from Bulletin 94 will hopefully succinctly educate the reader on the geologic setting of the area.

The allochthonous remnants of a late Paleozoic to early Mesozoic Tethyan ocean (Monger, 1975, 1977a, b; Monger *et al.*, 1982) are represented in the northern Cache Creek Terrane by the Atlin Accretionary Complex and Atlin Ophiolitic Assemblage. The ophiolitic assemblage of the Atlin area is comprised of individual thrust slices which form part of an imbricated package of late Paleozoic oceanic crust and lithologies. This ophiolitic assemblage was obducted onto the subduction-related Atlin accretionary complex during the Middle Jurassic collision of Stikinia with North America. The timing of this event is well constrained in Northern British Columbia by both stratigraphic evidence (Gabrielse, 1991; Ricketts *et al.*, 1992) and the age of the cross-cutting plutons (Mihalynuk *et al.*, 1992).

Ultramafic rocks include foliated harzburgite, subordinate dunite pods and peridotite cummulates, and wherlite. All ultramafic rocks show evidence of strong serpentinization or carbonate alteration The serpentinized ultramafic rocks mark fault zones of deep crustal origin (Hoffman, 1990). These lithotectonic elements are intruded granodiorite to granitic batholiths and related dike rocks of Middle Jurassic, Cretacous and Lower Tertiary age. The fault zones and intrusions are intimately associated with the development of asbestos mineralization.

The Atlin Ultramafic Allochthon is part of the Intermontane Superterrane. It is located physiographically to the northeast in the Teslin Plateau, and to the southwest in the Taku Plateau. Both areas are host to asbestos showings.

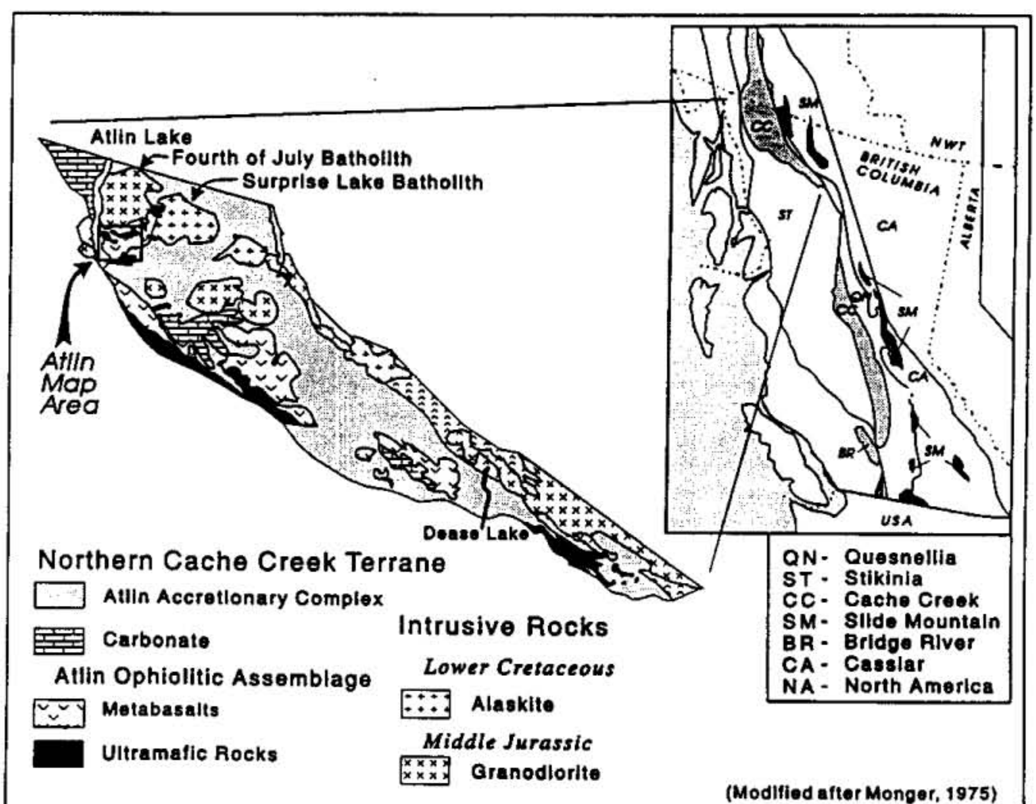


FIGURE 6: REGIONAL GEOLOGY SETTING OF THE ATLIN MAP AREA (Ash, 1994)

Teslin Plateau

The Teslin Plateau area is host to three asbestos showings, none of which have any significant economic value. Pub (3) and Pereye Asbestos (4) are asbestiform amphibole (tremolite) showings while Monarch Mountain (5) is reported to be cross-fibre asbestiform serpentine (chrysotile) showing. All three are located within the Pennsylvanian to Permian serpentinized peridotites of the Atlin Ultramafic Allochthon.

NO. 3 & 4

NTS MAP: 104N11W

NAME: PUB (3)
MINFILE NUMBER: 104N 055
LAT/LONG: 59° 43′ 30″ / 133° 19′ 43″
ELEVATION: 1500 m

NAME: PEREYE ASBESTOS (4)
MINFILE NUMBER: 104N 124
LAT/LONG: 59° 42′ 44″ / 133° 19′ 19″
ELEVATION: 1750 m

LOCATION: At the headwaters of Cracker Creek which drains eastward into the north end of Surprise Lake.
STATUS: Asbestiform Amphibole (Tremolite) Showings
HOST UNIT: Atlin Ultramafic Allochthon
DEPOSIT TYPE: Veins
TERRANE: Cache Creek
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinized Peridotite

The area is underlain by porphyritic alaskite to quartz monzonite of the Early Cretaceous Surprise Lake Batholith. These rocks have intruded serpentinized peridotites of the Atlin Ultramafic Allochthon and Mississippian to Triassic Cache Creek Group rocks. The Cache Creek Group is represented by cherts and argillites of the Carboniferous Kedahda Formation and greenstone of the Mississippian to Pennsylvanian Nakina Formation. The ultramafics are spatially related to Nakina Formation mafic volcanics and, according to Monger (GSC Paper 74-47), they may also be genetically related.

At Pib (3) a minor zone of serpentinite contains thin seams of asbestos (tremolite?). Veins of the asbestiform amphibole tremolite cut the ultramafic body in the northwestern part of the Pereye claim(4). The veins are from 0.5 to 4.0 millimetres wide and have a density of 6 veins per metre. (**EMPR EXPL** 1979; **EMPR ASS RPT** 2541, 7278, 8049; **GSC MEM** 307; **GSC P** 74-47; **GSC MAP** 1082A; **GSC OF** 1565)

NO. 5

NTS MAP: 104N12E

NAME: MONARCH MOUNTAIN (5)
MINFILE NUMBER: 104N 050
LOCATION: 4.0 kilometres southwest of Atlin.
LAT/LONG: 59° 32′ 36″ / 133° 36′ 54″
ELEVATION: 1533m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showings
HOST UNIT: Atlin Ultramafic Allochthon
DEPOSIT TYPE: Veins
TERRANE: Cache Creek
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinized Peridotite

The Monarch Mountain area is underlain by a large body of ultramafic rocks composed largely of variably altered peridotite of the Atlin Ultramafic Allochthon. The lower southern and eastern slopes of Monarch Mountain are transected by the Monarch Mountain Thrust. This thrust defines the structural base of the ultramafic allochthon and the tectonic contact between the upper Atlin ophiolitic assemblage and the underlying accretionary complex (Ash, 1994).

The asbestos occurrence consists of narrow veinlets from 3 to 6 millimetres wide composed of rather harsh, cross-fiber chrysotile material. The best showing comprises a 3 metre wide zone with numerous parallel veinlets. Numerous other patches containing similar fibers are present in the area. Several gold occurrences have been prospected in the area since the discovery of placer gold on Pine Creek and during this time, the asbestos occurrences on Monarch Mountain was discovered. The showing received minor attention in 1950 and 1980. (**EMPR AR** 1951, 1960; **EMPR ASS RPT** 53, 9055; **GSC MEM** 307; **GSC P** 74-47)

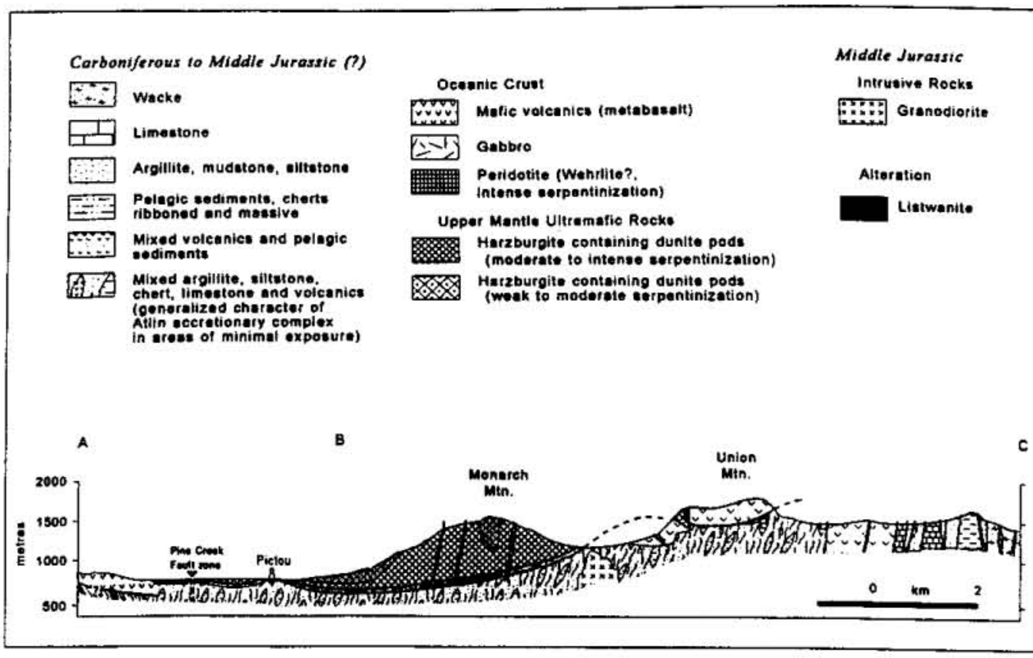


FIGURE 7: SCHEMATIC GEOLOGICAL CROSS SECTION OF THE ATLIN AREA (Ash, 1994)

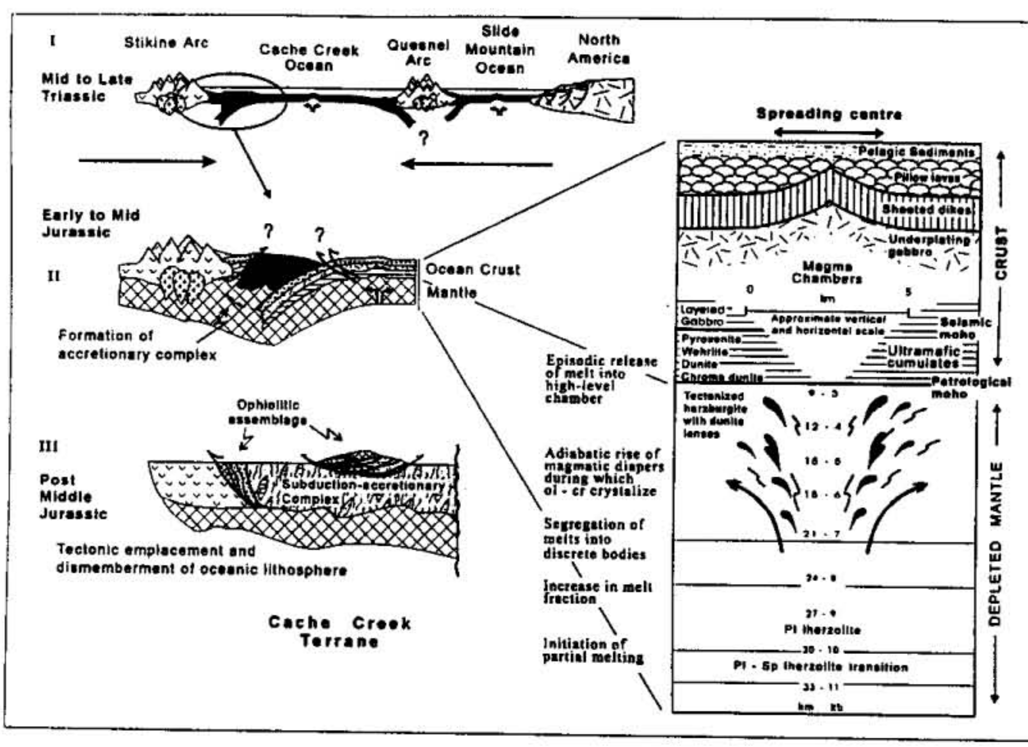


FIGURE 8: ORIGIN AND EMPLACEMENT OF ATLIN AREA OPHIOLITIC ULTRAMAFICS (Ash, 1994)

Taku Plateau

The Taku Plateau hosts 1 developed prospect and 8 showings of asbestiform serpentine (chrysotile), and 1 asbestos showing of unidentified mineralogy. Next to the Cassiar Mountain Area this region exhibits a high potential for asbestos mineralization. The occurrences are found to the north within the Atlin Ultramafic Allochthon and to the south within the Pennsylvanian to Permian Nahlin Ultramafic Body.

The Nahlin Ultramafic body is a 100 kilometres long and up to 8 kilometres wide alpine-type ultramafic. Though partly disrupted, the lithologies are characteristic of ophiolitic assemblages (Terry, 1977). On the southwest it is faulted against Triassic volcanic and Jurassic sedimentaray rocks, and on the northeast against upper Paleozoic rocks of the Cache Creek Group. The ultramafic body and the surrounding volcanics and sediments are intruded by the Nakina River stock, a quartz diorite pluton.

The Nahlin Fault zone is complex and appears to result from several episodes of deformation. It is characterized by a series of high-angle, northeasterly-dipping or almost vertical faults. Carbonatized serpentine masses occur along most of the length of the body.

NO. 6, 7 & 8

NTS MAP: 104N03E, 104N03W

NAME: CHIKOIDA MOUNTAIN (6)
MINFILE NUMBER: 104N 070
LOCATION:

LAT/LONG: 59° 14′ 00″ / 133° 00′ 00″
ELEVATION: 1524 m

NAME: FOCUS MOUNTAIN (7)
MINFILE NUMBER: 104N 071
LOCATION:

LAT/LONG: 59° 08′ 36″ / 133° 07′ 00″
ELEVATION: 1370 m

NAME: COP (8)
MINFILE NUMBER: 104N 049
LOCATION:

LAT/LONG: 59° 09′ 35″ / 133° 23′ 18″
ELEVATION: 1000 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showings
HOST UNIT: Nahlin Ultramafic Body (Atlin Ultramafic Allochthon) **DEPOSIT TYPE:** Veins
TERRANE: Cache Creek
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinized Peridotite

The area is underlain by the northeast contact of the Permo-Pennsylvanian Nahlin Ultramafic body of the Atlin Ultramafic Allochthon within Mississippian to Triassic Cache Creek Group rocks. The Cache Creek Group is represented by cherts and argillites of the Upper Mississippian to Upper Pennsylvanian Kedahda Formation and altered green basalt of the Lower Mississippian to Middle Pennsylvanian Nakina Formation. The ultramafics are spatially related to Nakina Formation rocks and Monger (GSC Paper 74-47) believes that they may also be genetically related. Small bodies of Lower Tertiary granodiorite and granophyre (Tertiary?) intrude the ultramafics locally.

At the Chikoida Mountain (6) and on Focus Mountain (7) asbestos fibre (chrysotile?) mineralization occurs in Atlin Ultramafic Allochthon rocks near contact of Early Tertiary granitic intrusions.

At the COP (8) showing some fibres of chrysotile asbestos were observed in serpentine just north of the Sloko River and southwest of Mount O'Keefe. (**EMPR ASS RPT** 321, *1231, 14090; **EMPR AR** 1960, 1967; **EMPR EXPL** 1985-C397; **GSC P** 74-47**GSC MEM** 307; **GSC MAP** 1082A, 1418A; **GSC OF** 1565; **DIAND OF** *1990-4; Cordey, F. *et al*,1987)

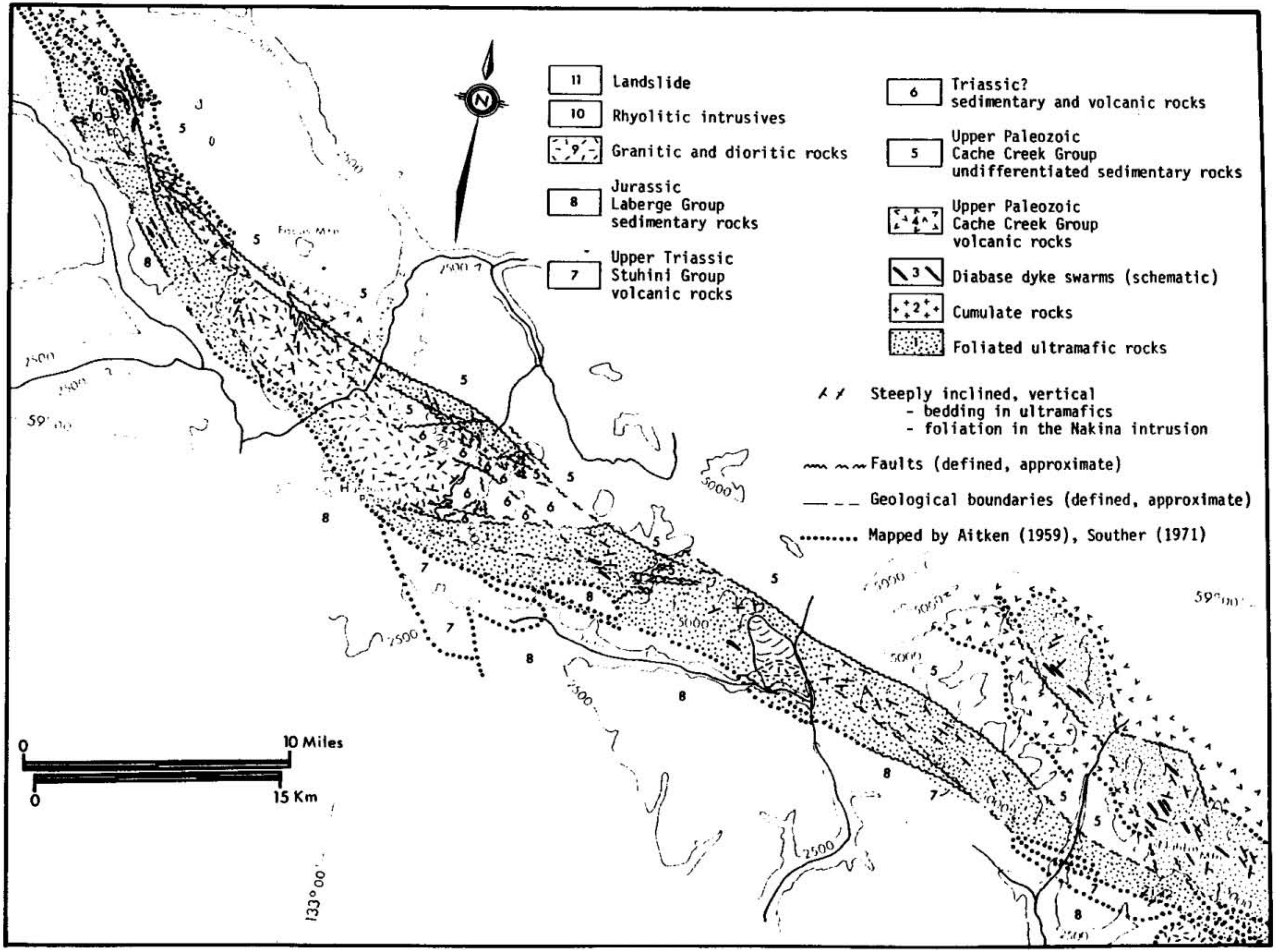


FIGURE 9: GEOLOGICAL MAP OF THE NAHLIN ULTRAMAFIC BODY (Terry, 1977)

NO. 9, 10, 11, 12, 13 & 14 **NTS MAP:** 104K15E, 104K16E,W

NAME: <u>YETH CREEK ASBESTOS (9)</u> **LAT/LONG:** 58° 57' 32" / 132° 34' 13"
MINFILE NUMBER: 104K 066 **ELEVATION:** 1400 m
LOCATION: Near the headwaters of Yeth Creek on the east-southeastern flanks of Peridotite Peak.

NAME:<u>MENATATULINE RANGE (10)</u> **LAT/LONG:** 58° 56' 57" / 132° 13' 39"
MINFILE NUMBER: 104K 044 **ELEVATION:** 1600 m
LOCATION: Menatatuline Range near Victoria Lake.

NAME: <u>MAGNET (11)</u> **LAT/LONG:** 58° 54' 30" / 132° 11' 46"
MINFILE NUMBER: 104K 024 **ELEVATION:** 1070 m
LOCATION: 300 metres east of Teditua Creek on a small tributary creek, on the northwest flanks of Nahlin Mountain.

NAME: <u>ACE (12)</u> **LAT/LONG:** 58° 52' 57" / 132° 06' 56"
MINFILE NUMBER: 104K 025 **ELEVATION:** 1525 m
LOCATION: 19 km southeast of Victoria Lake, Menatatuline Range, along Camp Creek, a tributary of Tseta Creek.
COMMENTS: Estimated fibre potential from surface work (1966): 11793401 Tonnes of asbestos at a grade of 5%.
REFERENCE: Assessment Reports 1030, 4913.

NAME:<u>TEDITUA CREEK (13)</u> **LAT/LONG:** 58° 52' 31" / 132° 20' 46"
MINFILE NUMBER: 104K 043 **ELEVATION:** 1300 m
LOCATION: Along the Nahlin Fault

NAME: <u>NAHLIN (14)</u> **LAT/LONG:** 58° 49' 46" / 132° 05' 23"
MINFILE NUMBER: 104K 065 **ELEVATION:** 1200 m
LOCATION: Southern flanks of Nahlin Mountain, north of the Nahlin River.

STATUS: Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Showings & Developed Prospect (Ace (12))
HOST UNIT: Nahlin Ultramafic Body (Atlin Ultramafic Allochthon) **DEPOSIT TYPE:** Vein & Stockwork
TERRANE: Cache Creek **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinized Peridotite

The Taku Plateau area is underlain by the Pennsylvanian to Permian Nahlin ultramafic body which is part of a large belt of ultramafics that parallel the southwestern side of the Atlin Horst. It forms two long, narrow prongs that converge in an acute angle at Nahlin Mountain. The longer axis of the body trends west-northwest from Nahlin Mountain to Peridotite Peak, paralleling the Nahlin fault. The small axis trends northwest from Nahlin Mountain into the Menatatuline Range.

The ultramafics consist of dark green to black peridotite containing fine-grained, partly serpentinized olivine, orthopyroxene, augite, and chrome spinel. The pyroxene forms discrete crystals and crystal clusters ranging from 0.3 to 1.3 centimetres across. The principal variation in the body is the degree of serpentinization .

Exposed contacts between the Nahlin ultramafic body and layered Jurassic and Triassic rocks are invariably marked by fault zones adjacent to which the peridotite has been sheared and serpentinized. The Nahlin fault, which bounds the southwestern margin of the body, comprises a subparallel network of anastomosing shear planes and fractures with steep northerly or vertical dips.

Along the Nahlin Fault at Yeth Creek Asbestos (9), Menatatuline Range (10) and Teditua Creek (13) the highly serpentinized rock contains a filigree of fine chrysotile veinlets usually less than 1 millimetre across. At the head of Yeth Creek (9), prospectors report an occurrence of commercial quality chrysotile, in veins containing slip fibre up to 2 centimetres. Generally, most of the asbestos occurrences host short, brittle fibre of little commercial value.

Adjacent to this major fault network the serpentinized peridotite has also been carbonitized (listwanite). Ankerite is the principal carbonate but veins of pure white, microgranular magnesite and coarsely crystalline dolomite are also present. Where serpentinization is complete, veinlets of antigorite blades with disseminated magnetite grains also occur.

The chrysotile occurrence at Magnet (11) is within pyroxenite which is slightly serpentinized and has phenocrysts of pyroxene up to 0.9 centimetres in diameter. The chrysotile occurs in both walls of a small stream canyon and is intermittently exposed for a distance of 35 metres along the canyon. Chrysotile occurs in varying amounts throughout this section in small discontinuous veinlets and boxwork structures which contain fibre generally less than 0.6 centimetres in length. A 0.3 metre section near the centre of the fibre zone, which is an intersection of two faults contains approximately 20 % fibre that averages 0.6 centimetres in length. The longest fibre noted was 1.3 centimetres long. Several of the chrysotile veins average 2.5 centimetres in width, but parting of the longest, strong fibres in these veins is common. Magnetite occurs along the fibre vein walls and at the parting planes within the vein. Veins of serpentine occasionally containing discontinuous veins of chrysotile occur in the vicinity of the fibre zone. Less magnetite is present here. Calcite veinlets also occur infrequently in fractures in the pyroxenite.

Also at Magnet (11) diorite dikes were noted to crosscut the ultramafic mass. A 1.5 metre wide diorite dike, located immediately west of the chrysotile occurrence, was noted to host traces of pyrrhotite.

Ace (12) is the only developed prospect within the Taku Plateau area. The asbestos fibre occurrence lies within pyroxenite which is slightly serpentinized and host phenocrysts of pyroxene. All of the ultramafic rocks are well jointed and are crosscut by felsic dikes.

The main fibre zone, at Ace (12) occurs on the north side of Camp Creek and consists of a continuous zone about 122 by 60 metres, containing greater than 5 % chrysotile with fibre lengths averaging about 2 centimetres. Another possible continuous fibre zone is located on the south side near the headwaters of Camp Creek. An extensive shear zone, about 305 metres long and 30 metres wide, has resulted in the rocks of the immediate area being serpentinized. There are three major shears in the area that branch off to the northwest which have also resulted in local serpentinization of the rocks.

The chrysotile fibre at Ace (12) occurs in two rock types. Firstly, as stockworks in the highly serpentinized zones and secondly, as lenses within the serpentinized peridotite which, in turn, are situated in peridotite with pyroxene phenocrysts. Disseminated magnetite occurs in the vicinity of the serpentinized zones and is associated with the chrysotile fibre veinlets. In 1966, it was estimated from surface work that the fibre zone had a potential of up to 11,793,400 tonnes of ore (Assessment Reports 1030, 4913).

On the southern flanks of Nahlin Mountain, along the Nahlin River, faulted blocks of serpentinized peridotite are in contact with Permian Horsefeed limestone, dolomitic limestone and argillite. At Nahlin (14) the peridotite contains small veinlets up to 1.5 centimetres wide of chrysotile and serpentine. As well, small quartz-carbonate veinlets hosting disseminated pyrite occur within the altered peridotite adjacent to a Jurassic and/or Cretaceous hornblende diorite intrusive. (**EMPR GEM** 1973; **EMPR AR** 1966; **EMPR ASS RPT** 1030, 1925, 4913, 7610; **GSC MEM** 362; **GSC MAP** 6-1960, 1262A; **GSC P** 74-47)

NO. 15

NTS MAP: 104J12W

NAME: <u>DUDIDONTU RIVER</u>
MINFILE NUMBER: 104J 030
LOCATION: 96 km north of the community of Telegraph Creek.

