A Review of Alberta Limestone Production, Marketing, Distribution and Future Development Possibilities

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Prepared for:

CANADA ALBERTA Partnership on Minerals

Finding Minerals and Technology for Tomorrow

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1. INTRODUCTION

The current study was initiated following the acceptance of a proposal submitted to the Canada-Alberta Partnership on Minerals program in June, 1993. The objectives, relevant to a study of the limestone industry in Alberta, were as follows:

1. Review the industry as it now stands by evaluating the currently producing sites in terms of geological, quality, and reserve parameters of the quarries; plant operations; types and quantities of products manufactured; and distribution and marketing systems now employed.

2. Identify excess shipping distances with respect to closer undeveloped deposits that might supply an equivalent product.

3. Determine local markets for limestone-derived products which are not currently satisfied by Alberta sources and match in-province production to these conditions.

4. Research the status of current technologies for possible application of more sophisticated limestone processing procedures and the industrial useage of resultant byproducts.

Acceptance and final approval of the proposed project was established in October, 1993 and preliminary efforts to contact industry and government information sources was initiated immediately. These efforts resulted in some data collection and visits to a most of the quarries and plants in November and December. However, due to other contract committments full-time efforts could not be extended to the project until January, 1994.

Starting on January 3rd, 1994 the writer began another round of visits to limestone operators and facilities to follow up on the original contact work. A questionaire was also faxed to the five major companies outlining detailed data requirements for the study. During the ensuing weeks, prior to the deadline for project completion, some responses were received and repeat visits were made to company offices in Edmonton and Calgary. For the most part, industry cooperation was favorable but some exceptions have resulted in an incomplete data base. It is especially noteworthy that product marketing and distribution information was not made completely available. This was deemed to be an understandable outcome in view of the fact that the limestone industry has been a highly competitive business in western Canada for many years and such information is considered confidential by some companies. The daily pressures of business committments undoubtedly prevented some operators from responding within the time frame allocated to this study.

The resultant study may be biased towards technical aspects of geological and operational aspects of the industry more so than economic aspects since the former proved to be more generally available. Marketing and distribution documentation is largely based on comments and insights provided by a variety of individuals familiar with the current status of the industry. This input has been particularly useful in cases where documented facts and statistics are not readilly accessible.

The writer acknowledges several individuals for their assistance and cooperation. The following randomly-ordered listing may not be complete but does represent the majority of those who are to be credited with providing significant assistance:

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Edmonton, Alberta

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2. USES, SPECIFICATIONS, AND PROCESSING OF LIMESTONE

Limestone is an indispensible constituent of several products and processes in industries such as construction, agriculture, chemical manufacturing, metallurgical, glass production, and a wide assortment of other specialized applications. Table 1 attempts to indicate some of the more common useages. Reference has been made to a number of workers in preparing this tabulation including: Boyton (1980), Harben and Bates (1990), Lamar (1961), Rooney and Carr (1971), Scott and Dunham (1984), and Tower (1985). Specifications are not always the same from one author to another but the best compromise considered possible has been made in preparing this summarization from these various specialists.

In its purest form limestone (calcium carbonate) has unique chemical properties that provide for its effective use for cement and lime making, neutralization of acidic conditions, reactivity with several chemicals to produce other constituents, and fluxing of metallutical impurities. Specialized physical characteristics provide for limestone rock to be used as a durable aggregate, rip rap, building stone or, with more sophisticated processing, an invaluable agent to be used as a filler, carrier, extender, or whitener. Specialized applications vary widely from water filtering to mine dusting. Thus, it can be recognized that limestone, one of the least glamorous of the economic minerals, is probably one of the most valuable commodities in common use in the world today.

A number of uses and industrial processing approaches are especially worthy of discussion in connection with this study as they relate specifically to the Alberta industry. Applications to construction are, for example, well established in western Canada and provide reasonable expectations of future aggressive growth. Agricultural and light industry applications are also worthy of attention. On the other hand, other uses of limestone that are dependent on the proximity to large scale manufacturing operations or specialized industrial processing complexes such as metals refineries are of more limited impact in this region. The relatively low cost of even the most sophisticated limestone byproduct negates the possibility of long range transportation to more distant markets.