LAT/LONG: 58° 40′ 44″ / 131° 45′ 38″
ELEVATION: 1219 m

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Cache Creek
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

Numerous small veins of asbestos are noted cutting serpentinite in the centre of an ultramafic body located northwest of Hatin Lake. Asbestos fibre does not exceed 3 millimetres in length. (**EMPR AR** 1960; **GSC SUM RPT** 1925; **GSC MAP** 9-1957, 21-1962, 1418A; **GSC OF** 707)

Tanzilla Plateau

The asbestos occurrences within the Tanzilla Plateau Area straddle the Kutcho Fault. Most of the occurrences in the area are confirmed asbestiform serpentine (chrysotile) showings and are associated with fault-bounded ultramafic bodies extending diagonally across the map area (Figure 10). The ultramafic are mainly serpentinized pyroxenite, wherlite with small bodies of dunite, pyroxenite and dunite.

The most important occurrence is the developed prospect at Letain (28) which has possible geological reserves of 15700000 tonnes grading 4.7 % cross-fibre chrysotile asbestos at a 3 % asbestos fibre cutoff to the 1600 metre level (Prospectus, Cassiar Mining Corporation, December 5, 1985).

NO. 16

NTS MAP: 104O06W

NAME: ATSUTLA RANGE (16)
MINFILE NUMBER: 104O 019
LOCATION: 3.2 km northest of Kedaho Lake.
LAT/LONG: 59° 19′ 00″ / 131° 26′ 50″
ELEVATION: data not available

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Slide Mountain
TECTONIC BELT: Omineca
DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

On the Atsula Range of the Tanzilla Plateau of northern British Columbia, a steeply dipping, serpentinite body about 2 kilometres long and 90 metres wide occurs conformably to the trend of a Permo-Carboniferous metasedimentary sequence of the Kedahda Formation. In a few places the serpentinite is intersected by narrow veinlets of cross-fibre chrysotile. (**EMPR BULL** 19; **GSC MAP** 18-1968; GSC P 68-55; **GSC OF** 561)

NO. 17

NTS MAP: 104J15W

NAME: CALATA LAKE (17)
MINFILE NUMBER: 104J 037
LOCATION: west of Calata Lake, about 74 kilometres northwest of the community of Dease Lake..
LAT/LONG: 58° 49′ 00″ / 130° 58′ 00″
ELEVATION: 1248 m

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Cache Creek
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Vein?
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite?

An asbestos showing is reported to be located just west of Calata Lake. This area is shown to be underlain by basalt, tuff, agglomerate, minor chert and argillite of the Permian French Range Formation (Cache Creek Complex). (**GSC MAP** 9-, 21-1962, 15-1968, 1418A; **GSC P** 68-48; **GSC OF** 707, 2779; **EMR MP CORPFILE *MRF** 216 (1968); **EMPR PF** (104J General File - Claim map 73M, Dec. 1970))

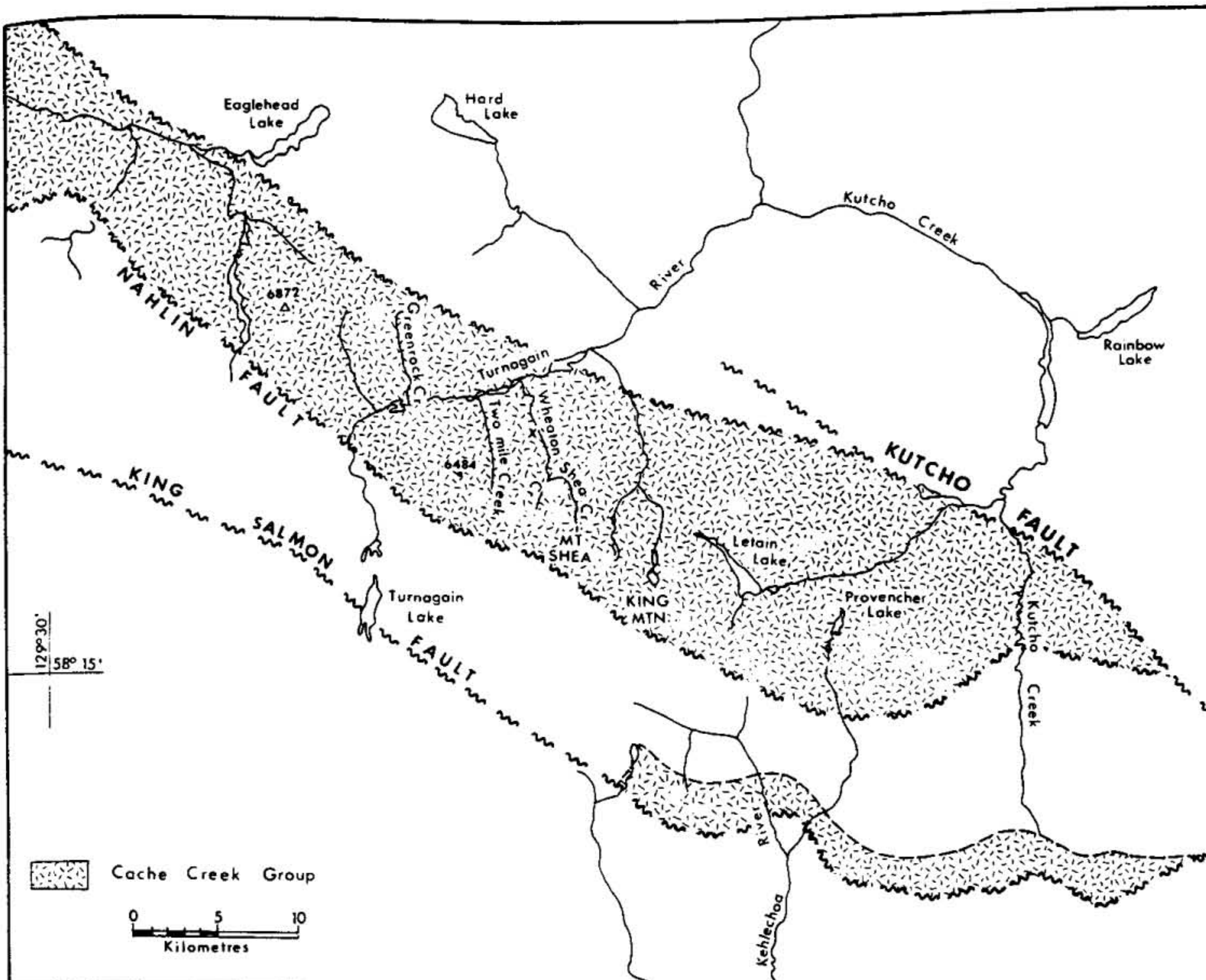


FIGURE 10: GEOLOGY OF THE TANZILLA PLATEAU (Leaming, 1978)

NO. 18 **NTS MAP:** 104J16E

NAME: DEASE LAKE (18) **LAT/LONG:** 58° 46′ 04″ / 130° 05′ 32″
MINFILE NUMBER: 104J 029 **ELEVATION:** 884 m
LOCATION: Trenches, on the east side of Dease Lake near its north end.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Cache Creek Complex **DEPOSIT TYPE:** Vein
TERRANE: Cache Creek **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinite

At the Dease Lake showing, chrysotile asbestos occurs as very small veins in Upper Mississippian-Permian serpentinite of the Cache Creek Complex referred to as the King Mountain ultramafics (Leaming, 1980). Serpentinite occurs adjacent to the Thiebert Creek fault(**GSC MAP** 9-1957; 21-1962; 15-1968; 1418A; GSC P 68-48; **GSC OF** 707; 2779; **GSC SUM RPT** 1925; S(Whiting, B.H. (1980): Report on Physical Work for the Ellert Project; 104J General File - Claim map 73M, Dec. 1970)

NO. 19 & 20 **NTS MAP:** 104I12W

NAME: JAY (19) **LAT/LONG:** 58° 41′ 42″ / 129° 52′ 00″
MINFILE NUMBER: 104I 018 **ELEVATION:** 1300 m
LOCATION: 3.2 km east of Halfmoon Lake.

NAME: EYE (20) **LAT/LONG:** 58° 41′ 06″ / 129° 50′ 12″
MINFILE NUMBER: 104I 017 **ELEVATION:** 1400 m
LOCATION: 4.02 km east of Halfmoon Lake.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Cache Creek Complex? **DEPOSIT TYPE:** Vein
TERRANE: Cache Creek **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinized Peridotite

At Jay (19) and Eye (20) cross-fibre chyrsotile asbestos, up to 1 centimetre in length, occurs sparingly in serpentinized peridotite. The serpentine outcrops show a northwest trend with a probable southwest dip of 50-80°. In 1971 the American Smelting and Refining Company performed surficial geological mapping, and a magnetometer survey over the Jay claims.(**EMPR AR** 1960; **EMPR GEM** 1970, 1971; **EMPR ASS RPT** 315, 1649, 3082, 3363; **GSC MAP** 1962-29)

NO. 21 **NTS MAP:** 104J10W

NAME: TUYA (21) **LAT/LONG:** 58° 37′ 04″ / 130° 52′ 28″
MINFILE NUMBER: 104J 003 **ELEVATION:** 949 m
LOCATION: Between Tachilta Lakes and the Tuya River, 60 km west-northwest of the community of Dease Lake.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Cache Creek Complex **DEPOSIT TYPE:** Vein
TERRANE: Cache Creek **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinized Peridotite

Cross-fibre veins of chrysotile asbestos occur in a body of serpentinized peridotite located between Tachilta Lakes and the Tuya River. The Upper Mississippian-Permian ultramafic body is part of the Cache Creek Complex and is about 4.8 kilometres long and 0.8 kilometre wide.

Chrysotile veins wider than 3 millimetres appear to be spaced at least one to every 0.8 square metre and in numerous places are found several per 0.09 square metre. The veins cover a 182 to 274 metre area. Many of the veins have a central parting, but clean 1.2-centimetre fibre is abundant. The largest fibre noted was about 3.1 centimetres in length. (**EMPR PF** (104J General File - Claim maps 73M, 73M-3, Dec. 1970); **EMPR AR** 1960; **EMPR ASS RPT** 293, 316, 3772; GSC OF 707, 2779; **GSC MAP** 9-1957, 21-1962, 15-1968, 1418A; **GSC P** 68-48)

NO. 22 & 23 **NTS MAP:** 104J09E, 104I12W

NAME: BAK (22) **LAT/LONG:** 58° 35′ 00″ / 130° 01′ 00″
MINFILE NUMBER: 104J 033 **ELEVATION:** 914 m
LOCATION: 1.25 km east of Dease Lake and about 2 km northeast of Nine Mile Point.

NAME: SERPENTINE CREEK (23) **LAT/LONG:** 58° 35′ 00″ / 129° 58′ 00″
MINFILE NUMBER: 104I 084 **ELEVATION:** 1000 m

STATUS: Asbestos Showing
HOST UNIT: Cache Creek Complex **DEPOSIT TYPE:** Vein
TERRANE: Cache Creek **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinized Peridotite

At the Bak (22) showing, asbestos occurs in serpentinized peridotite. Geological Survey of Canada Open File 2779 indicates the area is underlain by Upper Mississippian-Permian, generally serpentinized peridotite, dunite and pyroxenite of the Cache Creek Complex. (**EMPR GEM** 1971; **GSC MAP** 9-1957, 21-1962, 15-1968, 1418A; **GSC OF** 707, 2779; **GSC SUM RPT** 1925; **GSC P** 68-48)

NO. 24, 25 & 26 **NTS MAP:** 104I06W, 104I06E

NAME: ASB 8 (24) **LAT/LONG:** 58° 29′ 24″ / 129° 15′ 06″
MINFILE NUMBER: 104I 044 **ELEVATION:** 1433 m

NAME: ASB 4 (25) **LAT/LONG:** 58° 29′ 06″ / 129° 14′ 30″
MINFILE NUMBER: 104I 045 **ELEVATION:** 1433 m
LOCATION: South branch of Eagle River, 5.6 km southwest of foot of Eaglehead Lake. .

NAME: OCCURRENCE (26) **LAT/LONG:** 58° 27′ 00″ / 129° 16′ 00″
MINFILE NUMBER: 104I 083 **ELEVATION:** 1600 m

STATUS: Asbestos Showing (26) and Asbestiform Serpentine (Chrysotile) Showings (24 & 25)
HOST UNIT: unidentified metamorphic assemblage **DEPOSIT TYPE:** Vein
TERRANE: Cache Creek? **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinized Peridotite

At ASB 8 (24) chrysotile occurs in veinlets up to 2 cm in width in serpentinized peridotite. Fine-grained disseminated chalcopyrite and pyrite also occur in the peridotite. At ASB 4 (25) asbestos mineralization ranges from veins up to 2 cm thick, to areas with asbestos in picrolite veins outcropping along 5 km of a northwest trending mineralized zone. In 1972 a magnetometer survey was done in the area. (**EMPR GEM** 1972; **EMPR ASS RPT** 3992)

NO. 27 **NTS MAP:** 104I07W

NAME: WHEATON CREEK (27)
MINFILE NUMBER: 104I 082

LAT/LONG: 58° 22′ 00″ / 128° 57′ 00″
ELEVATION: 1700 m

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Cache Creek?
TECTONIC BELT: Omineca

DEPOSIT TYPE: Unknown
MINERALIZATION AGE: Unknown
LITHOLOGY: Unkknown

Description and capsule geology not available.

NO. 28 **NTS MAP:** 104I07E, 104I07W

NAME: LETAIN (28)
MINFILE NUMBER: 104I 006
LOCATION: Centre of Main zone, 76.5 km east of Dease Lake .

LAT/LONG: 58° 19′ 59″ / 128° 44′ 03″
ELEVATION: 1720 m

STATUS: Asbestiform Serpentine (Chrysotile) Developed Prospect
HOST UNIT: Cache Creek Complex
TERRANE: Cache Creek
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Vein & Stockwork
MINERALIZATION AGE: Unknown
LITHOLOGY: Seperntinized Dunite & Peridotite

COMMENTS: Possible geological reserves are 15,700,000 tonnes grading 4.7 % asbestos at a 3 % asbestos fibre cutoff to the 1600 metre level (Prospectus, Cassiar Mining Corporation, December 5, 1985).

The Kutcho Creek occurrence area is underlain by argillites, chert arenites, limestones and greenstones of the Carboniferous to Jurassic Cache Creek Complex (Group) intruded by serpentinized peridotite and dunite, and diorite of Jurassic(?) age. The sedimentary and volcanic rocks form a conformable assemblage striking northwest and dipping moderately northeast. An irregular body of serpentinite, 11 kilometres long by 3 kilometres wide, intrudes the volcano-sedimentary rocks approximately along the contact between sediments and volcanics. This body is essentially sill-like, striking northwest and dipping 45 degrees northeast. Irregular apophyses extend to the southwest and southeast from the main body. Associated small stocks of fine-grained diorite cut the serpentinite or are marginal to it. Isolated rafts of country rock have been converted to gneisses, schists or marbles within the serpentinite.

The serpentinite is well-jointed in regular patterns. Compositional differences and varying magnetite content within the serpentinite result in differential weathering patterns, the colour changing from light yellow through to brown. Some of the banding is transverse to the trend of the serpentinite.

Mineralization consists of cross-fibre chrysotile asbestos occurring in fracture-related veinlets concentrated in an area near the centre of the serpentinite body. The fractures occur in two prominent sets: one striking 050 to 060 degrees and dipping steeply northwest, and the other striking 320 to 330 degrees and dipping nearly vertical. The serpentinite containing the fibre is generally medium to light green and weathers to a greyish pitted surface, the pits having been formed by the weathering out of bastite crystals. A thin section of this rock consists mainly of granular and mesh antigorite, pyroxene "ghosts" and abundant magnetite and chrysotile veinlets. The serpentinite without fibre is generally darker green, tends to weather brownish, and is harder and more brittle than the other type. It is commonly highly sheared with abundant slickensides. Vein fractures are not abundant, and most of those present contain picrolite or a massive apple-green material. A thin section of this rock consists essentially of feathery sheaves of antigorite with considerable carbonate, some actinolite and very minor magnetite.

The chrysotile veins range from microscopic to 3.1 centimetres wide, and most have one or more central partings. The partings are sometimes thin irregular films of magnetite or serpentine, but often they are 0.6 to 1.2 centimetre thick seams and brecciated masses of the light green massive chrysotile mentioned previously. Where the massive material is brecciated, it is frequently striped and striated parallel to the vein walls, but tiny multidirectional fractures within it contain asbestos fibres oriented perpendicular to the walls of the main vein. In some places the massive material grades laterally into good cross-fibre asbestos. Because of the partings, the fibre length is normally much less than vein widths. Most of the fibre is in the 0.3 to 0.6 centimetre range.

Diamond drilling has indicated three chrysotile asbestos fibre zones: the Main, West and East zones. The West zone is 183 metres northwest and the East zone is 183 metres southeast of the Main zone, respectively. The zones have a combined length of approximately 1500 metres with a maximum width of 200 metres. The fibre zone extends to at least 300 metres downdip. (**EMPR ASS RPT** 825, 1075, 1076, 6470, 7028; **EMPR PF** (Metallurgical report; Storey, A.E. (1956): Report on Letain Asbestos Prospect, Cry Lake Area); **EMPR AR** 1956, 1960, 1966; **EMPR GEM** 1970; **EMPR MAP** 65 (1989); **EMPR EXPL** 1977, 1978; **EMPR OF** 1992-1, 1992-9; **GSC OF** 56, 610; **GSC MAP** 29-1962; **EMR MP CORPFILE** (Conwest Exploration Co. Ltd.; Cassiar Asbestos Co. Ltd.); **EMR MIN BULL MR** 223 B.C. 339)

NO. 29

NTS MAP: 104I07E

NAME: B (29)
MINFILE NUMBER: 104I 053

LAT/LONG: 58° 19′ 54″ / 128° 43′ 24″
ELEVATION: 1800 m

STATUS: Asbestos Showing
HOST UNIT: Cache Creek Complex
TERRANE: Cache Creek
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Unknown
MINERALIZATION AGE: Unknown
LITHOLOGY: Seprentinized Peridotite

Small amounts of asbestos in serpentinized peridotite. Same geological setting as Letain (28) (**EMPR ASS RPT** 825, 1076).

NO. 30

NTS MAP: 104I02W

NAME: J (30)
MINFILE NUMBER: 104I 042
LOCATION: South of a small lake 5.2 km southwest of Letain Lake.

LAT/LONG: 58° 14′ 54″ / 128° 49′ 00″
ELEVATION: 1539 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Cache Creek Complex?
TERRANE: Cache Creek?
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Fractures
MINERALIZATION AGE: Unknown
LITHOLOGY: Seprentinized Peridotite

Chrysotile asbestos in cross-fibres 0.8 to 12.5 millimetres long occurs in a network of fractures within an area of serpentinized peridotite.The showing occurs in a magnetic high, over an area 610 by 46 metres. In 1971, Tournigan Mining Explorations Ltd. performed surficial geological mapping and magnetometer surveys over the entire claim. (**EMPR GEM** 1971; **EMPR ASS RPT** 3628)

NO. 31 & 32

NTS MAP: 104I02W

NAME: KEHLECHOA RIVER (31)
MINFILE NUMBER: 104I 088

LAT/LONG: 58° 12′ 18″ / 128° 49′ 30″
ELEVATION: 1600 m

NAME: OCCURRENCE (32)
MINFILE NUMBER: 104I 048

LAT/LONG: 58° 10′ 30″ / 128° 49′ 12″
ELEVATION: 1833 m

STATUS: Asbestos Showing
HOST UNIT: Cache Creek Complex?
TERRANE: Cache Creek?
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Unknown
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

A small belt of serpentine pods extends across the head of the Kehlechoa River. Two occurrences of chrysotile asbestos fibre have been reported in serpentine west of this. (**EMPR GEM** 1960; **GSC MAP** 1957-9, 1962-29)

Cassiar Mountains (McDame Area)

A belt of serpentinite lying in Sylvester Group rocks runs from Cry Lake to McDame and continues beyond to the Yukon border. The Cassiar serpentinite, located in the north-central area of the province, is a completely serpentinized peroditite tectonite which hosts two past-producing chrysotile asbestos deposits Cassiar (38) and McDame (39). A historical perspective of the area's mining history can be found in a 1991 article by Hutson and Brunet.

Mount McDame is situated in north-central British Columbia, near the town of Cassiar, 15 kilometres northeast of the Stuart-Cassiar Highway. It is composed of both platformal and eugeosynclinal rock sequences. Its slopes are underlain by Lower Cambrian to Devonian carbonates and shales of the Cassiar platform, which is part of the ancestral North American continental margin. The upper part of the mountain consists of Pennsylvanian-Permian(?) argillite and chert, and Mississippian argillite, chert, limestone, greywacke, and greenstone sequences of oceanic and island arc affinities, and serpentinite, all part of the Sylvester allochthon emplaced in Jurassic time (Harms, 1986; Nelson and Bradford, 1989). Harms (1985) has documented thrust faults that were active during the Permian and thus predate emplacement of the allochthon. The postemplacement history of this part of British Columbia is dominated by post-Jurassic dextral-transcurrent faults that have dismembered the accreted terranes (Gabrielse, 1985).

O'Hanley (1989) succinctly summarizes the structural geology of the Mount McDame area. What follows is an excerpt from his paper on the subject. The base of the allochthon is a roof thrust in a duplex structure involving some of the platformal unit. The duplex had its roots in the Road River Group, and thrust sheets are composed of the Road River Group, the Tapioca sandstone and the McDame and Earn groups.

The Cassiar (38) and McDame (39) asbestos deposits occur on Mount McDame within the Sylvester allochthon, close to the basal contact with the platformal units. The Cassiar serpentinite lies between the chert-argillite and the Mississippian sequences. The Earn Group is found immediately below the allochthon. Successively older units are in contact with the base of the Sylvester allochthon from south to north. Nelson and Bradford (1989) projected the Marble Creek fault, a late-stage, high-angle fault, into this contact near the Cassiar Mine.

O'Hanley (1988) in his structural analysis of Cassiar concludes that the principal stress axes must have changed during the formation of the Cassiar asbestos deposit. The direction of principle compression changed from the northeast-southwest to north-south. According to Gabrielse (1985) this occurred in the Middle to Late(?) Cretaceous.

The Cassiar serpentinite developed in two stages (O'Hanley and Wicks, 1987). The first stage was the hydration or partial hydration of the peridotite. The second stage was the recrystallization of the first-stage serpentinite, which produced the ore zone and the hangingwall alteration zone.

Serpentine recrystallization and the formation of the ore zone are both due to fault-controlled processes: for serpentine recrystallization fault-controlled flow of fluid (which acts as a heat source); and for the ore zone, fault-controlled deformation (O'Hanley, 1991). Using a technique which involves measurements of homogenization temperatures from fluid inclusions in rodingite and $\delta^{18}O$ values, O'Hanley *et al.* (1992) have produced estimates of the temperature and pressure for the second episode of serpentization at the Cassiar Mine. They concluded that an externally derived, CO_2 poor, but moderately saline fluid caused serpentization at a temperature of $300 \pm 36°C$ and a pressure of <800 bars.

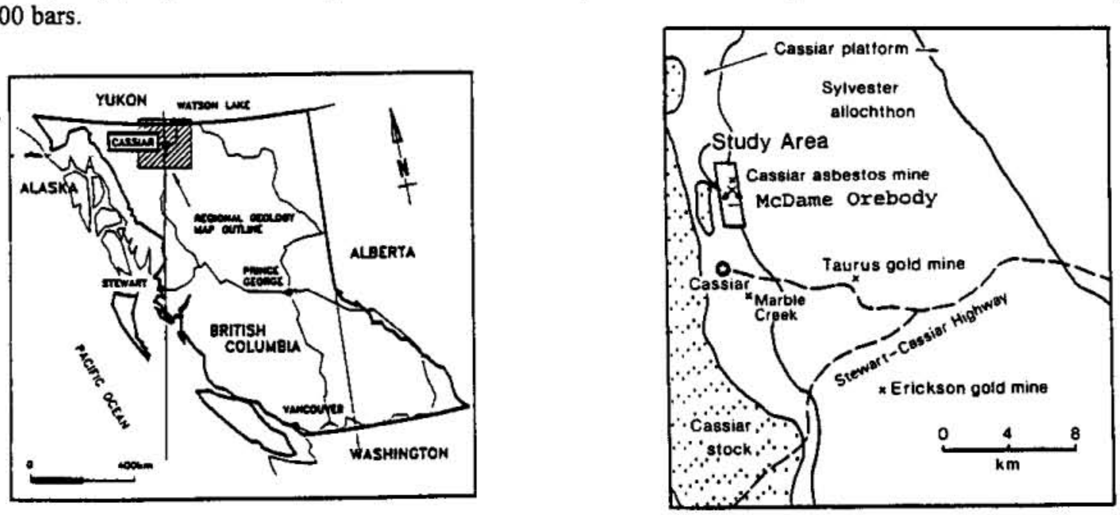


FIGURE 11: LOCATION MAPS OF CASSIAR

NO. 33

NTS MAP: 104P12W

NAME: WOLFE (33)
MINFILE NUMBER: 104P 055

LAT/LONG: 59° 33' 25" / 129° 59' 20"
ELEVATION: 1700 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Blue River Ultramafic Body
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Dunite & Peridotite

West of Blue River, chromite grains occur in lenses and pods up to 15 centimetres thick and 15 metres long in dunites and peridotites of the Early Mississippian Blue River ultramafic body. The Blue River ultramafic body is weakly serpentinized with minor associated asbestos. (**GSC P** *64-48; **EMPR AR** 1955, 1956; **GSC MAP** *17-1964; **GSC MEM** *319; **EMPR FIELDWORK** 1987; **EMPR OF** 1988-10; **EMPR MP MAP** 1992-11)

NO. 34

NTS MAP: 104P05E

NAME: RET (34)
MINFILE NUMBER: 104P 064
LOCATION: About 5.0 kilometres East of Gallic Lake.

LAT/LONG: 59° 26' 10" / 129° 41' 15"
ELEVATION: data not available

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Sylvester Allochthon
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

At Ret (34) serpentinized peridotite of the Upper Paleozoic Sylvester Allochthon outcrops in a north-trending cirque. A few chrysotile fibre veins are present.

NO. 35, 36 & 37

NTS MAP: 104P05E, 104P05W

In 1979 Teslin Joint Venture (subsequently Brinco Mining Limited and then Cassiar Mining Limited) staked 5 claims comprising 74 units covering the Mars (35) and Moon (36) showings. Between 1980 and 1983 soil sampling, geologic mapping, trenching, road construction diamond drilling (1219 metres) and rotary percussion drilling (1518 metres) were carried out. In the Mars showing area a 1-3 metre zones of up to 5% chrysotile next to rodingite dikes were intersected. At that time no significant deposits were discovered (Murray, 1982; Murray, 1983). In 1983 and 1984 Brinco Mining Ltd. contracted aeromagnetic surveys of the area. In 1985 more roads were constructed to perform a ground magnetic survey and the drilling of 18 holes for a total of 16732.7 metres on a variety of geological and geophysical targets.

The region is underlain by ultramafics and Upper Paleozoic chert, greenschist and argillite. These lithologies are similar to those which host the Cassiar orebody (38). The magnetic anomalies, and strong serpentinization observed at Mars (35) and Moon (36) do not have any economic asbestos intimately associated with them (Lyn and Cooper, 1985). Chrysotile occurs in two manners: as widespread, very low-grade, veins distributed within a few hundred metres of the basal contact of the ultramafic; and as very local occurrences of high grade veins near some rodingite dikes. Lyn and Cooper (1985) state that neither type of occurrence reaches mineable concentrations.

NAME: MARS (35)
MINFILE NUMBER: 104P 086
LOCATION: Approximately 10 kilometres west of Gallic Lake.