Processing of limestone is accomplished in a variety of ways depending on the quality of end product desired. Portland cement production represents the largest industrial useage of limestone in western Canada. It is manufactured by heating a mixture composed dominantly of limestone and shale (or clay) in a rotary kiln, through either a wet or dry process, until the carbon dioxide is driven off and the remaining materials combine into a complex series of calcium-aluminum-iron silicates which are capable of hydration to form a rock-like product. Additional details of the process are provided in subsequent portions of this report.

Lime-making similarly represents a large volume useage of limestone and also involves the burning of the rock in kilns with either vertical or horizontal configurations resulting in the expulsion of carbon dioxide and the production of calcium oxide (quicklime). Slaked lime is a commercial byproduct resulting from hydrating quicklime to produce a dry powder, putty or aqueous suspension. The raw material flow through commercial lime plants in Alberta will be discussed at a later point in this study.

At present, lime is extensively used in construction-related operations in western Canada but also finds application in at least two other unique industries. Lime is a necessary agent in the production of sugar from sugar beets in southern Alberta. Approximately 20,000 tonnes of high grade rock are used annually at the Taber operations of the British Columbia Sugar Refining Company where the limestone is burned on site. The resultant slaked lime and carbon dioxide are introduced into the raw juice circuit to aid in the primary purification of the sugar-ladened liquors. The precipitation of many of the impurities takes place at this stage (see Figure 2-1).

A second unique use of lime is to be found in the pulp and paper industry. The general circuitry of a typical pulp and paper plant is provided in Figure 2-2 and there are at least two stages at which lime plays an important part (refer also to Hamilton, 1993). Lime may be produced on site from shipped limestone or as a pre-processed product delivered to the plant from independent producers. It is then introduced into the chemical recovery phase of the operations (Figure 2-3). The reaction of slaked lime solutions with plant liquors from the digester results in the removal of impurities and the production of fresh cooking chemicals which are then returned to the main circuit. An established plant is capable of recirculating most of the calcium carbonate to the kiln, although some make-up of lime or limestone is generally necessary. It is reported, for example, that the Diashawa pulp mill at Peace River utilizes in excess of 10,000 tonnes of 3/8" by 3/4" limestone rock per year to feed its onsite kiln.

In the case of a plant that manufactures paper products another highly significant use is found for lime or limestone. Either ground calcium carbonate (GCC) or precipitated calcium carbonate (PCC) are added to the wood pulp mixture at the start of the paper-making process. The mineral particles help to fill voids in the overlapping cellolose fibres to produce a smoother paper and to act as a coating agent to produce an improved surface that effectively increases the opacity and brightness of the paper, as well as providing better ink receptivity and other beneficial surface characteristics (Hamilton, 1986 and 1987; Holter and Hamilton, 1989; Scafe and Hamilton, 1985).

Although the use of precipitated calcium carbonate has been somewhat limited in western Canada to this date the impressively high quality of the product is such that some attention to its more extensive future use is warranted. The manufacturing process involves the calcining of limestone which is then hydrated and carbonated to reconstitute an extremely pure form of calcium carbonate of very fine and uniform particle size (Figure 2-4). Continental Lime was instrumental in setting up such an ancilliary plant for the Weyerhauser operations at Prince Albert, Saskatchewan.

Total volumes of Alberta lime or limestone delivered to western pulp and paper plants have not been determined. Locations of mills are discussed later in this report.

The consideration of GCC leads to a discussion of the use of fine-ground limestone for a variety of other purposes. Depending on the ultimate use to which the limestone may be put there are various physical and chemical criteria applied and many of these are provided in Table 1 in connection with agricultural, environmental, glass production, filler materials, and some miscellaneous applications. The techniques adopted for achieving finer particle sizes may require sophisticated systems of grinding, air classification, and filtration (see Figure 2-5). There is no significant production of ultra-fine ground product in Alberta at this time but the operations of Limeco Products Limited produce other ground limestone materials that will discussed at a later point in this report.