LAT/LONG: 59° 24′ 25″ / 129° 45′ 50″
ELEVATION: 1630 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Prospect
HOST UNIT: Sylvester Allochthon
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Stockwork, Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentintie

At Mars (35) a dense network of chrysotile veins occurs in a serpentinized peridotite zone about 10 metres long and 3 metres wide in the Zus Mountain ultramafite sheet within the Upper Paleozoic Sylvester Allochthon. Chrysotile veins intersect to form a blocky pattern. The zone dips about 15 degrees southeast and extends for at least 114 metres, with the grade rapidly changing from good to very poor at depth. A 100 kilogram test sample of near-surface mineralization graded 12.3 % fibre, but the best drill intersection was 4 % fibre over 1 metre.

The Mars showing was discovered in 1950. Early exploration was carried out by Johns-Mansville Ltd. (dip needle survey and geologic mapping program in 1953). (**EMPR AR** 702, 1052, 1950, 1951, 1960, 1965; **EMPR ASS RPT** 103, *702, *8607, 10818, *11324, 14649; **EMPR EXPL** 1982, 1986; **EMPR FIELDWORK** 1987, 1988; **EMPR MP MAP** 1992-13; **GSC MEM** 319; **GSC MAP** 1110A; Harms, 1986)

NAME: MOON(36)
MINFILE NUMBER: 104P 036
LOCATION: 13 km north-northeast of the town of Cassiar.

LAT/LONG: 59° 24′ 10″ / 129° 41′ 30″
ELEVATION: 1675 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Sylvester Allochthon
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

In an area 8 kilometres northeast of Cassiar, peridotite of the Upper Paleozoic Sylvester Allochthon is altered to serpentinite near a rodingite dike. Silky chrysotile fibre up to 60 millimetres long has been reported to occur in ribbon veins. Strong serpentinization occurs along the upper and lower contacts of the ultramafics and are characterized by strongly sheared dark green to black fishscale serpentinite which extends up to 50 metres from the contact.

The Moon showing was discovered in 1960, hand trenched and sampled in 1962. In 1965 Johns-Mansville Ltd. performed a magnetometer survey and bulldozer trenching. (**EMPR AR** 702, 1052, 1950, 1951, 1960, 1965; **EMPR ASS RPT** 103, *702, *8607, 10818, *11324, 14649; **EMPR EXPL** 1982, 1986; **EMPR FIELDWORK** 1987, 1988; **EMPR MP MAP** 1992-13; **GSC MEM** 319; **GSC MAP** 1110A; Harms, 1986)

NAME: ZUS (37)
MINFILE NUMBER: 104P 002

LAT/LONG: 59° 23′ 50″ / 129° 46′ 30″
ELEVATION: 1830 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Sylvester Allochthon
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentintie

Near Zus Mountain in the Cassiar Mountain Range an arc-shaped, north-trending, body of serpentinite is exposed over a length of 4.5 kilometres and a width of 0.5 to 1.3 kilometres structurally overlying Upper Paleozoic Sylvester Allochthon metasediments and metavolcanics. The serpentinite body is cut by numerous rodingite dikes.

Cross-fibre chyrsotile occurs in veinlets, generally less than 2.5 millimetres in width and commonly less than 1.0 millimetre. The veinlets are widely scattered and strike in all directions, with a slightly dominant northwest trend.. A visual assay over 3 metres of drill core from Hole P-4 grades 4.7 % asbestos. (**EMPR AR** 702, 1950, 1951, 1960, 1965; **EMPR ASS RPT** 103, *702, *8607, 10818, *11324, 14649; **EMPR EXPL** 1982, 1986; **EMPR FIELDWORK** 1987, 1988; **EMPR MP MAP** 1992-13; **GSC MEM** 319; **GSC MAP** 1110A; Harms, 1986)

NO. 38 **NTS MAP:** 104P05W

NAME: CASSIAR ASBESTOS (38) **LAT/LONG:** 59° 19′ 31″ / 129° 48′ 59″
MINFILE NUMBER: 104P 005 **ELEVATION:** 1800 m
LOCATION: Open pit, 4.5 kilometres north-northeast of the town of Cassiar.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Past Producer (Open Pit & Underground)
HOST UNIT: Sylvester Allochthon **DEPOSIT TYPE:** Stockwork, Vein & Massive
TERRANE: Slide Mountain **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Omineca **LITHOLOGY:** Serpentinized Harzburgite

MODIFIER: Faulted Sheared
CASSIAR OREBODY DIMENSION: 600 x 150 x 150 Metres (mined out in 1990)

TOTAL INVENTORY OF ORE TAILINGS:
QUANTITY: 25,000,000 Tonnes (1994)
Asbestos 4.2 %
COMMENTS: Low-grade stockpile (waste from the former dry-milling operation) determined by drilling on 30 metre centres in the mid-1980s.(P. Wojdak, personal communication, 1994)

The area is underlain by four major thrust sheets, distinguished on McDame Mountain, of the Devonian to Triassic Sylvester Allochthon. These comprise greenstones, argillites, limestones, ultramafites and ultramafic bodies of variable size, shape and form. These bodies of antigorite serpentinized harzburgites occur along at least three distinct horizons which are probably major thrust fault surfaces. The lowest horizon occurs just above the Sylvester basal thrust fault, and contains a serpentinite thrust slice that hosts the Cassiar and McDame (104P 084) deposits. There were two episodes of faulting postulated with asbestos forming during the change from normal to dextral motion on a north trending fault that transects the serpentinite ("45 degree shear").

The Cassiar pit occupies a zone of anomalous structure, with a north trending high angle fault (Marble Creek fault) juxtaposing bedded chert (Sylvester) to the east and graptolitic Ordovician-Silurian Road River Group slate to the west. The latter is complexly imbricated with slivers of dolostone (Lower Devonian Tapioca sandstone or Middle Devonian McDame Group) below the Sylvester basal thrust.

The Cassiar orebody is roughly crescent-shaped with northeast and southeast trending horns. The orebody as a whole dips about 45 degrees east and measures approximately 600 by 150 by 150 metres. North striking, east dipping thrusts and shears slice the orebody into a number of massive blocks with well-developed systems of conjugate joints, most of which contain long cross fibre chrysotile. The orientation of joint systems within successive blocks varies widely, but tends to favour two directions, north-northwest to north-northeast, and east-southeast.

The orebody is a fibre-bearing zone containing upwards of 10 % cross fibre chrysotile asbestos varying in length up to 3 centimetres. Most veins are the two-fibre type, with a central parting. The short fibre component is also significant economically. There are two generations of asbestos veins with different orientations. Magnetite is abundant in partings and along vein walls. Brucite and jade also occur within the serpentinite.

Post-vein shearing is most apparent in the footwall of the deposit. In country rocks near the orebody, there are many steeply dipping veins with quartz, tremolite, talc, zoisite and carbonates.

Reserves at the Cassiar Asbestos mine were exhausted in June 1989, after 38 years of production. Stockpiled ore (1.4 million tonnes) from the pit supplied sufficient millfeed while the McDame deposit was being prepared for production. The McDame deposit commenced production in February, 1991. Large, unknown quantities of jade were also produced over the years.

Current reserves at the Cassiar mine are approximately 25 million tonnes grading 4.2 % asbestos in a low-grade tailings stockpile (waste from the former dry-milling operation) determined by drilling on 30 metre centres in the mid-1980s (P. Wojdak, personal communication, 1994).

The most recent owner of the Cassiar open pit asbestos mine and the McDame orebody was the Cassiar Mining Corporation, a wholly owned subsidiary of the Princeton Mining Corporation. In the 9-month period ending September 30, 1992, the Cassiar Mining Corporation reported an operating loss of $6.9 million, before depreciation and taxes (The Northern Miner, January 20, 1992).

On October 15, 1991, due to threatened action by its bankers, the Cassiar Mining Corporation sought protection under its Creditor Arrangement Act. On February 4, 1992, the Corporation was put into receivership by the British Columbia Government under the terms of a debenture held on Cassiar's mining assets (*1992 Princeton Mining Corporation Annual Report*). The province had previously loaned it parent company, the Princeton Mining Corporation, $20 million and guaranteed a further $15 million in loans.

The mine was shut down in early 1992 when cash flow problems arose from production delays which were caused by problems with underground mining techniques. Cassiar Mining went into receivership after the provincial government turned down the company's request for an additional loan of $13 million and $5 million in loan guarantees to buoy a revised debt-restructuring plan. The province then allocated $12 million to provide financial settlements to the residents of Cassiar and another $3.4 million to maintain essential community services to the town of Cassiar. The Minister of Forests acknowledged that the allocation exceeded the amount of dollars requested by the company in its refinancing plan, and justified it by stating that another government loan would not have ensured the viability of the mine. In September of 1992 , $4 million worth of assets, including the town of Cassiar and the adjacent mining operations were dismantled and liquidated. The remaining townsite was destined to be burned and bulldozed.

SELECTED CASSIAR REFERENCES:

(**EMPR FW** 1978, pp. 51-60; 1979, pp. 80-88; 1987, pp. 245-248; 1988, pp. 323-337; 1989 p. 223-228 **EMPR OF** 1988-19; 1992-1; 1992-3; 1992-9 **EMPR MINING** 1975-1980 p. 41; 1981-1985 p. 52; 1986-1987 p. 78; 1988 p. 78 **EMPR ENG INSP** (Mine plans); **Annual Report** 1989, 1990 **EMPR INF CIRC** 1985-1, p. 17; 1986-1, p. 26; 1989-1, p. 18; 1990-1, p. 25; 1991-1, p. 40 **EMPR PF** (*Plumb, W.N. (1968): The Geology of the Cassiar Asbestos Deposit; O'Grady, B.T. (1950): Preliminary Report on Asbestos occurrences, Northwest of McDame Lake, Stikine; Asbestos, 1972, Cassiar Mining Corp., date unknown; Cassiar Asbestos Mine, Prospectus; Cassiar Mining Corp. Annual Report, 1987; "Shifting Fortunes" article in BC Business Magazine Feb. 1989; Jakubec, J. (1992): Support at Cassiar Underground Mine, MASSMIN 92) **EMPR MER** 1984, p. 17; 1985, p. 26; **EMPR MP MAP** 1992-13; **EMPR EXPL** 1981-323; 1986-A41,A48; 1987-A42; 1989-229-236 **EMPR ASS RPT** 562, *9525, *10655, 13628; **EMPR AR** 1950-207-214; *1951-212-214; 1952-243; 1953-181; 1954-174, 175; *1955-88-90; 1956-146-148; 1957-76,77; 1958-83; 1959-150, 151; 1960-127,128; 1961-138; 1962-143; 1963-137; 1964-179; 1965-256; 1966-259; 1967-299; 1968-295 **EMPR GEM** 1969-379; 1970-487; 1971-451; 1972-573-577; 1973-536,537; 1974-370,371 **EMPR MINING** 1975-1980, p. 41 GSC P 78-19, pp. 32,35 **GSC MEM** 194; *319, pp. 123-126 GSC MAP 381A; 1110A **GSC EC GEOL** 1963, pp. 123-126 **EMR MP CORPFILE** (Canwest Exploration Company Ltd., Cassiar Resources Ltd.) Precambrian Magazine *Vol.34, No.6, pp. 23-30 (June 1961) CIM Vol.71, No.792, April 1978; Vol.79, No.896, 1986 GCNL #66,#163,#191,#214,Oct.4,Nov.7, 1978; #163, 1979; #65, 1976; #69,Apr.29, 1977; #41,#85,#228,#231, 1982; #61,#96, 1980; #19, #146, 1984; #26,#78,#230,#247, 1985; #125, 1986; #78,#143, 1985; #105, 1987; *#45(Mar.5), 1990; #14(Jan.21),#26(Feb.6),#53(Mar.15), 1991; #87(May 5), #90(May 8),#169(Sept.1), 1992 **N MINER** Apr.8, 1976; Apr.21,Aug.11, 1977; Aug.23, 1979; May 4, 1978; Nov.13, 1980; Mar.4,Apr.15,May 6,Aug.5,Nov.4,Dec.9, 1982; May 26, Dec.1, 1983; Feb.2,May 17,24,Aug.2,Sept.13, 1984; Apr.25,May 23, Aug.29,Dec.2, 1985; May 18,June16,July7, 1986; Mar.,Apr., 1988; Jan.2, Aug.7, Sept.11, 1989; Jan.15, 1990; Mar.30, 1992 W MINER May 1977; June,Apr., 1979; Aug.,Vol.37, pp. 48-54, 1964; Nov., 1981; Apr., 1982 **EMPR MINING** Jan./Feb. 1991, Vol.2, No.1, pp. 8-11 Hewett, F.G. (1984): *Cassiar asbestos mine, Cassiar, British Columbia; in the Geology of Industrial Minerals in Canada, CIM Spec. Vol. 29, pp. 258-262 Gabrielse, H. (1960): *The Genesis of chrysotile asbestos in the Cassiar asbestos deposit, Northern British Columbia, ECON GEOL Vol.55, No.2, pp. 327-337 Burgoyne, A.A. (1985): *Geology and Exploration of the McDame asbestos deposit, Cassiar, British Columbia; Paper presented to 87th Annual General Meeting, CIM Apr.22, 1985 Smitheringale, W.V. (1957): The Geology of Canadian Industrial Mineral Deposits, 6th Commonwealth Mining and Metallurgical Congress, 1957, pp. 49-53 Harms, T.A. (1986): Structural and Tectonic Analysis of the Sylvester Allochthon, Northern British Columbia, Implications for Paleogeography and Accretion, Ph.D. Thesis, University of Arizona O'Hanley, D.S. (1987): The Origin of Alpine-Peridotite Hosted Chrysotile-Asbestos Deposits (In preparation)

NO. 39 **NTS MAP:** 104P05W

NAME: MCDAME (39) **LAT/LONG:** 59° 19′ 20″ / 129° 48′ 50″
MINFILE NUMBER: 104P 084 **ELEVATION:** 1536 m
LOCATION: McDame mountain, 1 km from the Cassiar deposit (38).

STATUS:STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Past Producer (Underground)
HOST UNIT: Sylvester Allochthon **DEPOSIT TYPE:** Stockwork & Vein
TERRANE: Slide Mountain **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Omineca **LITHOLOGY:** Serpentinized Harzburgite

MODIFIER: Faulted Sheared
DIMENSION: 540 x 320 x 15 Metres
COMMENTS: Deposit thickness varies from 15 to 20 metres.

INVENTORY OF MCDAME ORE ZONE
QUANTITY: 19,940,000 Tonnes (Proven reserves with a 6.21 % mill yield of asbestos). The orebody is open on two sides. Production up to October 1991, totalled 40,000 tonnes (Princeton Mining Corp. Annual Report 1990).
High quality asbestos underground reserves in the McDame deposit were estimated at 16 million tonnes (10 years of production) in 1989 (P. Wojdak, personal communication, 1994).

The McDame asbestos orebody is a high grade blind deposit located one kilometre south of the Cassiar Mine open pit. The following exploration history of the deposit is taken directly from Nelson (1990), and supplemented by Cassiar Mining Corporation reports.

In 1978 asbestos mineralization was intersected in 1563-metre adit driven to provide access for infill drilling in the Cassiar orebody. This was followed by four more years of further adit development and underground drilling which defined reserves of 30.8 million tonnes having a fibre value per tonne similar to the Cassiar deposit. In 1983-84 aeromagnetic and geological surveys were conducted south of the pit indicating that the serpentinite hosting the deposit indicated was substantially larger than previously delineated. The McDame orebody was intersected by a drillhole from near the top of McDame Mountain in 1984, grading 7.6% fibre over 151 metres of core length. This doubled possible reserve value to 63 million tonnes. In 1985-86 an adit at 1415-metre level was driven for drill and sampling access. The mineralized zone was bulk sampled, 1073 tonnes were processed and concentrated to produce 84.5 tonnes of long length, high value fibre. In 1987 the Cassiar Mining Corporation received a B.C. provincial grant to aid in the development of the orebody. 1988 to 1989 saw the development of access, ventilation and production workings culminating with the startup of production by block caving mining techniques in 1990.

The area is underlain by four major thrust sheets, distinguished on McDame Mountain, of the Devonian to Triassic Sylvester Allochthon. These comprise greenstones, argillites, limestones, ultramafites and ultramafic bodies of variable size, shape and form. These bodies of serpentinized peridotites occur along at least three distinct horizons which are probably major thrust fault surfaces. The lowest horizon occurs just above the Sylvester basal thrust fault, and contains a serpentinite thrust slice that hosts the Cassiar (104P 005) and McDame deposits. The ultramafite sheet dips 32 to 50 degrees east under McDame Mountain where it attains a thickness of 300 metres. There are two episodes of faulting postulated with asbestos thought to have formed during the change from normal to dextral motion on a north trending fault that transects the serpentinite (45 degree shear).

Chrysotile veining is controlled primarily by the joint system. Joint sets in the serpentinite strike east-northeast and south-southeast. Normal faulting is prominent in an east and northeast direction.

The hanging wall of the McDame ultramafite is marked by shearing, serpentinization, chloritization, pods of schistose tremolite, talc soapstone, zoisite, epidote and clay.

The footwall is mechanically troublesome and is the result of a structural anomaly common with the west side of the Cassiar pit. This has necessitated difficult and expensive development work. A summary paper by Jakubec (1992)details the mine's ground-support design, and addresses the issues of rock response and failure.

The footwall is characterized by sheared carbonaceous argillite and gouge and is lacking a section of competent carbonate preserved elsewhere in the stratigraphic rock record. The footwall is composed of graphitic slate of the Ordovician-Silurian Road River Group, structurally overlain by 50 metres of ribbon cherts at the base of the Sylvester allochthon, and then barren serpentinite directly below the asbestos stockwork. Pyrite and magnetite are disseminated throughout.

Drilling has outlined an east dipping body of cross fibre chrysotile ore which thickens towards the east. Reserves have been calculated for a deposit having the approximate dimensions of 540 metres dip length (east-west), 320 metres width (north-south), and 15 to 150 metres thickness. Measured geological reserves are 19.94 million tonnes with a 6.21 % mill yield of asbestos (Princeton Mining Corp. Annual Report 1990).

Production at the McDame deposit began in February 1991 after three years of underground development, prompted by declining reserves from open pit operations at the adjoining Cassiar Asbestos mine. Production up to October 1991 totaled 40,000 tonnes (George Cross News Letter No.200, 1991). The ore has averaged 9.2 % asbestos fibre, suggesting overall grade is higher than expected (Northern Miner - February 11, 1991).

SELECTED MCDAME REFERENCES:

(**EMPR ASS RPT** 562, 13628, 15702, 16776; **EMPR OF** 1992-1; 1992-3; 1992-9; **EMPR INF CIRC** 1986-1, 1987-1, 1988-1, 1989-1, 1990-1, 1991-1; **EMPR FIELDWORK** 1979, 1987, 1988; **EMPR MINING** 1975-1980 , 1981-1985, 1986-1987 , 1988; **EMPF PF** (Notice of Annual Meeting of Shareholders, March 1988; Cassiar Mining Corporation, date unknown; Cassiar Mining Corp. Annual Report 1987; Press Releases, Mar.17,21, Apr.25, May 30, June 16, Jul.19,27, 1988; First Quarter Report to Shareholders, May 1988, Cassiar Mining Corp.); **EMPR EXPL** 1988; **GSC MEM** 194, 319; **GSC MAP** 381A, 1110A; **GCNL** #174, 1984; #26,#78,#158, 1985; #217, 1986; #230, 1989; *#14,#200, 1991; **N MINER** Sept.13, 1984; Apr.25, 1985; Nov.24, 1986; Jan.2, 1989; Jan.15,22, May 14, Aug.30, 1990; Feb.11, Mar.18,25, Apr.1, May 13, Oct.7,28, 1991; Feb. 1,17, Mar.30, 1992; **N MINER MAGAZINE** Vol.4, No.11 (Nov. 1990); **MINING IN BRITISH COLUMBIA** Jan/Feb 1991, Vol. 2, No. 1, p. 8-11; Burgoyne, A.A. (1985): **CIM Annual General Meeting**, April 22, 1985; Geology and Exploration, McDame Asbestos Deposit, Cassier, B.C.(Harms, T.A.,1986; **EMPR MP MAP** 1992-13)

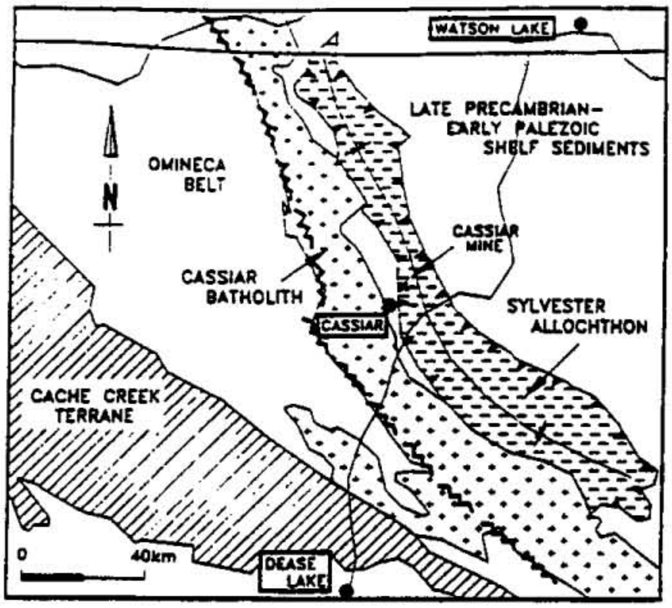


FIGURE 12: REGIONAL GEOLOGY OF THE CASSIAR AREA (Jakubec, 1992)

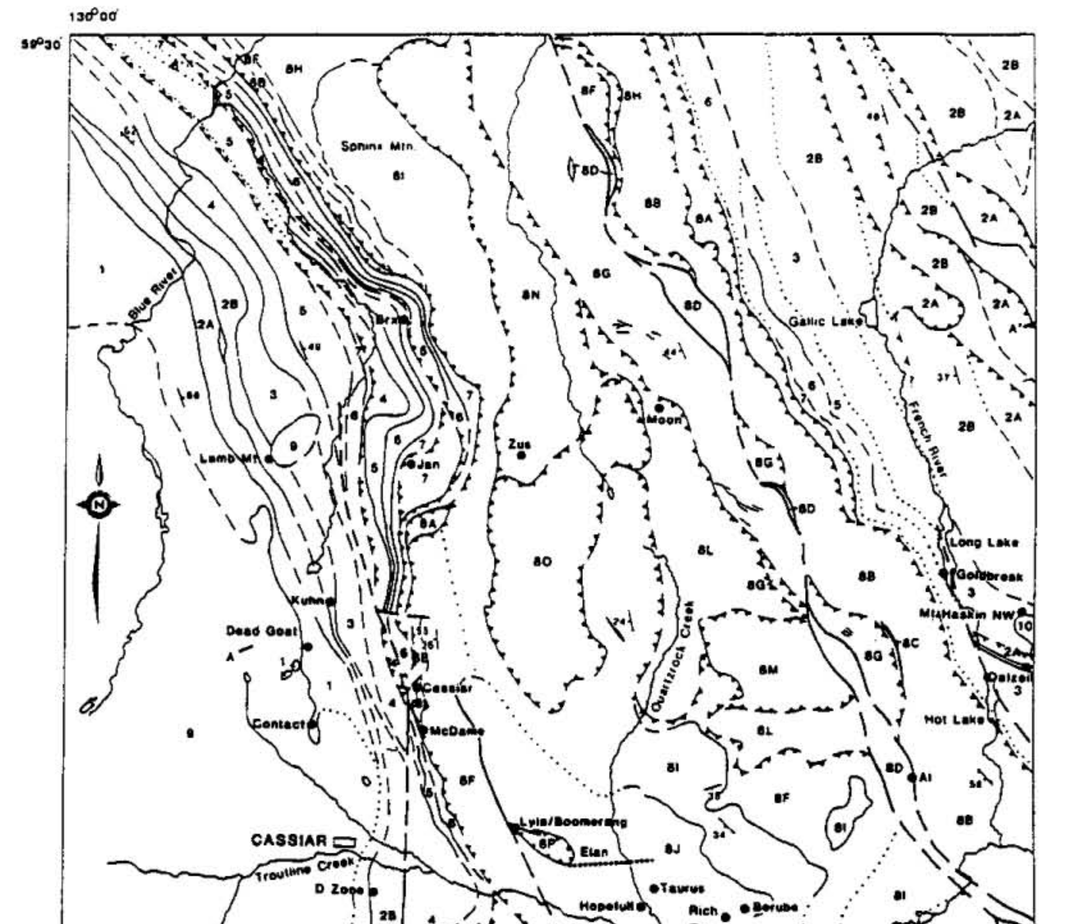


FIGURE 13: GEOLOGY AND MINERAL OCCURRENCES OF THE CASSIAR MAP AREA
(Nelson and Bradford, 1988)

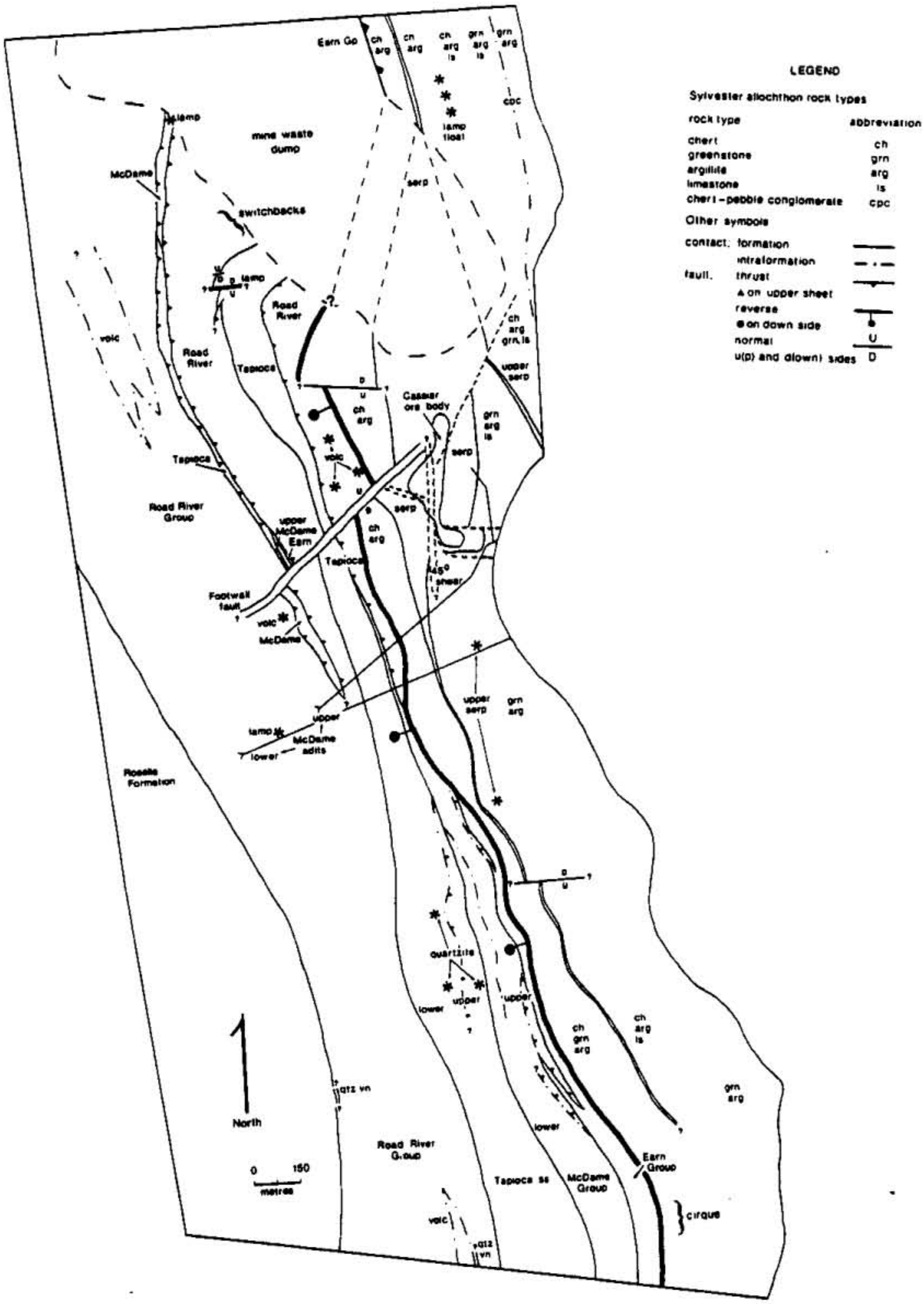


FIGURE 14: INTERPRETIVE GEOLOGIC MAP OF THE WESTERN FACE OF MOUNT MCDAME
(O'Hanley, 1989)

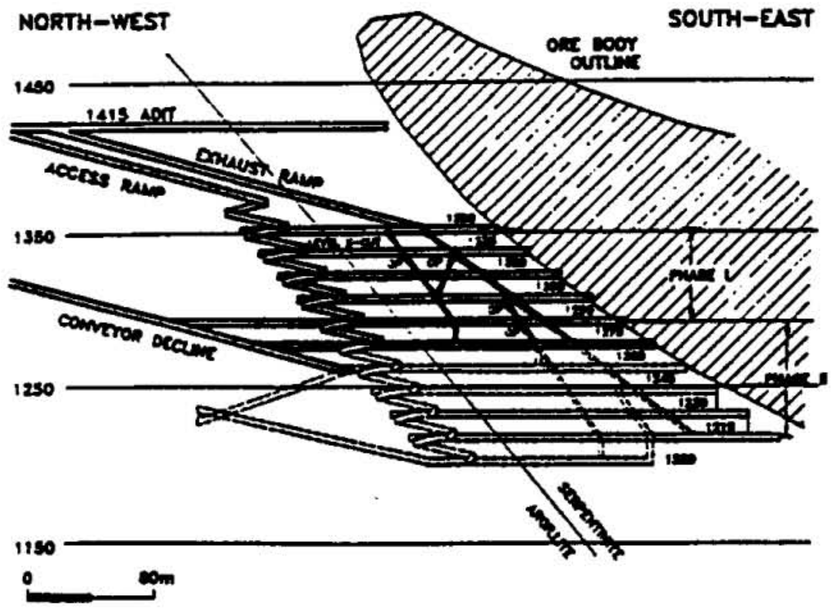


FIGURE 15: SCHEMATIC UNDERGROUND MINE SECTION OF CASSIAR (Jakubec, 1992)

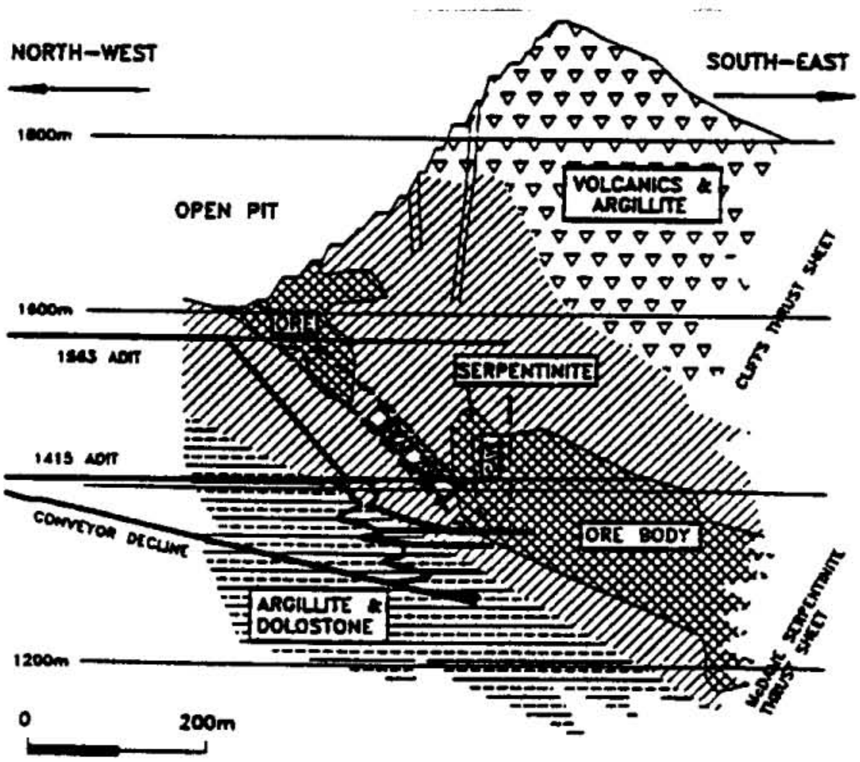


FIGURE 16: GENERALIZED GEOLOGICAL SECTION OF MCDAME OREBODY (Jakubec, 1992)

NO. 40 **NTS MAP: 104I15W**

NAME: GB (40)
MINFILE NUMBER: 104I 030
LOCATION: 9.7 km northeast of outlet of Cry Lake

LAT/LONG: 58° 54′ 48″ / 128° 52′ 12″
ELEVATION: 1700 m

STATUS:STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Slide Mountain
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

A few chrysotile veinlets are present in foliated anf fractured serpentinite and peridotite containing sulphide mineralization. (**EMPR PF; EMPR GEM** 1970; **EMPR ASS RPT** 2580, 2797, 2796)

Boundary Ranges

The Boundary Ranges asbestos showings are a scattered group of 6 occurrences outcropping along the western margin of the Stikinia Terrane. The showings parallel the boundary between the Intermontane and Coast Belts. The mineralogy is predominantly the asbestiform amphibole mineral actinolite, a crocidolite showing at Galore Creek (43) being the one exception.

Tatsamenie Lake (41) hosts an asbestos showing, of unconfirmed mineralogy, in serpentinized amphibolite. A serpentinized olivine clinopyroxenite to the south, at Mount Hickman (42), hosts a showing of chrysotile. The Mount Hickman Ultramafic Complex is intruded by the Upper Triassic Mount Hickman Pluton. Intrusions adjacent or proximal to asbestos showings are common in this area. Galore Creek (43), Eagle Crag (44), Unuk (45) and Mike Peak (46) all host asbestiform amphibole mineralization within rocks of, or correlative to, Upper Triassic Stuhini Group metavolcanics.

NO. 41 **NTS MAP:** 104K08W

NAME: TATSAMENIE LAKE (41)
MINFILE NUMBER: 104K 038
LOCATION: South of Tatsamenie Lake.

LAT/LONG: 58° 17′ 11″ / 132° 19′ 38″
ELEVATION: 2040 m

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Stikinia
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Unknown
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Amphibolite

In the Tatsamenie Lake area, intensely folded and regionally metamorphosed Permian, Triassic and older strata are separated from less folded and less metamorphosed Mesozoic sedimentary and volcanic rocks by a pre-Upper Triassic unconformity. Hornblende diorite and quartz-monzonite of Juro-Triassic Age intrude and are in fault contact with the pre-Upper Triassic rocks. These are commonly altered to chlorite, hematite and epidote. The Mesozoic strata are overlain unconformably by flat-lying Upper Tertiary and Pleistocene plateau basalts of the Level Mountain Group.

A major north to northwest trending fault, known as the Ophir Break Zone, extends through the area for over 10 kilometres. This zone is about 3500 metres wide, and is defined by areas of intense fracturing with abundant slickensiding; areas of carbonaceous and siliceous black siltstone and gouge; and linear quartz-iron carbonate-pyrite-fuchsite (listwanites) and quartz-dolomite alteration zones. The listwanites occur in the tuffs. The Ophir Break Zone is bounded on the west by the West Wall fault and on the east by the Ultramafic fault.

The pre-Upper Triassic rocks consist of fine-grained crystal to lapilli tuff, phyllite, limestone, siltstone and intraformational breccia. A sliver of Permian? ultramafic rock, consisting of serpentinized amphibolite, occurs adjacent to the West Wall Fault. Short, brittle asbestos fibre has been noted. In thin section, the rock contains antigorite, talc and minor carbonate and magnetite. These rocks are considered to be part of the Stikinia Terrane. (**EMPR ASS RPT** 10757, 11408, 12688, 16523, 16726; **EMPR EXPL** 1983, 1984; **GSC MAP** 6-1960, 1262A; **GSC MEM** 362)

NO. 42 **NTS MAP:** 104K08W

NAME: MOUNT HICKMAN (42)
LAT/LONG: 57° 15' 45" / 131° 05' 00"
MINFILE NUMBER: 104G 054
ELEVATION: 1700 m
LOCATION: Mount Hickman summit on the northeast spur 1 km from the peak.

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Mount Hickman Ultramafic Complex
DEPOSIT TYPE: Vein
TERRANE: Stikinia
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Olivine Clinopyroxenite

The Mount Hickman occurrence is located along the northern boundary of the Upper Triassic or older Mount Hickman Ultramafic complex which is located along the southeast boundary of the Upper Triassic Hickman pluton. The ultramafic complex is composed mainly of medium to coarse-grained, buff to brown to black weathering olivine clinopyroxenite to peridotite. These rocks contain anywhere form 5 to 20 % olivine which is generally wholly or partly serpentinized. Accessory magnetite and chromite are ubiquitous. In the central portion of the complex, several bodies of lighter weathering dunite occur within the pyroxenite. The contacts are sharp but the genetic relationship between the two main rock types is uncertain. Along the southeast margin of the complex, the olivine pyroxenites grade into hornblende-pyroxene gabbros with 5 to 15 % chalky white feldspar filling interstices between pyroxene grains. Magnetite is also abundant. This "border phase" of the complex appears to intrude pyroxene and feldspar porphyritic volcanic flows of the Upper Triassic Stuhini Group. To the north, a narrow belt of variably metamorphosed and altered volcanic rocks of uncertain age separate the ultramafic complex from hornblende diorite to hornblendite of the mafic phase of the Hickman pluton. These rocks grade into more intermediate quartz monzonites and granodiorites of the main phase of the pluton located to the north. The ultramafic rocks are unequivocally intruded by the main phase of the Hickman pluton; the genetic relationship between the pluton and ultramafic complex is uncertain.

Mineralization is comprised of narrow seams of chrysotile asbestos which have partly or completely replaced olivine in the olivine clinopyroxenites of the ultramafic complex. (**EMPR FW** 1988; **EMPR OF** 1989-7; **GSC P** 71-44; **GSC MAP** 9-1957, 11-1971, 1418A; **EMPR AR** 1960-131)

NO. 43 **NTS MAP:** 104G03W

NAME: GALORE CREEK (43)
LAT/LONG: 57° 08' 10" / 131° 27' 13"
MINFILE NUMBER: 104G 090
ELEVATION: 730 m

STATUS: Asbestiform Amphibole (Crodicolite) Showing
HOST UNIT: Stuhini Group
DEPOSIT TYPE: Unknown
TERRANE: Stikinia
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Metavolcanics

The Galore Creek region is mainly underlain by Upper Triassic volcanics and sediments of the Stuhini Group. This area is flanked to the west by Tertiary-Jurassic quartz diorite to granodiorite of the Coast Plutonic Complex. Middle Triassic sediments with Permian sedimentary and metamorphic rocks are at the northern and eastern limit of the area. Permian limestone is the dominant rock

Ten major copper deposits are known to occur within the Galore Creek syenite complex, a structure which appears to be an eroded volcano. This is a roughly 5 by 2.5 kilometre area of intrusive syenite porphyry stocks, dikes and metavolcanics.

Mineralization occurs in rock of volcanic origin that has been altered and metasomatized near syenite intrusions Other common gangue minerals found in the metavolcanics of the Central zone include sericite, chlorite, albite, apatite and calcite. Less common minerals include analcite, natrolite, sodalite, sphene, fluorite, barite, actinolite, vesuvianite and the asbestiform amphibole crocidolite. (**EMPR GEOLOGY** 1976; **EMPR FIELDWORK** 1975; **EMPR AR** 1956, 1957, 1961, 1962, 1964-1967;**EMPR GEM** 1972-1974; **EMPR OF** 1992-1, 1992-3; **EMPR MAP** 58, 64,65 (1989); GSC MEM 246; **GSC P** 71-44; **GSC MAP** 9-1957, 11-1971, 310A, 1418A)

NO. 44 **NTS MAP:** 104B13E

NAME: EAGLE CRAG (44) **LAT/LONG:** 56° 54′ 24″ / 131° 41′ 24″
MINFILE NUMBER: 104B 110 **ELEVATION:** 1200 m
LOCATION: Southern flanks of Eagle Crag.

STATUS: Asbestiform Amphibole Showing
HOST UNIT: unidentified metamorphic assemblage **DEPOSIT TYPE:** Unknown
TERRANE: Stikinia **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Metavolcanics

Near the contact of the Permian to Carboniferous metamorphics and the Coast Plutonic Complex, just south of Eagle Crag, is an occurrence of amphibole asbestos. Also noted, along the hornblende granodiorite contact, on the ridge south of Eagle Crag, are heavy impregnations of pyrite and arsenopyrite. (**GSC MEM** 246; **GSC MAP** 9-1957, 311A, 1418A; **GSC P** 89-1E)

NO. 45 **NTS MAP:** 104B09W

NAME: UNUK (45) **LAT/LONG:** 56° 31′ 08″ / 130° 24′ 21″
MINFILE NUMBER: 104B 175 **ELEVATION:** 1150 m
LOCATION: Headwaters of Gingras Creek, a southeast flowing tributary of Sulphurets Creek.

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage **DEPOSIT TYPE:** Unknown
TERRANE: Stikinia **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Metavolcanics?

The area is underlain by volcanic breccia and sediments of the Lower Jurassic Unuk River Formation (Hazelton Group). The eastern contact between Lower Jurassic diorite and the Hazelton Group rock is found within a kilometre to the west of the occurrence. Two showings of asbestos, one with magnetite and some copper mineralization, occur within a kilometre of each other. Magnetite showingshave been reported to the west and northeast. (**EMPR PF** (*Geology Map - 1:31,250 Scale - Newmont Exploration of Canada Ltd., 1960's); **EMPR OF** 1988-4, 1989-10; **EMPR BULL** 63; **EMPR FW** 1987, 1988; **GSC MAP** 9-1957,1418A; **EMPR ASS RPT** 15961, 17087; GSC P 89-1E)

NO. 46 **NTS MAP:** 104B08W

NAME: MIKE PEAK (46) **LAT/LONG:** 56° 27′ 08″ / 130° 18′ 321″
MINFILE NUMBER: 104B 175 **ELEVATION:** 1829 m
LOCATION: Located near the top of Mike Peak Mountain (Open File 1988-4).

STATUS: Asbestiform Amphibole (Actinolite) Showing
HOST UNIT: unidentified metamorphic assemblage **DEPOSIT TYPE:** Unknown
TERRANE: Stikinia **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Phyllite

Actinolite asbestos is reported to occur within a north trending band of phyllites between Sulphurets Glacier and Ted Morris Glacier (Newmont Map). These phyllites, developed from pelites and tuffs, are corellative, with rocks of the Upper Triassic Stuhini Group. Metamorphism is believed to be Cretaceous. (**EMPR FW** 1987). (**EMPR PF** (Geology Map-1:31,250 Scale - Newmont Exploration of Canada Ltd., 1960's); **EMPR BULL** 63; **EMPR OF** 1988-4, 1989-10; **EMPR FW** 1984, 1987; **GSC MAP** 9-1957, 1418A; GSC P 89-1E)

INSULAR SUPERTERRANE

Pacific Ranges

NO. 47 **NTS MAP:** 093D08W

NAME: BELLA COOLA VALLEY (47)
MINFILE NUMBER: 093D 016
LOCATION: Near logging road 9.6 km southwest of Firvale.

LAT/LONG: 52° 24' 00" / 126° 20' 00"
ELEVATION: data not availble

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Stikinia
TECTONIC BELT: Coast

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

The Bella Coola Valley asbestos showing occurs within the eastern part of the Coast Crystalline Belt. The region is underlain by supracrustal metasedimentary and metavolcanic rocks into which pre- to post-kinematic batholithic intrusions have been emplaced. The supracrustal rocks may be, in part, Jurassic Hazelton Group or, in some cases, older.

The asbestos occurs as short, narrow stringers within serpentinite which occurs in rocks described as greenstone and chlorite schist. (**EMPR AR** 1964-A74; **GSC MEM** 372; **GSC MAP** 1327A; 1424A)

Omineca Mountains

NO. 48 **NTS MAP:** 094C05E, 094C12E & W

NAME: AIKEN LAKE (48)
MINFILE NUMBER: 094C 090
LOCATION: In the Lay Range east of Polaris Creek, approximately 7 kilometres northeast of Aiken Lake.

LAT/LONG: 56° 29' 18" / 125° 42' 15"
ELEVATION: 1800 m

STATUS: Asbestiform Serpentine (Chrysotile) Showings
HOST UNIT: Polaris Ultramafic Complex
TERRANE: Quesnellia Harper Ranch
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

The Middle Triassic to Early Jurassic (?) Polaris Ultramafic Complex is composed of peridotite, dunite and pyroxenite. In the west-central and southeastern parts of the stock, east of Polaris Creek, serpentinized ultramafics are host to "a few thin bands of grey, flexible, asbestiform chrysotile.

The Complex is primarily known for its chromite occurrences. Prospecting for platinum group metals has delineated stream sediment geochemical anomalies but no bedrock occurrences. (**EMPR ASS RPT** 15955, 16236, 16574, 16628; **EMPR FW** 1991, 1992, EMPR OF 1992-11, 1993-2; **GSC MAP** 1030A **GSC MEM** 274)

NO. 49 **NTS MAP:** 093N10E

NAME: GERMANSEN RIVER (49) **LAT/LONG:** 55° 44′ 36″ / 124° 39′ 59″
MINFILE NUMBER: 093N 115 **ELEVATION:** 828 m
LOCATION: On Germansen River approximately 10 km from its mouth and 1 km east of the Germansen Landing road.

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Manson Lakes Ultramafites **DEPOSIT TYPE:** Vein
TERRANE: Slide Mountain **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane **LITHOLOGY:** Serpentinite

This occurrence is hosted within a fault-bounded slice of the Pennsylvanian-Permian Manson Lakes Ultramafites. The ultramafics are altered and are predominantly serpentinite. This fault bounded ultramafic package is found within the northwest striking, right-lateral Manson fault zone of probable Late Cretaceous to Tertiary age. To the immediate southwest, across a fault boundary, are sediments of the Middle to Upper Triassic Slate Creek Formation (Takla Group). To the north of this ultramafic package, are fault-bounded rocks of North American affinity; the Mississippian to Permian Cooper Ridge Group and the Upper(?) Devonian to Mississippian Big Creek Group.

This occurrence was originally described in Geological Survey of Canada Paper 45-9 as a low-grade chrysotile asbestos showing. The chrysotile occurs as thin discontinuous veinlets running through the serpentinite. Two grab samples near this location yielded 0.25 % nickel. (**EMPR ASS RPT** 1938, 12130, 12362; **EMPR AR** 1924-111; 1927-158; 1936-C3,39; 1938-C7; **EMPR OF** 1989-12 **EMPR FW** 1988; **EMPR BULL** *Ferri, F. and Melville, D.M., in preparation, Geology of the Germansen Landing - Manson Creek Area, North Central British Columbia; **GSC MEM** 252; **GSC MAP** 876A,; 907A, 971A, 1424A, 5249G; GSC P 41-5, 42-2, 45-9; 75-33)

Nechako Lowland

The Nechako Lowlands are underlain to the west by the Mississippian to Triassic Cache Creek Terrane and to the east by the Quesnellia Terrane and the Omineca Belt. Middle Jurassic and Tertiary volcanic and sedimentary rocks overlie the Cache Creek Group. The boundary between the Quesnellia and Cache Creek Terranes is probably the southern extension of the Pinchi fault system. Within the Cache Creek Terrane tectonically emplaced ultramafic rocks of ophiolitic affinity host 6 documented asbestos showings. None of the showings have been cited as having any economic value.

To the north, tremolite and chrysotile showings (50 & 51) occur within a tremolite-chlorite alteration zone which has developed between the serpentinized peridotite of the Mount Sidney Williams ultramafic massif and the Cache Creek sedimentary rocks.To the south chrysotile and anthophyllite showings (52 - 55) occur within variably deformed and metamorphosed serpentinized peridotite.

NO. 50 & 51 **NTS MAP:** 093K14W

NAME: VAN DECAR ASBESTOS (50)
LAT/LONG: 54° 55′ 00″ / 125° 26′ 00″
MINFILE NUMBER: 093K 068
ELEVATION: data not available
LOCATION: North slope of Mt. Sidney Williams.
STATUS: Cross-fibre Asbestiform Amphibole (Tremolite) Showing

NAME: MT. SIDNEY WILLIAMS (51)
LAT/LONG: 54° 53′ 50″ / 125° 23′ 55″
MINFILE NUMBER: 093K 043
ELEVATION: 1770 m
LOCATION: Centered south of Tear Drop lake, 87 km northwest of Fort St. James.
STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing

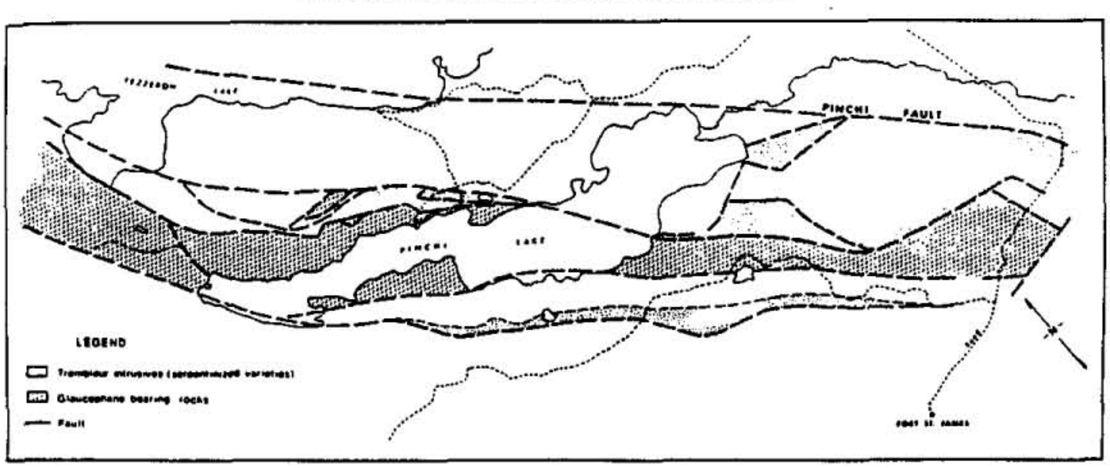
HOST UNIT: Mount Sidney Williams Ultramafic Massif
TERRANE: Cache Creek
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Vein & Stockwork
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

The Van Decar Asbestos (50) and Mount Sidney Williams (51) showings occur within ultramafic rocks of the Permian to Triassic referred to in the literature as the Trembleur Intrusions. This suite of rocks is probably of ophiolitic affinity, related to the oceanic Mississippian to Triassic Cache Creek Group on which it lies.

The area is underlain by rocks informally referred to as the Mount Sidney Williams ultramafic massif which consist of serpentinized peridotite and harzburgite with pods of dunite and Cache Creek Group andesitic volcanics and argillaceous schist. Asbestos mineralization at Van Decar Asbestos (50) occurs as veins within serpentinized peridotite of the Trembleur Intrusives. Three veins have been recognized, each 10 to 24 centimetres wide and 61 metres apart, outcropping over a distance of 6 metres. The asbestos fibres are tremolitic in composition and have their long axes normal to vein walls. The fibres are very brittle and are associated with some picrolite serpentine.

Mineralization at Mount Sidney Williams (51) consists of asbestos, chromite, pyrite, arsenopyrite, stibnite and poor quality jade. Cross fibre chrysotile asbestos occurs in a 7.6 metre wide zone in serpentinized peridotite. Stringers vary in width from 0.3 to 3.8 centimetres and are from 0.3 to 30 centimetres apart. The asbestos fibres are brittle and of poor commercial quality. (**GSC MEM** 252; **GSC P** 38-10; **EMPR AR** 1962-A67; **GSC MAP** 631A, 907A, 1424A; **EMPR ASS RPT** 17173, 18089)

FIGURE 17: TREMBLEUR INTRUSIVES



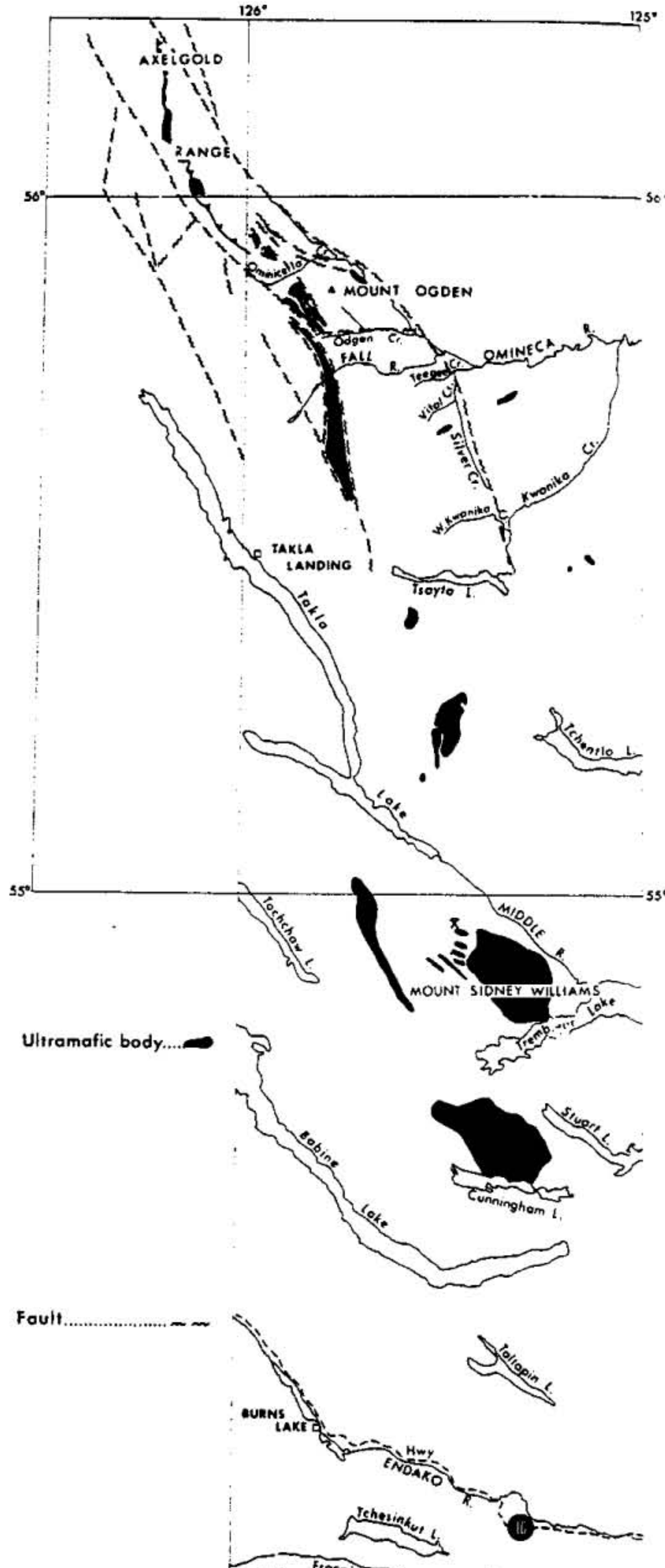


FIGURE 18: ULTRAMAFIC OCCURRENCES OF THE NECHAKO LOWLAND (Leaming, 1978)

NO. 52

NTS MAP: 093G13W

NAME: SINKUT MOUNTAIN (52)
LAT/LONG: 53° 48' 33" / 125° 58' 16"
MINFILE NUMBER: 093G 018
ELEVATION: 1311 m
LOCATION: Road cut 0.8 kilometres west of the forestry lookout on Sinkut Mountain.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) and Amphibole (Anthophyllite) Showing
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Vein?
TERRANE: Cache Creek
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinized Peridotite

The Sinkut Mountain occurrence consists of chrysotile asbestos within serpentinized peridotite. Fibrous anthophyllite also occurs in the area. (**GSC MEM** 324; **GSC MAP** 49-1960, 1424A; **EMPR PF** (Tipper, H.W., Geology Maps))

NO. 53, 54 & 55

NTS MAP: 093G11W, E & 093G05E

NAME: BALDY HUGHES (53)
LAT/LONG: 53° 37' 37" / 123° 05' 25"
MINFILE NUMBER: 093G 016
ELEVATION: data not available
LOCATION: On a bearing north 85° west from Mount Baldy Hughes.