The use of limestone for flue gas desulfurization (FGD) may be considered to be in its infancy in western Canada. One plant, the Saskatchewan Power operation at Shand, is currently using product obtained from Inland Cement's Mafeking quarry in Manitoba. The rock is delivered to the company's inactive cement plant at Regina for crushing and delivered from there to the power plant. The circuitry for this sulfur dioxide control system is provided in Figure 2-6 (as derived from a reporting in Power magazine, April, 1993, pp. 45 to 50) and other techniques for inclusion of limestone in the fuel burn as known to apply elsewhere. Any new construction or major retro-fit of new plant operations in Alberta may very well call for the use of such scrubbing systems.

Plans for the near future call for the shipment of rock to Shand from Cadomin instead of Manitoba. The volumes and specifications of the limestone used are not currently known.

Suncor has announced the construction of a utilities plant near Fort McMurray starting in 1996 that will burn coke and limestone to produce electricity and steam (Calgary Sun, October 29, 1992, p. 60). It's expected that this technology will result in a 75 percent reduction of sulfur dioxide emissions over the output of the current operations.

Although acid rain problems are not prevalent in western Canada at least one instance has been recorded of lime and limestone treatment of a small Alberta lake in an effort to alleviate other biochemical problems. A total of 58 tonnes of ground limestone and 49 tonnes of hydrated lime were added to Halfmoon Lake (located east of Edmonton) in an effort to lower algal biomass and phosphorous concentrations (Prepas and Babin, 1989). A similar program, which was not referenced by this writer, was purportedly carried out on Figure Eight Lake (Prepas and Murphy, 1987).

An unpublished mineral producers and consumers survey conducted by the Alberta Geological Survey in 1989 indicated other uses made of ground calcium carbonate in the province. At that time Domtar Construction Materials of Lloydminster utilized more than 14,000 tonnes of Alberta limestone for asphalt roofing production. The same survey revealed that Domglas Inc. of Redcliff consumed approximately 12,000 tonnes of limestone from provincial sources for glass bottle production. Similarly, Fibreglas Canada of Edmonton used 2,000 tonnes of Alberta limestone during the same year for the manufacture of fibreglass insulation. Manville Canada of Innisfail reported the use of 3,000 tonnes of Alberta limestone for the same purpose. Fargo Paint and Chemical of Calgary obtained 10 tonne of calcium carbonate from Surrey, B.C. for use in paint production.

Elanco, a division of Eli Lilly Canada Inc., is independently reported to use about 30,000 tonnes of ground limestone per year as a pesticide carrier.

One coal mine in Alberta, Smoky River Coal at Grande Cache, operates an underground mine which utilizes limestone as a dusting agent. No information is available on the current supplier or volumes consumed.

Limestone is undoubtedly used by Alberta towns and muncipalities for water treatment and filtering facilities. However, no data has been located on this end use.

Interest has been expressed from time to time in production of limestone and marl for ameliorization of acidic and/or solonetzic soils in Alberta and some relevant studies have been completed (MacDonald and Hamilton, 1979; MacDonald, 1982). It is generally recognized that single applications would be relatively light and not necessarillt administered on an annual basis for any one land parcel. In other words, the market for limestone for this particular useage would be somewhat specialized and not a large one.

CONSTRUCTION-RELATED

PRODUCT	PROCESSING	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USES
Cement	Mixtures of limestone and clay or shale, with other additives such as silica and iron compounds, are finely ground and blended in carefully proportioned amounts. These are burned in a rotary kiln to result in a complex mixture of hydrated calcium-aluminum-iron silicates.	Normally: >75% calcium carbonate, <5% to <3% magnesium carbonate, <0.5% phosphorous pentoxide, <0.01% iron oxide, low manganese and sulfur	Low amounts of hard chert masses and coarse quartz grains.	Concrete, mortar cement, masonry cement, slurry and grouting applications.
Aggregate	Crushing, screening, size separation, washing.	Relatively inert, with chemical soundness, resistant to soluble salts, limited alkalai reactivity with cement.	Typically 1 to 20 cm. size range, relatively high specific gravity (2.0 to 2.8), high crushing and impact strength (abrasion loss < 35 to 45%, soundness loss <10 to 25%), resistant to polishing, low porosity, tendency to form particles of particular shape and size range, freedom from dust and fines	Concrete use, bituminous materials, roadstone, railway ballast, roofing granules, terrazzo, and stucco. As an asphalt filler most pulverized limestones, including dust collector discharge, can be used. Roofing granules and pebbledash may require color standardization.