NAME: RAY (54)
LAT/LONG: 54° 37' 27" / 123° 27' 35"
MINFILE NUMBER: 093G 002
ELEVATION: 1158 m
LOCATION: On southwest ridge, 2.4 km from south end of Naltesby Lake.

NAME: TELEGRAPH RANGE (55)
LAT/LONG: 54° 53' 50" / 125° 23' 55"
MINFILE NUMBER: 093G 012
ELEVATION: data not available
LOCATION: On a bearing south 70° east from Tagai Lake.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Vein & Stockwork
TERRANE: Cache Creek
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinized Peridotite

Chrysotile asbestos occurs within serpentinized peridotite at Baldy Hughes (53), Ray (54) and Telegraph Range (55) At the Ray (54) showing small occurrences of cross fibre asbestos with fibres up to 1.3 centimetres long are found in widely spaced veinlets. These veinlets also have associated nickel silicate mineralization. (**EMPR ASS RPT** 2557, 10828, 15160; **EMPR GEM** 1970-199; **EMPR AR** 1961-139; **GSC MAP** 3-1969, 49-1960, 1424A)

COAST BELT TERRANES

Pacific Ranges

The Pacific Ranges of southern British Columbia host 5 asbestos showings. Excellent quality cross and slip-fibre asbestiform serpentine (chrysotile) occurs within serpentinite of the Shulaps Ultramafic Complex (56 & 57) and of the President Ultramafics (58). The northerly part of the Shulaps Range consists of a large mass of intensely serpentinized ultramafic rock, mainly harzburgite, with lesser amounts of dunite and pyroxenite. The Shulaps ultramafic bodies are in fault contact with Upper Triassic sedimentary rocks (Leaming, 1978).

The timing of the development of asbestos veins may be related to intrusive events of the Coast Plutonic Complex.

At the Glacier (59) and Rawhide (60) shear zone hosted asbestiform amphibole (tremolite-actinolite) coincides with magnesite-talc bearings micaceous and chloritic schists and phyllites of the Lower Cretaceous Bridge River Complex.

NO. 56

NTS MAP: 092J16W

NAME: SHULAPS MTN (56)
LAT/LONG: 50° 57′ 30″ / 122° 29′ 50″
MINFILE NUMBER: 092JNE112
ELEVATION: 2850 m
LOCATION: At the headwaters of Retaskit Creek, 3.6 kilometres east of Shulaps Peak.

STATUS: Slip-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Shulaps Ultramafic Complex
DEPOSIT TYPE: Vein
TERRANE: Bridge River
MINERALIZATION AGE: Unknown
TECTONIC BELT: Intermontane
LITHOLOGY: Serpentinite

The asbestos, intermediate between chrysotile and picrolite, is within serpentinite of the Permian and older Shulaps Ultramafic Complex. The asbestos occurs along fractures in the serpentinite forming fibres up to 15 centimetres long; it's extent is very limited. (**EMPR ASS RPT** 19599; **EMPR BULL** 32; **EMPR FW** 1987, 1988, 1989, 1990; **EMPR OF** 1990-10)

NO. 57

NTS MAP: 092J15W

NAME: MOUNT PENROSE (57)
LAT/LONG: 50° 52′ 55″ / 122° 57′ 45″
MINFILE NUMBER: 092JNE070
ELEVATION: 2784 m
LOCATION: On ridge separating north fork of Walker Creek and Roxey Creek, north of Mount Penrose.

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Shulaps Ultramafic Complex
DEPOSIT TYPE: Vein
TERRANE: Bridge River
MINERALIZATION AGE: Unknown
TECTONIC BELT: Coast
LITHOLOGY: Serpentinite

Asbestos occurs as dark green to yellow green cross fibre chrysotile in short veinlets that pinch and swell abruptly. The veinlets occur in parallel swarms in scattered parallel zones 20 to 60 centimetres wide. The zones are widely spaced and strike north across a small irregularly elongate serpentinite mass, 240 metres wide by 600 metres long, that is probably correlative with the Permian and older Shulaps Ultramafic complex. The serpentinite is cut by numerous thin irregular granodiorite dikes; the surrounding rock is predominantly granodiorite of the Jurassic to Tertiary Coast Plutonic Complex except for small patches of sediments reported to the southeast. The average fibre length of the chrysotile is 0.32 centimetres, with rare 1.27 centimetre material. The overall fibre content of the serpentine is considered very low. (**EMPR AR** 1953, 1960; **EMPR FW** 1974, 1985-1990; **EMPR OF** 1987-11, 1988-3, 1989-4, 1990-10; **GSC P** 77-2 ; **GSC OF** 482; **CJES** 1987, Vol. 24, pp. 2279-2291)

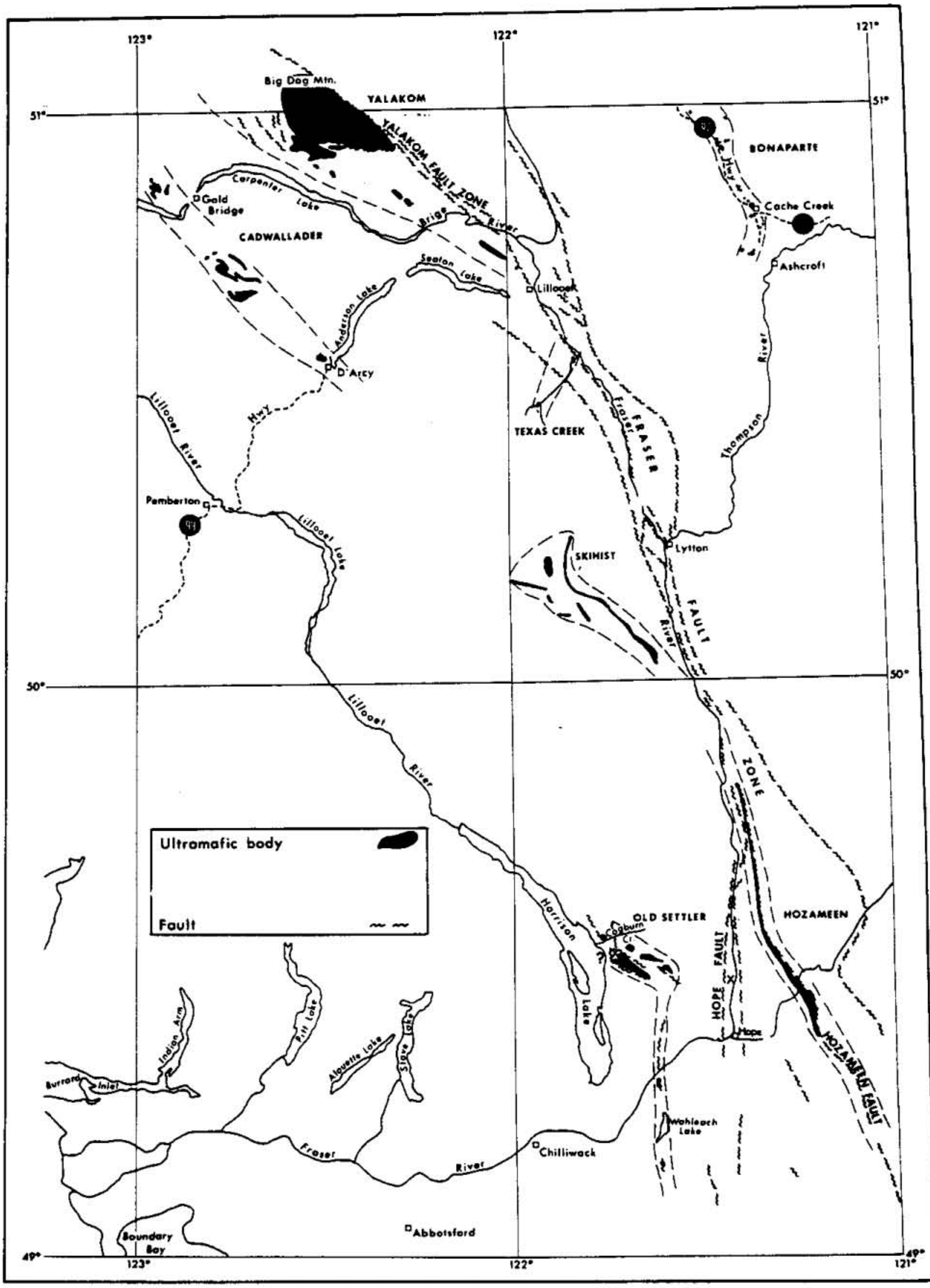


FIGURE 19: FAULT BOUND ULTRAMAFIC ROCKS OF SOUTHERN B.C. (Leaming, 1978)

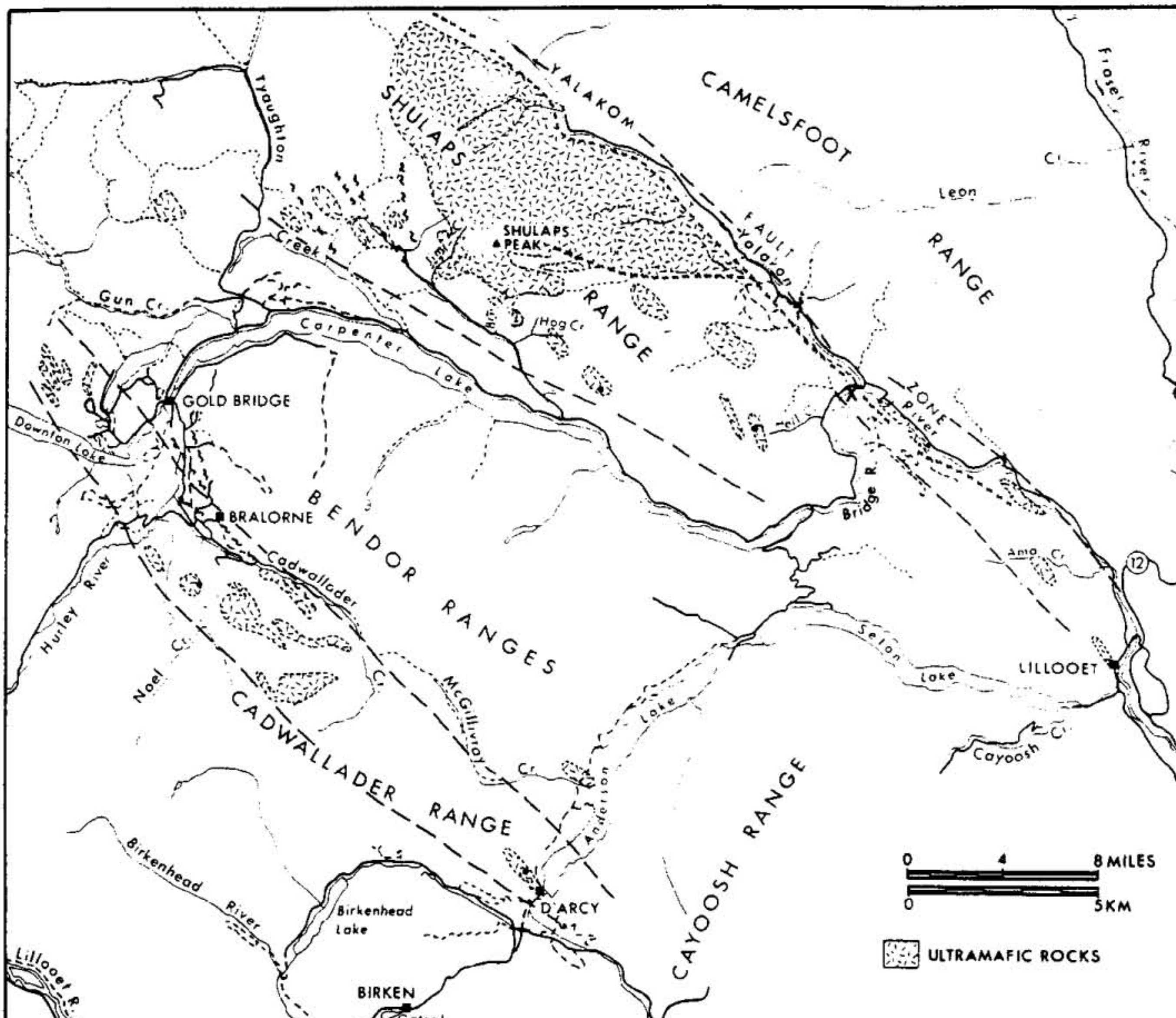


FIGURE 20: ULTRAMAFIC OCCURRENCES IN THE BRIDGE RIVER (Leaming, 1978)

NO. 58 | **NTS MAP:** 092J10E

NAME: CADWALLADER MOUNTAIN (58) **LAT/LONG:** 50° 39′ 50″ / 122° 42′ 00″
MINFILE NUMBER: 092JNE106 **ELEVATION:** 1770 m
LOCATION: At the head of Copp Creek.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: President Ultramafics? **DEPOSIT TYPE:** Vein
TERRANE: Bridge River **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Coast **LITHOLOGY:** Serpentinite

Serpentinized peridotite, possibly of the President Ultramafics (probably correlative with Permian and older Shulaps Ultramafics), occurs in a large body against granodiorite of the Jurassic to Tertiary Coast Plutonic Complex.

Excellent quality cross fibre chrysotile asbestos, up to 6.4 millimetres in length, occurs in closely spaced veinlets 3 millimetres wide in 30 centimetre widths of partly serpentinized peridotite. (**EMPR FW** 1974, 1987-1990; **EMPR OF** 1987-11, 1988-3, 1989-4, 1990-10; **GSC MEM** 213; **CMH** 1953, 1954)

NO. 59 & 60 | **NTS MAP:** 092I04W

NAME: GLACIER (59) **LAT/LONG:** 50° 09′ 31″ / 121° 50′ 07″
MINFILE NUMBER: 092ISW053 **ELEVATION:** 2065 m
LOCATION: Adit close to North Kwoiek Creek tributary, 6.8 km SE of Skihist Mountain and 3 km NE of Klept Lake.

NAME: RAWHIDE (60) **LAT/LONG:** 50° 09′ 28″ / 121° 49′ 35″
MINFILE NUMBER: 092ISW051 **ELEVATION:** 1860 m
LOCATION: 6.3 km SE of Skihist Mountain on the southern slopes of North Kwoiek Creek, 19.5 km W-SW of Lytton.

STATUS: Asbestiform Amphibole (Tremolite) Showing
HOST UNIT: Bridge River Ultramafics **DEPOSIT TYPE:** Vein
TERRANE: Bridge River **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Coast **LITHOLOGY:** Serpentinite

The area of the Glacier(59) and Rawhide (60) asbestos showings is underlain by a northwest trending belt of lower greenschist facies Permian(?) to Lower Cretaceous Bridge River Complex (Group) phyllites and schists. These occur in normal and fault contact with Bridge River serpentinized ultramafics and metasediments of the Upper Jurassic-Lower Cretaceous Relay Mountain Group. Late Cretaceous Scuzzy pluton granitic rocks intrude all of the above units to the north and south, and occur as plugs.

Units of serpentinite belts are interbedded with argillite, graphitic phyllite, micaceous and chloritic schists, and occasional bands of quartzite and limestone. Granodiorite occurs to the southwest. A lenticular, steeply dipping body of talc varying up to 75 metres in width, occurs within one of the serpentinite belts, and strikes 110 to 120 degrees for a distance of 450 metres.

At Rawhide (60) asbestiform amphibole occurs in tremolite-talc-carbonate pods hosted in serpentinite in a 150 metre wide, fractured and sheared serpentinite/metasediment contact zone north of the main talc body. The asbestos occurs in limited quantity and is of an undetermined grade.

At Glacier (59) a sheared fault contact between argillaceous phyllite and chlorite schist exhibits skarn mineralization in the form of actinolite, garnet, magnetite and pyrrhotite. One of the shear zones is 150 metres wide and contains pods of serpentine and talc. Minor asbestos occurs along slickensides.

These serpentinite masses were first explored for asbestos by Magnetron Mining Ltd. in 1970. They were subsequently assessed for their talc and magnesite potential by D. Cardinal and Highland Talc Minerals Ltd. between 1987 and 1990. (**EMPR GEM** 1970; **EMPR INF CIRC** 1991-1; **EMPR AR** 1929-C236; **EMPR EXPL** 1978, 1979, 1982; **EMPR ASS RPT** 2536, 6854, 7455, 9542, 10680, 14715, 15311, 16545, 18024; **EMPR OF 1988-19; GSC MEM** 262; **GSC P** 46-8; 47-10; **GSC MAP** 101A, 1386A; 42-1989; **GSC OF** 980)

Pavillion Ranges

The Pavillion Ranges host 3 chrysotile asbestos showings.

NO. 61 **NTS MAP:** 092J16E

NAME: MOON CREEK ASBESTOS (56)
MINFILE NUMBER: 092JNE104
LOCATION: East of Moon Creek on powerline right-of-way.
LAT/LONG: 50° 45′ 20″ / 122° 01′ 10″
ELEVATION: 1590 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Bridge River Ultramafics
TERRANE: Bridge River
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Vein & Stockwork
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Peridotite

Interbedded greywacke, small-pebble conglomerate and argillite with minor limestone lenses of the Mississippian an older Bridge River Complex (Group) trend northwest and dip moderately southwest. Serpentinized peridotite lies conformably beneath the sediments; the contact is irregular and sheared and contains white calcite veining. The ultramafic rocks are possibly continuous with Shulaps Ultramafics (Permian and older). The lens shaped peridotite, 3600 metres by 1050 metres, is intruded by few small albitized diorite dikes.

The asbestos is cross-fibre chrysotile occurring in thin, irregular discontinuous veinlets in multi-directional fractures in the serpentinized peridotite. The widest vein found is 8 millimetres; most of the asbestos is concentrated in a zone along the south contact of the peridotite mass. Outside this zone, the occurrences are patchy and scattered. (**EMPR ASS RPT** 1862, 2209; **EMPR AR** 1962; **EMPR GEM** 1969, 1975; **EMPR BULL** 44; **EMPR FW** 1974, 1985-1990; **EMPR OF** 1987-11, 1988-3, 1989-4, 1990-10; **GSC OF** 482)

NO. 62 & 63 **NTS MAP:** 092I12W

NAME: LILLOOET AREA (62)
MINFILE NUMBER: 092JNE104
LOCATION: Meadow at junction of Wood and Pukaist Creeks.
LAT/LONG: 50° 41′ 00″ / 121° 56′ 00″
ELEVATION: 1400 m

NAME: FRASER RIVER (63)
MINFILE NUMBER: 092JNE104
LOCATION: Between Bridge River and Texas Creek.
LAT/LONG: 50° 38′ 00″ / 121° 54′ 00″
ELEVATION: 1400 m

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Bridge River Ultramafic?
TERRANE: Bridge River?
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Vein & Stockwork
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

Chromite bearing serpentinite at Lillooet Area (62) is reported to be fractured and veined by chrysotile. At Fraser River (63) scarce chrysotile fibre is reported in serpentine bodies. The literatures cites the showings as small with short fibres and not of any economic significance. (**GSC ANN RPT VII B** 1894; **GSC MEM** 262)

Southern Fiord Ranges

The Southern Fiord Ranges host 3 asbestos showings. One of unconfirmed mineralogy (64), one of tremolite (65) and one of actinolite (66).

NO. 64

NTS MAP: 092H11W

NAME: GORDON CREEK ASBESTOS (64)
LAT/LONG: 49° 32′ 52″ / 121° 27′ 01″
MINFILE NUMBER: 092HNW057
ELEVATION: 152 m
LOCATION: On Gordon Creek, approximately 800 metres west of the Fraser River.

STATUS: Slip and Cross-fibre Asbestiform Serpentine Showing
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Vein
TERRANE: Shuksan
MINERALIZATION AGE: Unknown
TECTONIC BELT: Coast
LITHOLOGY: Serpentinite

The area is underlain by gneissic granite of the Cretaceous and/or Tertiary Custer Gneiss in contact with slate assigned to the Mesozoic Settler Schist along the north trending Hope fault. In the vicinity of Gordon Creek, a 150-metre wide slice of ultramafic rocks of unknown age occupies a short segment of the fault. An elongate body of granodiorite assigned to the Cretaceous Spuzzum Intrusions is in fault contact with the ultramafic rocks and has intruded the metasediments to the west.

The ultramafic rocks are dominated by shattered serpentinite, described as being dense and black and hosting minor disseminated chromite. Asbestos, occurring as slip fibre, was reportedly developed in fracture planes within the serpentinite. The only visible cross fibre apparently occurred in minute veins, which were not very abundant. Development work to 1911 consisted of several opencuts and a few tunnels. (**GSC SUM RPT** 1911; **GSC P** 69-47; **GSC MAP** 737A, 12-1969, 41-1989; **EMPR MAP** 1986-1C)

NO. 65

NTS MAP: 092H12E

NAME: HARRISON LAKE ASBESTOS (65)
LAT/LONG: 49° 32′ 20″ / 121° 44′ 12″
MINFILE NUMBER: 092HNW058
ELEVATION: 215 m
LOCATION: North side of Fifteen Mile (Talc?) Creek tributary, approx. two km east of Harrison Lake.

STATUS: Asbestiform Amphibole (Tremolite) Showing
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Vein
TERRANE: Bridge River
MINERALIZATION AGE: Unknown
TECTONIC BELT: Coast
LITHOLOGY: Serpentinite

The Talc Creek area is underlain by a northwest trending, fault bound belt of ultramafic rocks of probable Paleozoic and/or Mesozoic age. Light to dark green, brittle, fibrous tremolite in 15 to 30-centimetre wide veins are reported to be hosted by serpentine within or adjacent to this belt. (**EMPR AR** 1960; **EMPR IND MIN FILE**; **GSC P** 69-47; **GSC MAP** 737A, 12-1969, 41-1989)

NO. 66 **NTS MAP:** 092H05E

NAME: WAHLEACH CREEK (66) **LAT/LONG:** 49° 18' 30" / 121° 37' 54"
MINFILE NUMBER: 092HSW099 **ELEVATION:** 500 m
LOCATION: Bank of Wahleach Creek, 800 metres south of the Trans Canada Highway.

STATUS: Asbestiform Amphibole (Actinolite) Showing
HOST UNIT: unidentified metamorphic assemblage **DEPOSIT TYPE:** Vein
TERRANE: Chilliwack **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Coast **LITHOLOGY:** Serpentinized Peridotite

Actinolite in coarse brittle fibers with little tensile strength occurs in a series of north and west striking fractures in serpentinzed periotite along 61 metres of the bank of Wahleach Creek. (**EMPR AR** 1960; Richmond, 1932; **GSC MAP** 737A)

Cascade Mountains

NO. 67

NTS MAP: 092H06W

NAME: COQUIHALLA SERPENTINE (67)
LAT/LONG: 49° 28′ 12″ / 121° 15′ 18″
MINFILE NUMBER: 092HSW112
ELEVATION: data not available
LOCATION: Occurrences exist between Fifteen Mile and Sowaqua Creeks with the Serpentine Belt.

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: Coquihalla Serpentine Belt
DEPOSIT TYPE: Vein
TERRANE: Bridge River
MINERALIZATION AGE: Unknown
TECTONIC BELT: Coast
LITHOLOGY: Serpentinite

The Coquihalla Serpentine Belt forms a narrow, elongate north-northwest trending, steeply dipping unit separating supracrustal rocks of the Ladner Group to the east from the Hozameen Group in the west. Dark, highly sheared to massive serpentinite of probable peridotite parentage, characterizes the belt. It also contains substantial amounts of highly altered gabbro-diabase rocks.

The western boundary is delineated by a major fault which appears to dip steeply east. This is termed the "West" Hozameen Fault and the serpentinites in this vicinity contain highly sheared talcose rocks. The "East" Hozameen Fault separates the serpentinite from the Ladner Group metasediments.

Tiny veinlets of asbestos (chrysotile) are commonly observed in hand specimens of the serpentinites. Under microscopic examination this serpentine has been identified as antigorite. It varies considerably in appearance according to the local degree of serpentinization. Also, thin, bluish white and rather pearly films of another type of serpentine, somewhat resembling chrysotile, commonly coat factures or joint-planes within the rock.

Talc is extensively developed along shear zones in and bordering the main serpentine body and is also associated with carbonate in more massive bodies within the serpentine. (**EMPR OF MAP** 1986; **EMPR FW** 1982; **GSC SUM RPT** 1929; **GSC P** 69-47; **GSC MAP** 12-1969; **GSC MEM** 139; Canadian Rockhound Feb. 1966, p. 8)

NO. 68

NTS MAP: 092H04E

NAME: CHILLIWACK RIVER (68)
LAT/LONG: 49° 04′ 36″ / 121° 37′ 18″
MINFILE NUMBER: 092HSW111
ELEVATION: data not available
LOCATION: 2 km southeast of the junction of Nesakwatch Creek and the Chilliwack River.

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Vein
TERRANE: Chilliwack
MINERALIZATION AGE: Unknown
TECTONIC BELT: Coast
LITHOLOGY: Serpentinite

The area is underlain by the Juro-Triassic Cultus Formation which is predominantly comprised of sandstone and pelite. To the west is a high angle, steeply dipping fault which appears to have brought older crystalline gabbros and serpentinites over younger Cultus argillite and pelite.

Brittle harsh asbestos fibres, ranging up to 4.8 millimetres in length, occur in scattered veinlets 2.0 kilometres southwest of the junction of Nesakwatch Creek and the Chilliwack River. (**GSC P** 69-47; **GSC MAP** 12-1969)

INTERMONTANE SUPERTERRANE

Cariboo Plateau

The four asbestos showings of the Cariboo Plateau are all found in serpentinized allochthonous ultramafic bodies with in the Cache Creek Terrane.

NO. 69

NTS MAP: 093A04W

NAME: OCHILTREE (69)
MINFILE NUMBER: 093A 138
LOCATION: data not available

LAT/LONG: 52° 14′ 30″ / 121° 49′ 30″
ELEVATION: data not available

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Cache Creek
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

The Ochiltree showing is underlain by rocks of the Cache Creek Terrane, comprising argillaceous metasediments, limestone, mafic metavolcanics and serpentinite. The showing consists of outcrops of serpentinite with narrow veins of chrysotile. (**GSC MAP** 3-1961, 1424A)

NO. 70

NTS MAP: 093B01E

NAME: DRD (70)
MINFILE NUMBER: 093B 024
LOCATION: 1.6 km south of the east end of Williams Lake.

LAT/LONG: 52° 05′ 17″ / 122° 01′ 23″
ELEVATION: 914 m

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Cache Creek
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Stockwork
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Dunite & Peridotite

The DRD (70) showing is underlain by rocks of the Mississippian to Triassic Cache Creek Group which, in the vicinity of Williams Lake, is dominated by marine sedimentary rocks and metabasalt. Within this assemblage is an ultramafic body composed of serpentinized dunite and peridotite. Chrysotile asbestos occurs within more competent masses of serpentinized dunite and within more strongly deformed ultamafics, now serpentinite schist.

Cross-fibre chrysotile occurs in hairline fractures to veins, 2.54 centimetres in width, which are on average are 0.6 to 3 millimetres wide. The wider veins have one or more central partings resulting in relatively short fibre lengths. Veins are spaced approximately 30 centimetres apart, they pinch and swell and seldom persist for more than 30 to 60 centimetres.

In 1961 Bell Asbestos Mines Ltd., prospected the property, mapped the geology and stripped several areas with a bulldozer. Trenching has indicated that the extent of asbestos-bearing rocks is limited and that the asbestos is of too low a grade to constitute ore (**EMPR ASS RPT** *392; **EMPR AR** 1961-1962; **GSC MAP** 1424A).

NO. 71 | **NTS MAP:** 092P03W

NAME: BONAPARTE RIVER (71)
MINFILE NUMBER: 092P 082
LOCATION: 1.6 km south of the east end of Williams Lake.
LAT/LONG: 51° 07' 48" / 121° 28' 30"
ELEVATION: 730 m

STATUS: Asbestos Showing
HOST UNIT: Mika Ultramafic Body
TERRANE: Cache Creek
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Veinlet
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Dunite & Peridotite

The ultramafics of the Permian to Triassic Mika Ultramafic Body are zoned dunites and peridotites which are highly serpentinized and in places completely converted to talc. The fault bounded allochthonous segment is found within the Lower Permian metavolcanics and meta-sediments of the Cache Creek Group.

The ultramafics are medium-grained, light to dark green on fresh surfaces and weather to a green or reddish green. Magnesium carbonate alteration occurs preferentially in the dunites but there is a gradation from serpentinization and steatization. Harsh fibre asbestos veinlets, less than 1.6 millimetres wide are abundant throughout the serpentinite.

In addition to magnesite, the same ultramafics are known to carry chromite as grains, small pods and veinlets within the dunitic units and, locally within the magnesite, due to its resistance to the carbonate alteration processes. The occurrence has been of exploration interest, at various times, for its magnesite, asbestos and chrome mineralization. (**EMPR ASS RPT** 197, 1146, 8111, 8677; **EMPR AR** 1932, 1941, 1960; **EMPR OF** 1987-13; **SC SUM RPT** 1932; **GSC MAP** 1278A; **GSC MEM** 363)

NO. 72 | **NTS MAP:** 092P04E

NAME: MOUNT SOUES (72)
MINFILE NUMBER: 092P 143
LOCATION: Southern base of Mount Sous, near Junction Valley.
LAT/LONG: 51° 03' 30" / 121° 44' 36"
ELEVATION: 1800 m

STATUS: Asbestiform Serpentine (Chrysotile) Showing
HOST UNIT: undivided metamorphic assemblage
TERRANE: Cache Creek
TECTONIC BELT: Intermontane
DEPOSIT TYPE: Veins
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentine

Small veins of chrysotile asbestos were obseved in serpentine. (**GSC ANN RPT** 1894)

Thompson Plateau

The Thompson Plateau area is host to five asbestos showings, none of which have any significant economic value. The Pat (73) showing occurs in serpentine of possibly the Permian Kaslo Group. The Lone Star (74) and Chrome-Vanadium (75) are cross-fibre asbestiform serpentine (chrysotile) showings which occur in fault bounded serpentinized harzburgites within the Quesnellia Terrane. Small asbestos showings at D (76) and Olivine Mountain (77) are found within the Early Jurassic Tulameen Ultramafic Complex, a zoned Alaskan-type intrusive complex.

The entire Tulameen Ultramafic Complex is cut by northwest trending transcurrent strike-slip faults associated with the Fraser River Straight Creek fault system (Monger, 1985). Northeast trending extensional faults also transect the complex.

The dunite core of the Complex is exposed on the slopes between Olivine and Grasshopper Mountains and in the valley of the Tulameen River. It is roughly oval in shape and covers an area of about 6 square kilometres. Mapping by Findlay (1963) outlined areas of serpentinization that varied from 20 to 80 %. The degree of serpentinzation decreases, in general, from east to west.

NO. 73

NTS MAP: 082M04E

NAME: PAT (73)
MINFILE NUMBER: 082M 119
LOCATION: data not available

LAT/LONG: 51° 00′ 00″ / 119° 44′ 10″
ELEVATION: 425 m

STATUS: Asbestos Showing
HOST UNIT: Kaslo Group?
TERRANE: Kootenay
TECTONIC BELT: Omineca

DEPOSIT TYPE: Veins?
MINERALIZATION AGE: Unknown
LITHOLOGY: data not available

The area is underlain by Devonian or older Eagle Bay Formation rocks consisting of chlorite schist, phyllites, siliceous gneiss and greenstone.

Serpentine, possibly of the Permian Kaslo Group (Okulitch, 1979) hosts sparse short, 0.3 to 0.6 centimetre, asbestos fibres. (**EMPR ASS RPT** *3510; **EMPR GEM** 1972-86; **EMPR FIELDWORK** 1980; **GSC OF** 637; **EMPR MAP** 56; **GSC MAP** 48-1963)

NO. 74 & 75

NTS MAP: 082L04W

NAME: LONE STAR (74)
MINFILE NUMBER: 082LSW057
LAT/LONG: 50° 12′ 13″ / 119° 57′ 45″
ELEVATION: 1130m
LOCATION: 50 kilometres west of Vernon, on the south side of Chapperon Creek.

NAME: CHROME-VANADIUM (75)
MINFILE NUMBER: 082LSW056
LAT/LONG: 50° 00′ 26″ / 119° 51′ 55″
ELEVATION: 1450 m
LOCATION: 33 kilometres west-northwest of Kelowna, south of Alocin Creek. The showings are on top of a prominent northwest trending ridge.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showings
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Quesnellia Okanagan
TECTONIC BELT: Intermontane

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Harzburgite

Chrysotile asbestos showings have been noted at Lone Star (74) and Chrome-Vanadium (75) properties. In this area, Devonian to Triassic volcanic and sedimentary rocks of the Harper Ranch Group and the Permian and older Chapperon Group are unconformably overlain by Upper Triassic to Lower Jurassic Nicola Group sedimentary and volcanic rocks.

These are intruded by Middle Jurassic granitic rocks of the informally named Terrace Creek batholith. Extensive Eocene Kamloops Group volcanic and sedimentary rocks overlie the older units.

Serpentinized harzburgite hosts chromite, magnetite and asbestiform serpentine (chrysotile) mineralization. Relict orthopyroxene indicates that the protolith was harzburgite. It is fault bounded in the Permian and older Chapperon Group, and is likely a remnant of lower crustal oceanic rocks. The unit, striking 150 degrees and dipping 85 degrees east has been traced for 9 kilometres. The pelitic rocks comprise phyllite, greenstone and mica schist.

Serpentine contains small veinlets of cross-fibre chrysotile asbestos varying in thickness from a mere thread to 6 millimetres. Where shearing or slickensiding is pronounced, lenses of serpentine exhibit partially developed slip-fibre asbestos.

Chrome-Vanadium (75) was initially staked and prospected in the late 1920s by A.H. Raymer and Associates. Later, in the 1930s, the Chrome Ridge Mining Syndicate held claims that covered the better part of the serpentinite containing chromite mineralization. During that time a small amount of hand trenching, sampling and prospecting was done. In 1956, Noranda Exploration Company Ltd. did an extensive geological mapping, sampling, prospecting and aeromagnetic surveys of the area. By 1977, Nicola Copper Mines Ltd. and Buccaneer Resources Ltd. did further geological mapping, ground magnetometer surveys, soil sampling and trenching. At that time the Alocin and Cameo Lake showings were named. In 1986, the Laramie Mining Corp. collected heavy mineral samples. In 1995 the showings are covered by the Jack 5 claim, owned by Rea Gold Corp.

(**EMPR OF** 1988-19, 1989-5, 1990-30; **EMPR MAP** 5207G, 7216G; **EMPR RGS** 1976; **EMPR FIELDWORK** 1987, 1988; **EMPR AR** 1929; **EMPR GEM** 1977; **EMPR EXPL** 1986; **EMPR ASS RPT** 168, *6775, 15233; **EMPR P** 1991-4; **GSC MEM** 296; **GSC OF** *637 (Map C), 736, 2167; **GSC MAP** 46-7, *48-4A, 1059A, 1712A; **GSC P** 89-1E; **GSC SUM RPT** *1931A; Whittaker, P. (1983))

NO. 76 & 77 — NTS MAP: 092H10W

NAME: D (76) — **LAT/LONG:** 49° 31′ 39″ / 120° 54′ 06″
MINFILE NUMBER: 092HNE128 — **ELEVATION:** 908 m
LOCATION: Confluence of Britton (Eagle) Creek with the Tulameen River, 10.5 kilometres west-southwest of the town of Tulameen.

NAME: OLIVINE MOUNTAIN (77) — **LAT/LONG:** 49° 31′ 10″ / 120° 52′ 52″
MINFILE NUMBER: 092HNE184 — **ELEVATION:** 1637 m
LOCATION: Northwest slope of Olivine Mountain, 9 kilometres west-southwest of Tulameen.

STATUS: Asbestos Showing
HOST UNIT: Tulameen Ultramafic Complex — **DEPOSIT TYPE:** Vein?
TERRANE: Quesnellia — **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Intermontane — **LITHOLOGY:** Serpentinized Dunite & Peridotite

The D (76) and Olivine Mountain (77) asbestos showings are associated with chromite and magnetite mineralization and elevated platinum levels within the dunite-rich core of the Early Jurassic Tulameen Ultramafic Complex, a zoned Alaskan-type intrusive complex.

At D (76) mineralization occurs in a serpentine breccia zone containing fragments of dunite/peridotite cemented by a matrix of serpentine. The zone is 180 metres long, up to 155 metres wide and lies mostly north of the river, on either side of the creek. The breccia zone is noted to be practically free of sulphides (Assessment Report 17170), yet earlier reports suggest the presence of chalcopyrite and millerite. Magnetite, sperrylite and asbestos have also been reported in the past.

At Olivine Mountain (77) dunite outcrops over an elongate area extending up the northwest slope of the mountain. Higher platinum values occur in strongly serpentinized, mildly asbestos-veined peridotite and dunite (Assessment Report 16691).

D (76) was mapped and sampled by Imperial Metals Corporation, Newmont Exploration of Canada and Tiffany Resources between 1984 and 1987. The summit and north slope of Olivine Mountain (77) were extensively sampled by

Tarnation Mining, North American Platinum Corporation, D.K. Platinum Corporation and Dia Met Minerals Ltd. between 1983 and 1987.

SELECTED REFERENCES FOR D AND OLIVINE MOUNTAIN:

(**EMPR GEM** 1972, 1973; **EMPR EXPL** 1988-C105; **EMPR ASS RPT** 128, 1132, 1945, 2274, 2345, 11666, 11736, 12190, *16125, *16323, *16691, 17170; **EMPR FIELDWORK** 1981,1987; **EMPR EXPL** 1988; **EMPR OF** 1986-7; 1988-25; 1990-27; **GSC MEM** 26, 243; **GSC P** 85-1A; **GSC SUM RPT** 1923; **GSC MAP** 46A; 888A; 1386A; 41-1989; **GSC EC GEOL** No. 13, pp. 89-94 (1934); **CJES** Vol. 6, pp. 399-425 (1969); Vol. 24, pp. 2521-2536 (1987); Findlay, D.C. ,1963; **EMPR P** 1992-6)

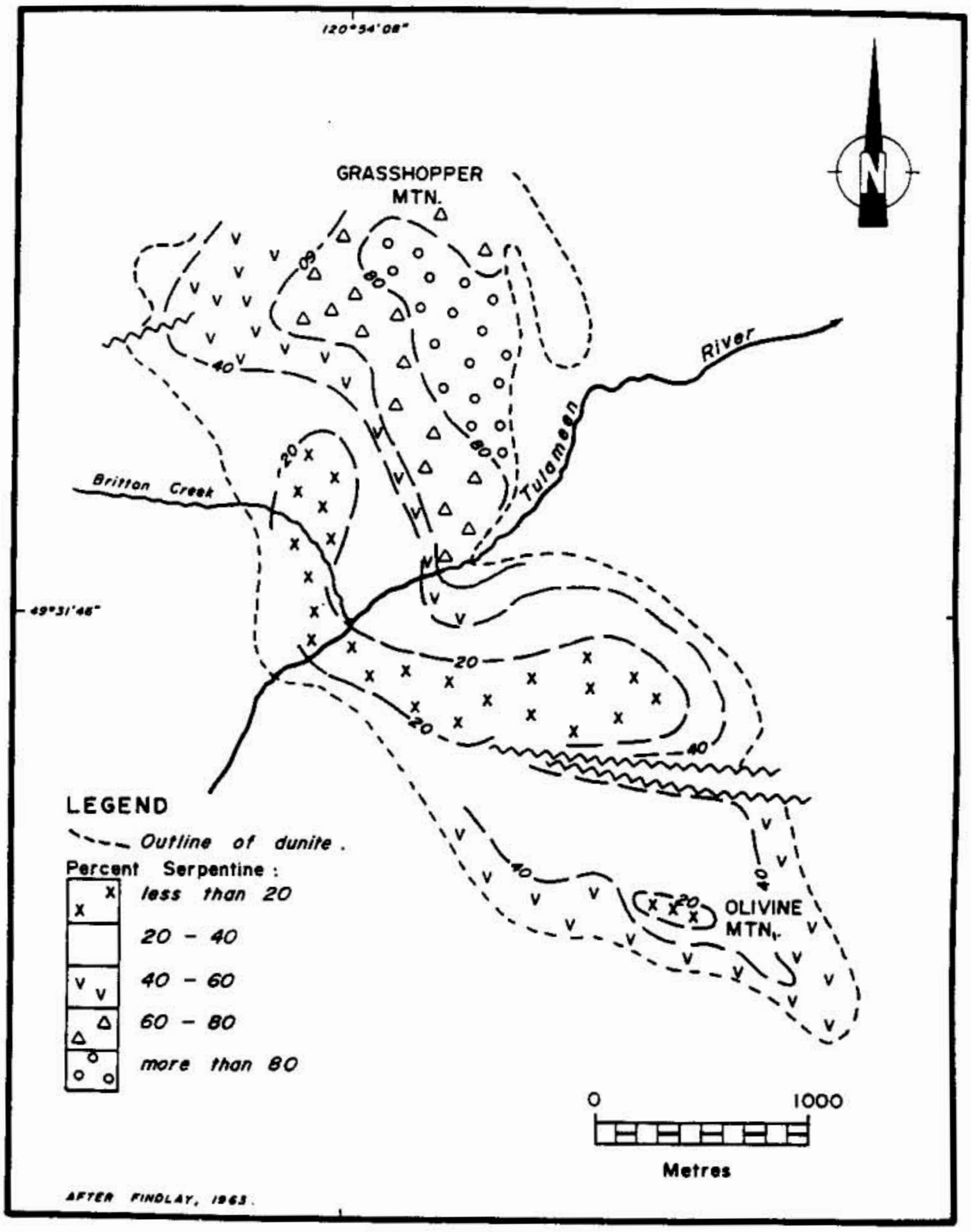


FIGURE 21: SERPENTINIZATION OF OLIVINE MOUNTAIN (Hancock *et al.*,1991)

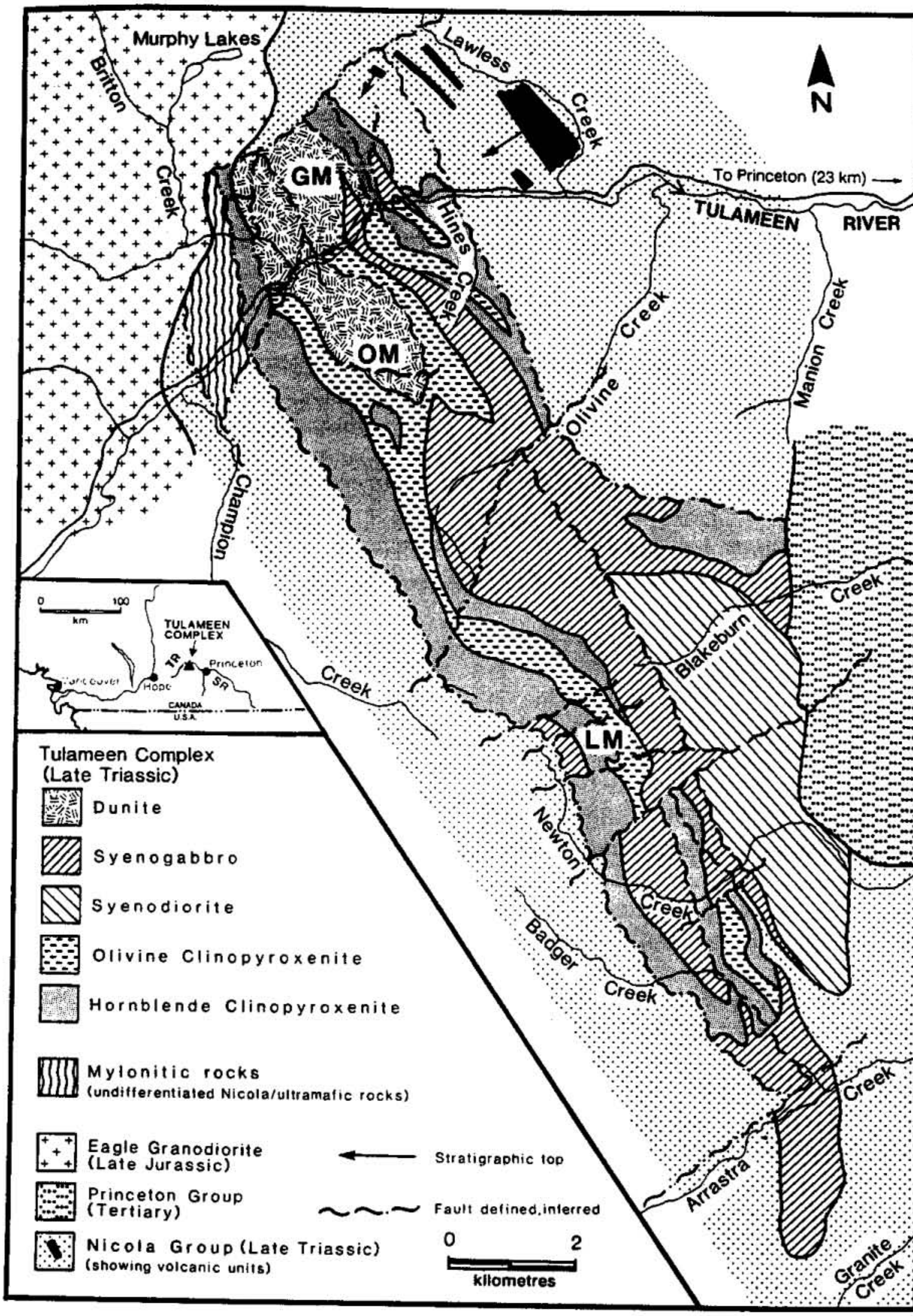


FIGURE 22: REGIONAL SETTING OF THE TULAMEEN ULTRAMAFIC COMPLEX (Nixon *et al.*, 1990)

Okanagan Highland

The western margin of the Okanagan Highland, which is coincident with the southern boundary of the Intermontane Belt and Omineca Belt, is host to four asbestsos occurrences. Two confirmed anthophyllite (79 & 80) and two of asbestos fibre in serpentine (78 & 81).

The two anthophyllite occurrences of the developed prospect Shuttleworth Creek (79 & 80) occur in body of serpentinized dunite which is bound by granitic to granodioritic gneiss. Though earlier reports identify the gneiss as Eocene, on the Tectonic Assemblage Map of the Canadian Cordilleran (Wheeler and McFeely, 1991) the occurrences plot within the Early Jurassic (EJg) foliated and altered hornblende granodiorite rocks of the Quesnellia Terrane.

To the southeast, at Rock Creek (81) the occurrence of asbestos fibres in serpentine probably shares the same geologic setting. This showing is slightly west of an outcropping of Carboniferous to Permian ocean volcanics and sediments (CPA) which mark the basement of Quesnellia. It is not clear how the serpentinzed harzburgite (78) of Hall Creek relates the other occurrences of the Okanagan Highland.

NO. 78

NTS MAP: 082E11E

NAME: Hall Creek (78)
MINFILE NUMBER: 082ENW033
STATUS: Asbestos (Chrysotile?) Showing

LAT/LONG: 49° 34′ 36″ / 119° 05′ 24″
ELEVATION: 1133 m

HOST UNIT: unidentified metamorphic assemblage
TERRANE: Quesnellia Harper Ranch
TECTONIC BELT: Omineca

DEPOSIT TYPE: Veinlet
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Harzburgite

Asbestos veinlets, up to 2.5 cm in width, within green bands of serpentine occur on the west side of Hall Creek Canyon, in the lower 3 metres of a flat sill-like mass of harzburgite (olivine and orthopyroxene peridotite). The bands and veinlets lie more or less parallel to the lower contact of the harzburgite. The ultramafic body underlies body of rock which is descibed in the literature as a "white andesite". (GSC MEM 79-143)

NO. 79 & 80

NTS MAP: 082E06W

NAME: SHUTTLEWORTH CREEK (79)
MINFILE NUMBER: 082ESW127

LAT/LONG: 49° 19′ 06″ / 119° 29′ 24″
ELEVATION: 884 m

NAME: BOOMERANG (80)
MINFILE NUMBER: 082ESW110

LAT/LONG: 49° 19′ 18″ / 119° 29′ 30″
ELEVATION: 1000 m

STATUS: Asbestifom Amphibole (Anthophyllite) Developed Prospect (79) and Showing (80)
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Quesnellia Okanagan
TECTONIC BELT: Omineca

DEPOSIT TYPE: Cross Fibre Veinlets, Lenses and Alteration Haloes
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinized Dunite

The Shuttleworth Creek occurrence lies on a hillside between 790 and 980 metres elevation, 0.8 kilometres south of Shuttleworth Creek and 6.5 kilometres southeast of Okanagan Falls.

The deposit is hosted in a mass of fine grained, dark green to black dunite that is flanked by and underlain by light to medium grey granitic and granodioritic gneiss of the Eocene Okanagan Gneiss. The entire ultramafic body is badly fractured by joints that strike in all directions. At the only exposed contact, the two rock types are juxtaposed along a shear.

The dunite body is 800 metres long, up to 200 metres in exposed width and approximately 30 metres thick. The rock is composed mostly of olivine with up to 10 % altered to amphibole and minor serpentine and magnetite. The amphibole is in turn partly altered to talc. A few patches and irregular veinlets of enstatite are also present. The dunite is intruded by felsic dikes and irregular pegmatitic masses 0.13 to 2.1 metres thick.

Asbestos mineralization consists of anthophyllite, occurring in irregular lenses and cross fibre veinlets scattered throughout the dunite. The lenses are 0.3 to 3 metres wide and up to 3.7 metres in length. In some exposures, cores of the dunite appear to be enveloped in layers of asbestos with the fibres oriented perpendicular to the dunite surface. The fibre layers are as much as 20 centimetres thick. The average width of individual veinlets varies between 5 to 15 centimetres. Veinlets strike in various directions, most commonly between 050 and 080 degrees and 135 and 150 degrees, and usually dip near vertical.

Frequently the asbestos and associated mica form zones along the walls of the felsic dikes. The common arrangement is with the dike in the centre, a zone of mica on each wall next to the dike, and a zone of fibre next to the mica.

The brittle anthophyllite is light greenish grey to pale green to white in colour and occurs in three forms; as hard woody chunks with fibres 20 to 25 centimetres long; as randomly orientated sheaf like clumps, 0.63 to 1.8 centimetres in length; and as powdery aggregates of tiny needle-like fibres. The second and third types of anthophyllite described above are commonly intermixed with varying amounts of silvery green to black biotite and brown vermiculite. A few lenses are comprised almost completely of fine grained biotite. The vermiculite, an alteration product of the biotite, is brittle, soft, slippery and exfoliates quite well when heated.

Percent Analysis of Shuttleworth Creek Anthophyllite (Minister of Mines Annual Report 1948, p. 182)

TYPE	SiO2	Al2O3	Cr2O3	Fe2O3	FeO	MnO	MgO	CaO	H2O+	H2O-
Long Fibre	57.50	0.36	0.03	1.10	5.69	0.25	29.21	2.24	3.60	0.22
Radiating	54.42	1.32	0.12	2.17	4.65	0.14	31.73	0.42	3.56	1.2
Mixed	55.66	1.94	0.97	1.15	4.24	0.15	29.06	1.56	4.32	0.86

This occurrence has been explored intermittently since its discovery in 1898. One lens of fine grained biotite was mined to produce material for use in roof manufacturing some time prior to 1948. The deposit was staked and trenched by W.J. Asseltine and associates in 1948 and trenched and drilled by Western Asbestos and Development Ltd in 1953. In 1988, the deposit was investigated as a source for the platinum reported to be found in Shuttleworth Creek. No production figures are available. (**EMPR AR** 1920, p. 164; *1948, p. 182; *1953, pp. 181-184; 1960, p. 132; **EMPR ASS RPT** 17354; **GSC SUM RPT** 1910, pp. 117, 118; **GSC MAP** 15-1961; 37-21; 538A; 1736A; **GSC OF** 481; 1969)

NO. 81

NTS MAP: 082E03E

NAME: ROCK CREEK (81)
MINFILE NUMBER: 082ESW116
STATUS: Asbestos (Chrysotile?) Showing

LAT/LONG: 49° 04′ 18″ / 119° 04′ 00″
ELEVATION: 1566 m

HOST UNIT: unidentified metamorphic assemblage
TERRANE: Quesnellia Okanagan
TECTONIC BELT: Omineca

DEPOSIT TYPE: Veinlets
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite?

Scattered narrow veinlets of fibre occur in serpentine on the west side of Kettle River, north of town Rock Creek (**EMPR IND MIN FILE**).

Southern Selkirk Mountains

The western margin of the Okanagan Highland, which is coincident with the southern boundary between the Intermontane and Coast Belts, hosts 8 cross-fibre asbestos showings.

NO. 82 & 83

NTS MAP: 082K03E

NAME: SB (82)
LAT/LONG: 50° 05′ 54″ / 117° 12′ 18″
MINFILE NUMBER: 082KSW068
ELEVATION: 2200 m
LOCATION: data not available

NAME: TOM (83)
LAT/LONG: 50° 04′ 36″ / 117° 08′ 48″
MINFILE NUMBER: 082KSW139
ELEVATION: 2333 m
LOCATION: Along Whitewater Creek, in the Whitewater Valley, 16 miles west of Kaslo.

STATUS: Cross-fibre Asbestiform Serpentine (Chrysotile) Showings
HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Fracture Filling
TERRANE: Quesnellia
MINERALIZATION AGE: Unknown
TECTONIC BELT: Omineca
LITHOLOGY: Serpentinized Peridotite

Within the Kaslo Ultramafic belt in areas of intense shearing fibrous serpentine in the form of picrolite and chrysotile occurs in hairline fractures. The host rocks are serpentinized peridotites. The fractures range in thickness from 1.5 to 3 mm. Occassional fibres of light green white cross-fibre chrysotile asbestos 6 to 25 mm in length have been recorded.

Within the Kaslo series quartz veining occurs in areas of intense shearing and contains minor amounts of copper, lead, zinc, and silver. Pyrite is prevalent in the felsic dikes that crosscut the area.

In 1972, Hi-Ridge Resources Ltd. ran exploration program in the immediate vicinity of the Tom (83) occurrence. After mapping, diamond drilling and performing a magnetometer survey on the area, the company concluded that the occurrence was too small and of insufficient quality to warrant further work. (**EMPR GEM** 1971, 1972; **EMPR ASS RPT** 3227, 3921, 3926; **GSC OPEN FILE** 288-283, 464-283)

NO. 84

NTS MAP: 082F07E

NAME: VALOAPARISO (84)
LAT/LONG: 49° 25′ 06″ / 116° 43′ 24″
MINFILE NUMBER: 082FSE038
ELEVATION: 1413 m
STATUS: Asbestos Showing

HOST UNIT: unidentified metamorphic assemblage
DEPOSIT TYPE: Unknown
TERRANE: Kootenay
MINERALIZATION AGE: Unknown
TECTONIC BELT: Omineca
LITHOLOGY: Unknown

An asbestos showing is associated with Ag-Pb-Zn polymetallic veins. (**EMPR AR** 1900, 1902-1903, 1924, 1926-1927, 1932-1934, 1953-1955, **GSC MEM** 228)

NO. 85, 86, 87, 88 & 89 **NTS MAP:** 082F04W

The allochtonous body of oceanic crust which outcrops along Little Sheep Creek, on O.K. Mountain, is approximately 1 square kilometre in area. Out of the two ultramafites which are referred to as the Rossland Ultramafics, asbestos mineralization has only been documented at Little Sheep Creek. The ultramafics at Little Sheep Creek consist of pervasively serpentinized dunite, with almost a complete loss of primary mineralogy and textures. Mineralogically the serpentinites are massive antigorite with accessory magnetite. Narrow veinlets of chrysotile, 2 to 6 millimetres across, occupy joints and fractures (Hancock, 1990; Stevenson, 1935).

The serpentinites have been associated with the Mount Roberts Formation sediments which have been assigned a Pennsylvanian age by Little (1982).

NAME: I.X.L. (85) **LAT/LONG:** 49° 04′ 23″ / 117° 50′ 31″
MINFILE NUMBER: 082FSW116 **ELEVATION:** 991m
LOCATION: West side of Little Sheep Creek, 3.2 km south-west of Rossland, lower eastern slopes of O.K. Mountain.

NAME: O.K. (86) **LAT/LONG:** 49° 04′ 21″ / 117° 50′ 45″
MINFILE NUMBER: 082FSW117 **ELEVATION:** 1250 m
LOCATION: 3.6 km west of Rossland on the lower eastern slopes of O.K. Mountain.

NAME: MIDNIGHT (87) **LAT/LONG:** 49° 04′ 20″ / 117° 50′ 19″
MINFILE NUMBER: 082FSW119 **ELEVATION:** 1067 m
LOCATION: 1.8 km west of Rossland, on the lower slopes of O.K. Mountain, on the west side of Little Sheep Creek.

NAME: LITTLE SHEEP CREEK ULTRAMAFICS (88) **LAT/LONG:** 49° 04′ 08″ / 117° 50′ 38″
MINFILE NUMBER: 082FSW214 **ELEVATION:** 990 m
LOCATION: Little Sheep Creek Valley between Deer Park Hill and O.K. Mountain; 2.8 km southwest of Rossland.

NAME: VANDOT (89) **LAT/LONG:** 49° 02′ 11″ / 117° 52′ 50″
MINFILE NUMBER: 082FSW130 **ELEVATION:** 1268 m
LOCATION: West side of Ivanhoe Ridge between the two main forks of Sophia Creek.

STATUS: Cross-fibre Asbestos Showings **DEPOSIT TYPE:** Fault Assoc. Veinlets
HOST UNIT: Devonian - Triassic ocean ultramafics (DTuo)
TERRANE: Slide Mountain **MINERALIZATION AGE:** Unknown
TECTONIC BELT: Omineca **LITHOLOGY:** Serpentinized Dunite

A brown weathering serpentinite body outcrops in the valley of Little Sheep Creek and is thought to be part of the Permian ultramafic intrusions of the Slide Mountain Terrane. The serpentinite is adjacent to altered volcanics of the Lower Jurassic Rossland Group, Elise Formation. These rocks are intruded by a syenite mass of the Middle Eocene Coryell Intrusions.

The two masses of serpentinite which lie within the Rossland map area have relatively straight margins. These lenticular masses form part of a linear belt extending 10 kilometres southwest from Rossland where it is truncated by the Coryell Batholith. The serpentinite is thought to have been emplaced along the Rossland break, a fault which was the locus of dislocation and intrusion before the emplacement of the Coryell syenite. The northerly trending eastern and western margins of the small serpentinite mass in Little Sheep Creek are known to be faults. The northern contact exposed in the workings of the Midnight (87) and I.X.L. (85) mines is highly sheared and associated with a zone of intense fracturing. This east trending fault is terminated by the Middle Eocene Marron Formation volcanics on the west and the Jumbo fault on the east.

The greenstone is very fine-grained, dense and massive rock of dark green to brownish hue. The original texture has been destroyed by both the development of chlorite and fibrous amphibole and by local silicification and serpentinization. It varies from a highly altered rock with small amounts of serpentine and magnetite to a mottled phase and then a phase which carries abundant, uniform serpentinite and magnetite. The typical massive serpentinite is a very dense black rock and hosts abundant serpentine and magnetite. Cross-fibre asbestos has infilled many joints as 0.2 to 0.6 centimetre veinlets. Light green talc mineralization is also present.

The serpentinite at Little Sheep Creek (88) and Vandot (89) has been explored for deposits of nickel and chromium. At O.K., I.X.L. and Midnight polymetallic veins within the Elise Formation are situated adjacent to the northern contact of the body of serpentinite and are past producers of gold, silver, lead, copper and zinc. (**EMPR ASS RPT** *4269, *4927, *7162, 8156, *8936, 10799, 12127, 13421, 17346; **EMPR AR** 1892-1897, 1899-1901, 1903-1904, 1906, 1908-1912, 1917-1918, 1921-1954, 1956-1956, 1960, 1963-1968; **EMPR EXPL** 1978-1979, 1980, 1982, 1984; **EMPR OF** 1988-1; 1990-27; 1989-11; 1990-8; 1990-9; 1991-2; 1991-16; **EMPR FIELDWORK** 1987-1990; **EMPR BULL** 1, 20, 74; **EMPR MINING** 1975-80; **GSC OF** 1195; **GSC MEM** 77; **GSC P** 79-26; **GSC MAP** 090A, 1004; 1090A; 1504A; 1518)

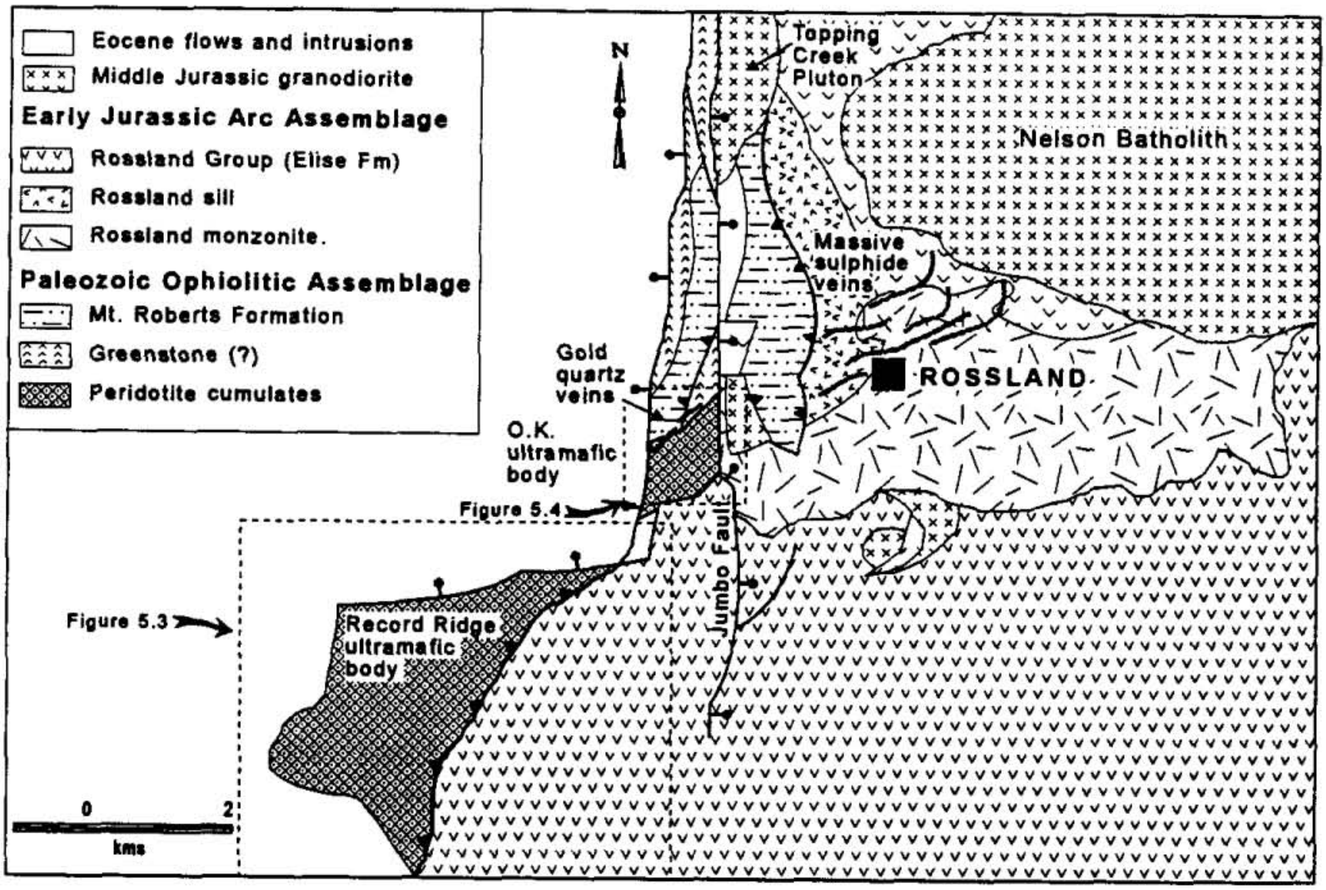


FIGURE 23: REGIONAL GEOLOGY MAP OF ROSSLAND AREA (Ash *et al., in prep.*)

PERICRATONIC TERRANES
Quesnel Highland

NO. 90

NTS MAP: 093A13W

NAME: FONTAINE CREEK (90)
MINFILE NUMBER: 093A 139
LOCATION: Near junction of Reddish and Fontaine Creeks.

LAT/LONG: 52° 56′ 36″ / 121° 47′ 42″
ELEVATION: data not available

STATUS: Asbestos Showing
HOST UNIT: Crooked Amphibolite Formation
TERRANE: Kootenay Barkerville
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

The Fontaine Creek showing is underlain by rocks of the Mississippian to Pennsylvanian Crooked Amphibolite Formation. These are considered to be correlative to the Slide Mountain Group. The Crooked Amphibolite is located along a major thrust fault (the Eureka Thrust) separating the Quesnellia Terrane from the Barkerville Terrane. Included within the Crooked Amphibolite are a number of ultramafic bodies, discontinuously distributed along the Eureka Thrust.

At Fontaine Creek (90) serpentinized ultramafic is crosscut by scattered occurrences of short fibre asbestos veinlets. (**GSC MAP** 3-1961; **GSC MAP** 1424A)

Northern Selkirk Mountains

The Northern Selkirk Mountains host 3 asbestiform amphibole showings, 2 asbestos showing of unidentified mineralogy and 1 developed prospect of slip and cross-fibre chrysotile.

NO. 91

NTS MAP: 082M10E

NAME: MONARCH (91)
MINFILE NUMBER: 082M 098
LOCATION: Near the mouth of Goldstream Creek on east side of the Columbia River, 112 km north of Revelstoke.

LAT/LONG: 51° 40′ 00″ / 118° 37′ 00″
ELEVATION: 600 m

STATUS: Asbestiform Amphibole (Actinolite) Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Kootenay
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Talc & Graphitic Schist

The area is underlain by probable Lower Paleozoic Lardeau Group metasediments and metavolcanics.

Serpentine layers occur in talc and graphitic schists. Some of the serpentine contains stringers and veinlets of asbestos of actinolitic variety. The rocks strike north-westerly and dip 25 to 40 degrees northeast.

Exposures in three crosscut tunnels show graphitic and talc schists with serpentine layers. Several "layers" of talcose material are reported. The rocks strike northwest and dip moderately northeast. At the No. 1 adit, 50 metres above the Columbia River, a 2.1 metre width of "fair quality" talc is reported. Impurities include fine-grained magnetite.

Some of the serpentine contains stringers and veinlets of asbestos of actinolitic variety. (**EMPR ASS RPT** 15484; **GSC P** 64-32; **EMPR AR** 1922-215; **GSC MAP** 12-1964; **GSC OF** 637; GSC SUM RPT 1928; **EMPR OF** 1988-19)

NO. 92 & 93

NTS MAP: 082M08E

NAME: STANDARD (92)
MINFILE NUMBER: 082M 090

LAT/LONG: 51° 23′ 05″ / 118° 14′ 40″
ELEVATION: 2100 m

NAME: STANDARD (93)
MINFILE NUMBER: 082M 166

LAT/LONG: 51° 22′ 50″ / 118° 15′ 05″
ELEVATION: 2180 m

LOCATION: On Standard Peak, 41 km north of Revelstoke in the Selkirk Mountains, northeast of the Columbia River.
STATUS: Slip-fibre Asbestos Showing
HOST UNIT: Lardeau Group
TERRANE: Kootenay
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Talc, Chlorite & Graphitic Schists

Ultramafic pods lie in a metasedimentary phyllite unit, within the upper Index Formation of the lower Paleozoic Lardeau Group (Geological Survey of Canada Paper 83-1A). The pods, consisting of coarse-grained, brown weathering talc-chlorite-serpentine-dolomite, are repeated as part of the Standard anticline. The north-south trending isoclinal anticline, which plunges gently to the north, consists of metamorphosed volcanics and sediments, marble, pyritic graphitic schists, grey sericite schists and hornblende-feldspar-chlorite schists.

Small quantities of slip-fibre asbestos and larger amounts of pure, light green talc are exposed along shear zones in the greenstones of the west limb of the antiform. The talc also occurs with carbonates and serpentine along broad zones of alteration in the greenstone.

Massive sulphide mineralization, consisting of a series of layers and lenses of massive pyrrhotite and pyrite with minor chalcopyrite and sphalerite, is most dominant within the greenstones on both sides of the Standard antiform. The property has been worked discontinuously since 1896 as a copper-silver-zinc-gold prospect. (**EMPR AR** 18981902, 1904-1907, 1912, 1917, 1919, 1921, 1926; **EMPR EXPL** 1976, 1977; **EMPR FW** 1976; **EMPR GEOL** 1976; **EMPR BULL** 71; **EMPR ASS RPT** 614, 6070, 6187, 11140; **EMPR OF** 1988-19; **EMPR MAP** 25; **GSC SUM RPT** 1928; **GSC P** 64-32, 83-1A; **GSC MAP** 12-1964, 237A; **GSC OF** 481, 637; Hoy, T., Gibson, G., and Berg, N.W., 1984 (EG V. 79, No. 5, pp. 789-800))

NO. 94

NTS MAP: 082N04W

NAME: ILLECILLEWAET (94)
MINFILE NUMBER: 082N 063

LAT/LONG: 51° 11′ 12″ / 117° 45′ 53″
ELEVATION: 1189 m

LOCATION: A pit, located 1000 metres west of the CPR Illecillewaet Station, 40 km east-northeast of Revelstoke.

STATUS: Asbestiform Amphibole (Actinolite) Showing
HOST UNIT: Lardeau Group
TERRANE: Kootenay
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Talc Dolomite/Limestone

At the Illecillewaet showing, a pit 1 by 5 metres long exposes a shear zone in Lower Cambrian and younger Lardeau Group slates and marble. Talc is found in the shear, and in outcrops extending for 600 metres. The talc is greenish grey to white, translucent and mixed with pale green fibrous. (**GSC OF** 481; **GSC P** 62-32; **GSC MAP** 237A, 4-1961, 43-1962; **GSC EC GEOL** No. 2; **EMPR AR** 1921, 1960; **EMPR OF** 1988-19)

NO. 95

NTS MAP: 082K13W

NAME: ASBESTOS (95)
LAT/LONG: 50° 45′ 10″ / 117° 56′ 00″
MINFILE NUMBER: 082KNW075
ELEVATION: 1260 m
LOCATION: Located on western slope of Mount Sproat, 38 kilometres southwest of Revelstoke.

STATUS: Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Developed Prospect
HOST UNIT: Lardeau Group
DEPOSIT TYPE: Vein
TERRANE: Kootenay
MINERALIZATION AGE: Unknown
TECTONIC BELT: Omineca
LITHOLOGY: Serpentinized Peridotite

The Asbestos deposit has been known since 1921 and a test shipment of asbestos fibre was made in 1928. In 1953 Western Asbestos and Development Ltd. performed an extensive exploration program on the area and concluded that there was not a sufficient quantity of the required grade of asbestos to encourage further exploration.

Talc and asbestos occur in a serpentine altered ultramafic body (peridotite or pyroxenite), 270 metres wide and 400 metres long, which strikes north and is in contact with Cambrian to Mississippian (?) Lardeau Group grey quartzite, phyllite, slate and schist. The ultramafics are situated near the base of the Lardeau Group, just above underlying limestone of the Badshot Formation; it is discordant to the metasediments in the vicinity of the workings, but becomes concordant to the northeast.

The ultramafic occurrence forms two parallel bluffs; the western bluff exposes talc and serpentine in contact with limestone. To the southwest, the gradation can be seen from talc-actinolite schists to mixed schists to interbedded argillites and limestone. Talc mineralization is absent at the eastern bluff-forming contact between serpentine and metasediments.

The central core of the ultramafic body is predominantly serpentine, while the outer edges are altered to talc-carbonate schist; in narrow portions the serpentine is absent and the entire width is talc-schist. The serpentine portion is mostly composed of antigorite with magnetite and olivine remnants and minor calcite and chrysotile cross-fibre veinlets. The talc schist is greenish white to dark grey, and greyish white when pulverized. The talc contains many crystals and veinlets of magnesite, which are weathered out on the surface. (**EMPR AR** 1895, 1914,1921, 1928, 1950, 1953, 1962; **EMPR ASS RPT** 469; **EMPR OF** 1988; **EMPR PF**; (Bancroft, M.F. (1921): Asbestos Group Manganese; Purdie, J.J. (1953): Report on the Exploration Program at the Sproat Mountain Property, Revelstoke, British Columbia); **EMPR BULL** 45; **GSC MEM** 161; **GSC MAP** 235A; **GSC OF** 288, 432, 464, 481; **GSC EG** Series #2)

NO. 96

NTS MAP: 082K11W

NAME: SILVER CUP (96)
LAT/LONG: 50° 36′ 00″ / 117° 20′ 30″
MINFILE NUMBER: 082KNW222
ELEVATION: 1800 m
LOCATION: Located on Silver Cup ridge, northeast of Trout Lake, about 50 km northeast of Nakusp.

STATUS: Asbestiform Amphibole Showing
HOST UNIT: Lardeau Group
DEPOSIT TYPE: Vein
TERRANE: Kootenay
MINERALIZATION AGE: Unknown
TECTONIC BELT: Omineca
LITHOLOGY: Talc Schist

Showings of brittle amphibole asbestos fibre and pale green micaceous were noted in the vicinity of several outcrops of rusty talc schist. The talc is hosted in the Lardeau series of the Upper Cambrian Windermere Group, which consists of schist, phyllite, quartzite, slate and limestone. (**EMPR OF** 1988-19; **GSC MAP** 235A; **GSC SUM RPT** 1903; **GSC EG** #2)

NO. 97

NTS MAP: 082K06E

NAME: ASBESTOS (97)
MINFILE NUMBER: 082KSW091

LAT/LONG: 50° 22' 24" / 117° 13' 00"
ELEVATION: 1400 m

STATUS: Asbestos Showing
HOST UNIT: unidentified metamorphic assemblage
TERRANE: Kootenay
TECTONIC BELT: Omineca

DEPOSIT TYPE: Vein
MINERALIZATION AGE: Unknown
LITHOLOGY: Serpentinite

The asbestos group of claims is located on a belt of serpentinized ultramafic rocks. Asbestos occurs in the seams and along slipfaces. (**EMPR AR** 1895, 1914, 1927; **GSC MEM** 161-112; **GSC MAP** 235A)

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APPENDICES 1 AND 2

The following tables are listings of the asbestos occurrences in British Columbia. The mineral occurrences have been subdivided into three main regions: northern, central, and southern British Columbia. In each region the occurrences are categorized by Terrane and then, secondarily by physiographic area. Each occurrence is referenced by a number unique to this report as well as by both name and by a MINFILE number (specific to each occurrence).

The table in Appendix 1 specifies the fibre type, asbestiform mineralogy, status, host lithology, tectonic belt, terrane and host unit of each occurrence.

The table in Appendix 2 specifies the geographic co-ordinates in both latitude and longitutde and UTM (northing and easting), in addition to referencing the NTS map sheet and zone for each occurrence.

APPENDIX 1: B.C. ASBESTOS SUMMARY

REPORT NO	MINIFLE NO	NAME	ASBESTIFORM MINERAL, FIBRE TYPE & STATUS OF OCCURRENCE	HOST LITHOLOGY	TECTONIC BELT	TERRANE	HOST UNIT	NTS MAP
NORTHERN BRITISH COLUMBIA								
Insular Superterrane								
Alsek Ranges								
1	114P 060	SQUAW VALLEY	Asbestos Showing	Serpentinite	Insular	Alexander	data not available	114P14E
2	114P 028	NADAHINI MOUNTAIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Insular	Alexander	data not available	114P10E
Intermontane Superterrane								
Teslin Plateau				Serpentinized Peridotite				
3	104N 055	PUB	Asbestiform Amphibole (Tremolite) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Atlin Ultramafic Allochthon	104N11W
4	104N 124	PEREYE ASBESTOS	Asbestiform Amphibole (Tremolite) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Atlin Ultramafic Allochthon	104N11W
5	104N 050	MONARCH MOUNTAIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Atlin Ultramafic Allochthon	104N12E
Taku Plateau								
6	104N 070	CHIKOIDA MOUNTAIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104N03E
7	104N 049	COP	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104N03E
8	104N 071	FOCUS MOUNTAIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104N03E
9	104K 066	YETH CREEK ASBESTOS	Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K15E
10	104K 044	MENATATULINE RANGE	Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K16W
11	104K 024	MAGNET	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K16E
12	104K 025	ACE	Cross-fibre Asbestiform Serpentine (Chrysotile) Developed Prospect	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K16E
13	104K 043	TEDITUA CREEK	Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K16W
14	104K 065	NAHLIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Nahlin Ultramafic body (AUA)	104K16E
15	104J 030	DUDIDONTU RIVER	Asbestos Showing	Serpentinite	Intermontane	Cache Creek	data not available	104J12W
Tanzilla Plateau								
16	104O 019	ATSUTLA RANGE	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Omineca	Slide Mountain	data not available	104O06W
17	104J 037	CALATA LAKE	Asbestos Showing	Serpentinite	Intermontane	Cache Creek	data not available	104J15W
18	104J 029	DEASE LAKE	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing		Intermontane	Cache Creek	Cache Creek Complex	104J16E
19	104I 018	JAY	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104I12W
20	104I 017	EYE	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104I12W
21	104J 003	TUYA	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104J10W
22	104J 033	BAK	Asbestos Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104J09E
23	104I 084	SERPENTINE CREEK	Asbestos Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104I12W
24	104I 044	ASB 8	Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek?	data not available	104I06W
25	104I 045	ASB 4	Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek?	data not available	104I06E
26	104I 083	OCCURRENCE	Asbestos Showing	Serpentinized Peridotite	Intermontane	Cache Creek?	data not available	104I06W
27	104I 082	WHEATON CREEK	Asbestos Showing	data not available	Intermontane	Cache Creek?	data not available	104I07W
				Seperntinized Dunite &				
28	104I 006	LETAIN	Asbestiform Serpentine (Chrysotile) Developed Prospect	Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104I07E
29	104I 053	B	Asbestos Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Cache Creek Complex	104I07E
30	104I 042	J	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek?	Cache Creek Complex?	104I02W
31	104I 088	KEHLECHOA RIVER	Asbestos Showing	Serpentinite	Intermontane	Cache Creek?	Cache Creek Complex?	104I02W
32	104I 048	OCCURRENCE	Asbestos Showing	Serpentinite	Intermontane	Cache Creek?	Cache Creek Complex?	104I02W

APPENDIX 1: B.C. ASBESTOS SUMMARY

REPORT NO	MINIFLE NO	NAME	ASBESTIFORM MINERAL, FIBRE TYPE & STATUS OF OCCURRENCE	HOST LITHOLOGY	TECTONIC BELT	TERRANE	HOST UNIT	NTS MAP
Cassiar Mountains								
33	104P 055	WOLFE	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Dunite & Peridotite	Omineca	Slide Mountain	Blue River Ultramafic Body	104P12W
34	104P 064	RET	Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Slide Mountain	Sylvester Allochthon	104P05E
35	104P 086	MARS	Cross-fibre Asbestiform Serpentine (Chrysotile) Prospect	Serpentinite	Omineca	Slide Mountain	Sylvester Allochthon	104P05W
36	104P 036	MOON	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Slide Mountain	Sylvester Allochthon	104P05E
37	104P 002	ZUS	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Omineca	Slide Mountain	Sylvester Allochthon	104P05W
38	104P 005	CASSIAR ASBESTOS	Cross-fibre Asbestiform Serpentine (Chrysotile) Past Producer (Open Pit & Underground)	Serpentinized Harzburgite	Omineca	Slide Mountain	Sylvester Allochthon	104P05W
39	104P 084	MCDAME	Cross-fibre Asbestiform Serpentine (Chrysotile) Past Producer (Underground)	Serpentinized Harzburgite	Omineca	Slide Mountain	Sylvester Allochthon	104P05W
40	104I 030	GB	Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Slide Mountain	data not available	104I15W
Boundary Ranges								
41	104K 038	TATSAMENIE LAKE	Asbestos Showing	Serpentinized Amphibolite	Intermontane	Stikinia	data not available	104K08W
42	104G 054	MOUNT HICKMAN	Asbestiform Serpentine (Chrysotile) Showing	Olivine Clinopyroxenite	Intermontane	Stikinia	Mount Hickman Ultramafic Complex	104G06E
43	104G 090	GALORE CREEK	Asbestiform Amphibole (Crodicolite) Showing	Metavolcanics	Intermontane	Stikinia	Stuhini Group	104G03W
44	104B 110	EAGLE CRAG	Asbestiform Amphibole Showing	Metavolcanics	Intermontane	Stikinia	data not available	104B13E
45	104B 175	UNUK (ZONE 3)	Asbestos Showing	Metavolcanics	Intermontane	Stikinia	data not available	104B09W
46	104B 279	MIKE PEAK	Asbestiform Amphibole (Actinolite) Showing	Phyllite	Intermontane	Stikinia	data not available	104B08W
CENTRAL BRITISH COLUMBIA								
Intermontane Superterrane								
Pacific Ranges								
47	093D 016	BELLA COOLA VALLEY	Asbestos Showing	Serpentinite	Coast	Stikinia	data not available	093D08W
Omineca Mountains								
48	094C 090	AIKEN LAKE	Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Quesnellia	Polaris Ultramafic Complex	094C05E
Manson Upland								
49	093N 115	GERMANSEN RIVER	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Omineca	Slide Mountain	Manson Lakes Ultramafites	093N10E
Nechako Lowland								
50	093K 068	VAN DECAR ASBESTOS	Cross-fibre Asbestiform Amphibole (Tremolite) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Mt. Sidney Williams Ultramafic Massif	093K14W
51	093K 043	MT. SIDNEY WILLIAMS	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	Mt. Sidney Williams Ultramafic Massif	093K14W
52	093G 018	SINKUT MOUNTAIN	(Anthophyllite) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	data not available	093G13W
53	093G 016	BALDY HUGHES	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	data not available	093G11E
54	093G 002	RAY	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	data not available	093G11W
55	093G 012	TELEGRAPH RANGE	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Cache Creek	data not available	093G05E
SOUTHERN BRITISH COLUMBIA								
Coast Belt Terranes								
Pacific Ranges								
56	092JNE112	SHULAPS MTN	Slip-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Intermontane	Bridge River	Shulaps Ultramafic Complex	092J16W
57	092JNE070	MOUNT PENROSE	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Coast	Bridge River	Shulaps Ultramafic Complex	092J15W
58	092JNE106	CADWALLADER MOUNTAIN	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Coast	Bridge River	President Ultramafics?	092J10E
59	092ISW053	GLACIER	Asbestiform Amphibole (Tremolite) Showing	Serpentinite	Coast	Bridge River	Bridge River Ultramafics	092I04W
60	092ISW051	RAWHIDE	Asbestiform Amphibole (Tremolite) Showing	Serpentinite	Coast	Bridge River	Bridge River Ultramafics	092I04W
Pavillion Ranges								
61	092JNE104	MOON CREEK ASBESTOS	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Intermontane	Bridge River	Bridge River Ultramafics	092J16E
62	092INW086	LILLOOET AREA	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Intermontane	Bridge River	Bridge River Ultramafics?	092I12W
63	092INW067	FRASER RIVER	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Intermontane	Bridge River	Bridge River Ultramafics?	092I12W

APPENDIX 1: B.C. ASBESTOS SUMMARY

REPORT NO	MINIFLE NO	NAME	ASBESTIFORM MINERAL, FIBRE TYPE & STATUS OF OCCURRENCE	HOST LITHOLOGY	TECTONIC BELT	TERRANE	HOST UNIT	NTS MAP
Southern Fiord Ranges								
64	092HNW057	GORDON CREEK ASBEST	Slip and Cross-fibre Asbestiform Serpentine Showing	Serpentinite	Coast	Shuksan	data not available	092H11W
65	092HNW058	HARRISON LAKE ASBESTOS	Asbestiform Amphibole (Tremolite) Showing	Serpentinite	Coast	Bridge River	data not available	092H12E
66	092HSW099	WAHLEACH CREEK	Asbestiform Amphibole (Actinolite) Showing	Serpentinized Peridotite	Coast	Chilliwack	data not available	092H05E
Cascade Mountains								
67	092HSW112	COQUIHALLA SERPENTINE	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Coast	Bridge River	Coquihalla Serpentine Belt	092H06W
68	092HSW111	CHILLIWACK RIVER	Asbestos Showing	Serpentinite	Coast	Chilliwack	data not available	092H04E
Intermontane Superterrane								
Cariboo Plateau								
69	093A 138	OCHILTREE	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Intermontane	Cache Creek	data not available	093A04W
70	093B 024	DRD	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Dunite & Peridotite	Intermontane	Cache Creek	data not available	093B01E
71	092P 082	BONAPARTE RIVER	Asbestos Showing	Serpentinized Dunite & Peridotite	Intermontane	Cache Creek	Mika Ultramafic Body	092P03W
72	092P 143	MOUNT SOUES	Asbestiform Serpentine (Chrysotile) Showing	Serpentinite	Intermontane	Cache Creek	data not available	092P04E
Thompson Plateau								
73	082M 119	PAT	Asbestos Showing	Serpentinite	Omineca	Kootenay	Kaslo Group?	082M04E
74	082LSW057	LONE STAR	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Harzburgite	Intermontane	Quesnellia	data not available	082L04W
75	082LSW056	CHROME-VANADIUM	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Harzburgite	Intermontane	Quesnellia	data not available	082L04W
76	092HNE128	D	Asbestos Showing	Serpentinized Dunite & Peridotite	Intermontane	Quesnellia	Tulameen Ultramafic Complex	092H10W
77	092HNE184	OLIVINE MOUNTAIN	Asbestos Showing	Serpentinized Dunite & Peridotite	Intermontane	Quesnellia	Tulameen Ultramafic Complex	092H10W
Okanagan Highland								
78	082ENW033	HALL CREEK	Asbestos (Chrysotile?) Showing	Serpentinized Harzburgite	Omineca	Quesnellia	data not available	082E11E
79	082ESW127	SHUTTLEWORTH CREEK	Asbestifom Amphibole (Anthophyllite) Developed Prospect	Serpentinized Dunite	Omineca	Quesnellia	data not available	082E06W
80	082ESW110	BOOMERANG	Asbestifom Amphibole (Anthophyllite) Showing	Serpentinite	Omineca	Quesnellia	data not available	082E06W
81	082ESW116	ROCK CREEK	Asbestos (Chrysotile?) Showing	Serpentinite	Omineca	Quesnellia	data not available	082E03E
Southern Selkirk Mountains								
82	082KSW068	SB	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Quesnellia	data not available	082K03E
83	082KSW139	TOM	Cross-fibre Asbestiform Serpentine (Chrysotile) Showing	Serpentinized Peridotite	Omineca	Quesnellia	data not available	082K03E
84	082FSE038	VALPARAISO (L.4907)	Asbestos Showing	data not available	Omineca	Kootenay	data not available	082F07E
85	082FSW116	I.X.L.	Cross-fibre Asbestos Showing	Serpentinized Dunite	Omineca	Quesnellia	Devonian - Triassic ocean ultramafics	082F04W
86	082FSW117	O.K.	Cross-fibre Asbestos Showing	Serpentinized Dunite	Omineca	Quesnellia	Devonian - Triassic ocean ultramafics	082F04W
87	082FSW119	MIDNIGHT (L.1186)	Cross-fibre Asbestos Showing	Serpentinized Dunite	Omineca	Quesnellia	Devonian - Triassic ocean ultramafics	082F04W
88	082FSW214	LITTLE SHEEP CREEK ULT	Cross-fibre Asbestos Showing	Serpentinized Dunite	Omineca	Quesnellia	Devonian - Triassic ocean ultramafics	082F04W
89	082FSW130	VANDOT	Cross-fibre Asbestos Showing	Serpentinized Dunite	Omineca	Quesnellia	Devonian - Triassic ocean ultramafics	082F04W

APPENDIX 1: B.C. ASBESTOS SUMMARY

REPORT NO	MINIFLE NO	NAME	ASBESTIFORM MINERAL, FIBRE TYPE & STATUS OF OCCURRENCE	HOST LITHOLOGY	TECTONIC BELT	TERRANE	HOST UNIT	NTS MAP
Pericratonic Terranes								
Quesnel Highland								
90	093A 139	FONTAINE CREEK	Asbestos Showing	Serpentinite	Omineca	Kootenay	Crooked Amphibolite Formation	093A13W
Northern Selkirk Mountains								
91	082M 098	MONARCH	Asbestiform Amphibole (Actinolite) Showing	Talc & Graphitic Schist	Omineca	Kootenay	data not available	082M10E
92	082M 090	STANDARD	Slip-fibre Asbestos Showing	Talc, Chlorite & Graphitic Schists	Omineca	Kootenay	Lardeau Group	082M08E
93	082M 166	STANDARD	Slip-fibre Asbestos Showing	Talc, Chlorite & Graphitic Schists	Omineca	Kootenay	Lardeau Group	082M08E
94	082N 063	ILLECILLEWAET	Asbestiform Amphibole (Actinolite) Showing	Talc Dolomite/Limestone	Omineca	Kootenay	Lardeau Group	082N04W
95	082KNW075	ASBESTOS	Slip and Cross-fibre Asbestiform Serpentine (Chrysotile) Developed Prospect	Serpentinized Peridotite	Omineca	Kootenay	Lardeau Group	082K13W
96	082KNW222	SILVER CUP	Asbestiform Amphibole Showing	Talc Schist	Omineca	Kootenay	Lardeau Group	082K11W
97	082KSW091	ASBESTOS	Asbestos Showing	Serpentinite	Omineca	Kootenay	data not available	082K06E

APPENDIX 2: MINFILE NUMBER INDEX BY GEOGRAPHIC COORDINATE

REPORT NO	MINIFLE NO	NAME	NTS MAP	LATITUDE	LONGITUDE	ZONE	NORTHING	EASTING
NORTHERN BRITISH COLUMBIA								
Insular Superterrane								
Alsek Ranges								
1	*114P 060*	*SQUAW VALLEY*	*114P14E*	*59 57 40*	*137 01 15*	*8*	*6648596*	*387157*
2	114P 028	NADAHINI MOUNTAIN	114P10E	59 40 15	136 42 45	8	6615790	403536
Intermontane Superterrane								
Teslin Plateau								
3	104N 055	PUB	104N11W	59 43 30	133 19 43	8	6621750	594000
4	104N 124	PEREYE ASBESTOS	104N11W	59 42 44	133 19 19	8	6620350	594400
5	104N 050	MONARCH MOUNTAIN	104N12E	59 32 36	133 36 54	8	6601163	578313
Taku Plateau								
6	104N 070	CHIKOIDA MOUNTAIN	104N03E	59 14 00	133 00 00	8	6567537	614119
7	104N 049	COP	104N03E	59 09 35	133 23 18	8	6558742	592162
8	104N 071	FOCUS MOUNTAIN	104N03E	59 08 36	133 07 00	8	6557324	607746
9	104K 066	YETH CREEK ASBESTOS	104K15E	58 57 32	132 34 13	8	6537800	639750
10	104K 044	MENATATULINE RANGE	104K16W	58 56 57	132 13 39	8	6537500	659500
11	104K 024	MAGNET	104K16E	58 54 30	132 11 46	8	6533020	661500
12	104K 025	ACE	104K16E	58 52 57	132 06 56	8	6530350	666250
13	104K 043	TEDITUA CREEK	104K16W	58 52 31	132 20 46	8	6529000	653000
14	104K 065	NAHLIN	104K16E	58 49 46	132 05 23	8	6524500	668000
15	104J 030	DUDIDONTU RIVER	104J12W	58 40 44	131 45 38	9	6507382	339948
Tanzilla Plateau								
16	104O 019	ATSUTLA RANGE	104O06W	59 19 00	131 26 50	9	6577664	360709
17	104J 037	CALATA LAKE	104J15W	58 49 00	130 58 00	9	6521096	386416
18	104J 029	DEASE LAKE	104J16E	58 46 04	130 05 32	9	6514500	436825
19	104I 018	JAY	104I12W	58 41 42	129 52 00	9	6506206	449767
20	104I 017	EYE	104I12W	58 41 06	129 50 12	9	6505070	451492
21	104J 003	TUYA	104J10W	58 37 04	130 52 28	9	6498800	391130
22	104J 033	BAK	104J09E	58 35 00	130 01 00	9	6493895	440885
23	104I 084	SERPENTINE CREEK	104I12W	58 33 00	129 58 00	9	6490141	443738
24	104I 044	ASB 8	104I06W	58 29 24	129 15 06	9	6483083	485327
25	104I 045	ASB 4	104I06E	58 29 06	129 14 30	9	6482524	485908
26	104I 083	OCCURRENCE	104I06W	58 27 00	129 16 00	9	6478632	484435
27	104I 082	WHEATON CREEK	104I07W	58 22 00	128 57 00	9	6469324	502925
28	104I 006	LETAIN	104I07E	58 19 59	128 44 03	9	6465600	515575
29	104I 053	B	104I07E	58 19 54	128 43 24	9	6465459	516202
30	104I 042	J	104I02W	58 14 54	128 49 00	9	6456162	510761
31	*104I 088*	*KEHLECHOA RIVER*	104I02W	58 12 18	128 49 30	9	6451336	510285
32	104I 048	OCCURRENCE	104I02W	58 10 30	128 49 12	9	6447997	510588
Cassiar Mountains								
33	104P 055	WOLFE	104P12W	59 33 25	129 59 20	9	6602279	444105
34	104P 064	RET	104P05E	59 26 10	129 41 15	9	6588608	461001
35	104P 086	MARS	104P05W	59 24 25	129 45 50	9	6585407	456630
36	104P 036	MOON	104P05E	59 24 10	129 41 30	9	6584899	460726
37	*104P 002*	*ZUS*	*104P05W*	*59 23 50*	*129 46 30*	*9*	*6584332*	*455987*
38	104P 005	CASSIAR ASBESTOS	104P05W	59 19 31	129 48 59	9	6576350	453540
39	104P 084	MCDAME	104P05W	59 19 20	129 48 50	9	6576007	453676
40	104I 030	GB	104I15W	58 54 48	128 52 12	9	6530200	507487
Boundary Ranges								
41	104K 038	TATSAMENIE LAKE	104K08W	58 17 11	132 19 38	8	6463500	656700
42	104G 054	MOUNT HICKMAN	104G06E	57 15 45	131 05 00	9	6348316	374341
43	104G 090	GALORE CREEK	104G03W	57 08 10	131 27 13	9	6335000	351500
44	104B 110	EAGLE CRAG	104B13E	56 54 24	131 41 24	9	6310000	336200
45	104B 175	UNUK (ZONE 3)	104B09W	56 31 08	130 24 21	9	6264500	413500
46	104B 279	MIKE PEAK	104B08W	56 27 08	130 18 32	9	6256975	419325

APPENDIX 2: MINFILE NUMBER INDEX BY GEOGRAPHIC COORDINATE

REPORT NO	MINIFLE NO	NAME	NTS MAP	LATITUDE	LONGITUDE	ZONE	NORTHING	EASTING
CENTRAL BRITISH COLUMBIA								
Intermontane Superterrane								
Pacific Ranges								
47	093D 016	BELLA COOLA VALLEY	093D08W	52 24 00	126 20 00	9	5808657	681421
Omineca Mountains								
48	094C 090	AIKEN LAKE	094C05E	56 29 18	125 42 15	10	6263500	333500
Manson Upland								
49	093N 115	GERMANSEN RIVER	093N10E	55 44 36	124 39 59	10	6178550	395380
Nechako Lowland								
50	093K 068	VAN DECAR ASBESTOS	093K14W	54 55 00	125 26 00	10	6088013	344031
51	093K 043	MT. SIDNEY WILLIAMS	093K14W	54 53 50	125 23 55	10	6085773	346182
52	093G 018	SINKUT MOUNTAIN	093G13W	53 48 33	123 58 16	10	5962510	436052
53	093G 016	BALDY HUGHES	093G11E	53 37 37	123 05 25	10	5941803	494029
54	093G 002	RAY	093G11W	53 37 27	123 27 35	10	5941588	469593
55	093G 012	TELEGRAPH RANGE	093G05E	53 24 56	123 30 20	10	5918401	466397
SOUTHERN BRITISH COLUMBIA								
Coast Belt Terranes								
Pacific Ranges								
56	092JNE112	SHULAPS MTN	092J16W	50 57 30	122 29 50	10	5645093	535312
57	092JNE070	MOUNT PENROSE	092J15W	50 52 55	122 57 45	10	5636478	502638
58	092JNE106	CADWALLADER MOUNTAIN	092J10E	50 39 50	122 42 00	10	5612273	521203
59	092ISW053	GLACIER	092I04W	50 09 31	121 50 07	10	5556700	583200
60	092ISW051	RAWHIDE	092I04W	50 09 28	121 49 35	10	5556600	583845
Pavillion Ranges								
61	092JNE104	MOON CREEK ASBESTOS	092J16E	50 45 20	122 01 10	10	5622881	569167
62	092INW086	LILLOOET AREA	092I12W	50 41 00	121 56 00	10	5614935	575357
63	092INW067	FRASER RIVER	092I12W	50 38 00	121 54 00	10	5609410	577794
Southern Fiord Ranges								
64	092HNW057	GORDON CREEK ASBEST	092H11W	49 32 52	121 27 01	10	5489275	612100
65	092HNW058	HARRISON LAKE ASBESTOS	092H12E	49 32 20	121 44 12	10	5487900	591400
66	092HSW099	WAHLEACH CREEK	092H05E	49 18 30	121 37 54	10	5462414	599465
Cascade Mountains								
67	092HSW112	COQUIHALLA SERPENTINE	092H06W	49 28 12	121 15 18	10	5480950	626429
68	092HSW111	CHILLIWACK RIVER	092H04E	49 04 36	121 37 18	10	5436674	600661
Intermontane Superterrane								
Cariboo Plateau								
69	093A 138	OCHILTREE	093A04W	52 14 30	121 49 30	10	5788350	580230
70	093B 024	DRD	093B01E	52 05 17	122 01 23	10	5771064	566937
71	092P 082	BONAPARTE RIVER	092P03W	51 07 48	121 28 30	10	5665168	606710
72	092P 143	MOUNT SOUES	092P04E	51 03 30	121 44 36	10	5656844	588070
Thompson Plateau								
73	082M 119	PAT	082M04E	51 00 00	119 44 10	11	5653169	308016
74	082LSW057	LONE STAR	082L04W	50 12 13	119 57 45	11	5565250	288600
75	*082LSW056*	*CHROME-VANADIUM*	*082L04W*	*50 00 26*	*119 51 55*	*11*	*5543150*	*294700*
76	092HNE128	D	092H10W	49 31 39	120 54 06	10	5487990	651850
77	092HNE184	OLIVINE MOUNTAIN	092H10W	49 31 10	120 52 52	10	5487140	653370
Okanagan Highland								
78	082ENW033	HALL CREEK	082E11E	49 34 36	119 05 24	11	5493443	348905
79	082ESW127	SHUTTLEWORTH CREEK	082E06W	49 19 06	119 29 24	11	5465608	319041
80	082ESW110	BOOMERANG	082E06W	49 19 18	119 29 30	11	5465982	318932
81	082ESW116	ROCK CREEK	082E03E	49 04 18	119 04 00	11	5437260	349055
Southern Selkirk Mountains								
82	082KSW068	SB	082K03E	50 05 54	117 12 18	11	5549365	485337
83	082KSW139	TOM	082K03E	50 04 36	117 08 48	11	5546946	489505
84	082FSE038	VALPARAISO (L.4907)	082F07E	49 25 06	116 43 24	11	5473779	520066
85	082FSW116	I.X.L.	082F04W	49 04 23	117 50 31	11	5435700	438500
86	082FSW117	O.K.	082F04W	49 04 21	117 50 45	11	5435640	438221
87	082FSW119	MIDNIGHT (L.1186)	082F04W	49 04 20	117 50 19	11	5435600	438750
88	082FSW214	LITTLE SHEEP CREEK ULT	082F04W	49 04 08	117 50 38	11	5435237	438359
89	082FSW130	VANDOT	082F04W	49 02 11	117 52 50	11	5431655	435639

APPENDIX 2: MINFILE NUMBER INDEX BY GEOGRAPHIC COORDINATE

REPORT NO	MINIFLE NO	NAME	NTS MAP	LATITUDE	LONGITUDE	ZONE	NORTHING	EASTING
Pericratonic Terranes								
Quesnel Highland								
90	093A 139	FONTAINE CREEK	093A13W	52 56 36	121 47 42	10	5866429	580975
Northern Selkirk Mountains								
91	082M 098	MONARCH	082M10E	51 40 00	118 37 00	11	5724984	388192
92	082M 090	STANDARD	082M08E	51 23 05	118 14 40	11	5693125	413400
93	082M 166	STANDARD	082M08E	51 22 50	118 15 05	11	5692670	412909
94	082N 063	ILLECILLEWAET	082N04W	51 11 12	117 45 53	11	5670650	446550
95	082KNW075	ASBESTOS	082K13W	50 45 10	117 56 00	11	5622530	434159
96	082KNW222	SILVER CUP	082K11W	50 36 00	117 20 30	11	5605181	475819
97	082KSW091	ASBESTOS	082K06E	50 22 24	117 13 00	11	5579944	484592

ASBESTOS RESEARCH, INDUSTRY AND REGULATORY BODIES

For information on Mining Sector publications:
Publications Distribution Office
Mining Sector
Natural Resources Canada
460 O'Connor Street
Ottawa, Ontario
K1A 0E4
613/992-1108

On Asbestos in Canada:
Patrick Morel-a-l'Hussier
-author of asbestos chapter in the Canadian Mineral's Yearbook
Mining Sector, Natural Resources Canada
613/992-3258

On Industrial Mineral in British Columbia:
Z. D. Hora
Industrial Minerals Specialist
Geological Survey Branch
B.C. Ministry of Energy, Mines and Petroleum Resources
5th floor, 1810 Blanshard Street
Victoria, B.C.
V8V 1X4
604/952-0414, Fax: 604/952-0381

The Asbestos Institute / Institut de l'amiante
#1750, 1002 rue Sherbrooke ouest
Montreal, PQ H3A 3L6
514/844-3956, Fax: 514/844-1381

The Canadian Chapter of the National Asbestos Council (CANNAC)
One Sparks Avenue
North York, ON M2H 2W1
416/499-4000 ext. 14, Fax: 416/499-8752

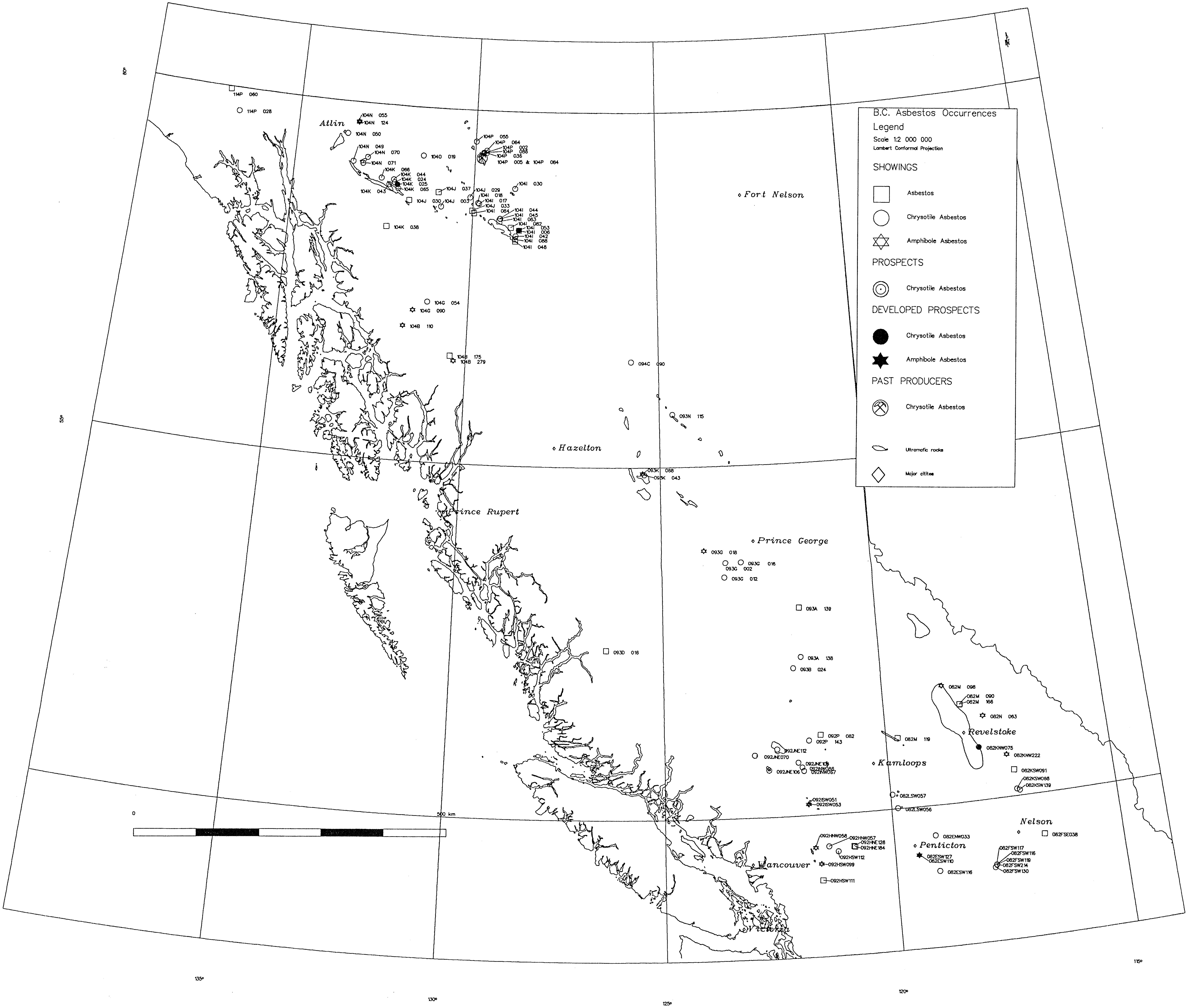
Workers' Compensation Board of British Columbia, Head Office
6951 Westminster Highway
Richmond, BC V7C 1C6
Mailing Address:
Box 5350
Vancouver, BC V6B 5L5
604/273-2266, 1-800-661-2112

ASBESTOS MARKET PRICES AS OF FEBRUARY 1995

(Industrial Minerals, 1995)

All prices are FOB mine.

ASBESTOS TYPE	GROUP	PRICE PER METRIC TONNE
Canadian Chrysotile	Group No. 3	C$1,450 - 1,750
Canadian Chrysotile	Group No. 4	C$1,080 - 1400
Canadian Chrysotile	Group No. 5	C$664 - 892
Canadian Chrysotile	Group No. 6	C$425 - 585
Canadian Chrysotile	Group No. 7	C$210 - 390
South African Chrysotile	Group No. 5	US$360 - 440
South African Chrysotile	Group No. 6	US$300 - 350
South African Chrysotile	Group No. 7	US$200 - 290
South African Crocidolite	Long	US$760 - 920
South African Crocidolite	Medium	US$680 - 750
South African Crocidolite	Short	US$640 - 600


B.C. Asbestos Occurrences
Legend
Scale 1:2 000 000
Lambert Conformal Projection
SHOWINGS
Asbestos
Chrysotile Asbestos
Amphibole Asbestos
PROSPECTS
Chrysotile Asbestos
DEVELOPED PROSPECTS
Chrysotile Asbestos
Amphibole Asbestos
PAST PRODUCERS
Chrysotile Asbestos
Ultramafic rocks
Major citites
Atlin
Fort Nelson
Hazelton
Prince Rupert
Prince George
Revelstoke
Kamloops
Nelson
Penticton
Vancouver
Victoria
0
500 km
135°
130°
125°
120°
115°