TABLE 2-1 USES AND SPECIFICATIONS OF LIMESTONE

CONSTRUCTION-RELATED, Continued

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE OF PRODUCT
Rip Rap	Coarse blasting	Immaterial	Typically >30 cm., not less than 15 cm., durable (soundness loss <25%), adequate compressive and impact strength, relatively high bulk density, free from cracks and laminae, adequate spacing of bedding and joints, frost resistance; pyrite veinlets, clay partings and chert are generally undesireable.	Protection from erosion of bridges, piers, dams, and other construction.
Dimension Stone, Building Stone, Cut and Polished Stone.	Coarse blasting of quarry cut.	Immaterial	Typically >30 cm., adequate spacing of bedding and jointing, good internal drainage if porous, consistent appealing appearance, high compressive strength, hard; of sufficient strength to withstand blasting, cutting and polishing; resistant to outside elements and indoor floor traffic, frost resistant. free of faults, brecciation, stylolites, clay and chert bands, and foreign mineralization.	Interior and exterior building facings, retaining walls, flagging, monumental use.

TABLE 2-1. C[illegible] USES AND SPECIFICATIONS OF LIMESTONE

AGRICULTURAL APPLICATIONS

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USES
Soil Conditioning	Crushing, screening.	Preferably high mineral purity.	Low moisture content to assist spreading process and maximize CaO available; typical size specifications are 80% or more passing a U.S. No. 8 sieve (2.38mm).	Reduces soil acidity, supplies calcium and magnesium nutrients, improves soil structure.
Animal feedstuffs	Moderately fine crushing.	No formal specifications, calcium carbonate as high as possible with minimal amounts of silica, iron, alumina, and moisture acting as diluting factors; low amounts of heavy metals to avoid toxidity, low magnesium oxide to avoid scouring in hogs, low fluorine.	Particle sizes >200 mesh (0.75 mm) to avoid plugging of dry mash feed flow and excessive dust, otherwise fines are acceptable.	Additives to dry mash or as pellets.
Poultry Grit	Moderately fine crushing, size control.	High-calcium limestone, fluorine <0.1%, some silica preferred.	Typically between 3 to 9 mm, free from fines, rounded grains preferred.	Aids in food grinding and provides a nutrient supplement.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

AGRICULTURAL APPLICATIONS, Continued

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USES OF PRODUCT
Pesticide Carrier, Fugicide Carrier Insecticide Diluent	Fine grinding	Chemical purity, otherwise immaterial.	Typically 95% passing 325 mesh (44 microns), low moisture contents, high chemical retention characteristics, low tendency to lump, near white color, low organic matter.	Carrying agent for insecticides, herbicides, or fugicides allowing efficient and safe dispersement of chemicals.
Fertilizer Additives	Moderately fine grinding, size control.	Reasonably pure limestone or dolomite.	Usually between No. 8 (2.38 mm) and No. 20 (0.84 mm) U.S. sieve sizes.	Serves to add weight, reduce caking, improve general condition of fertilizer mixture and to adjust the desired ratios of fertilizer elements.

CHEMICAL MANUFACTURING

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USES OF PRODUCT
Calcium Nitrate	Undetermined	High-calcium limestone.	Undetermined	Limestone treated with nitric acid.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

GLASS PRODUCTION

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE OF PRODUCT
Plate Glass, Container Glass, Fibre Glass, Special Glass	Fine grinding	>98.5% calcium carbonate, <0.035% iron oxide, <1.0% acid insoluble content including silica, <1.0% organic matter, <0.1% (or quantitatively declared if greater) manganese oxide, lead oxide, phosphorous pentoxide, and sulfur dioxide. Agreed limits of alumina or magnesia. Coloring elements, other than iron, should not be present in such quantities as to stain glass. Low moisture.	100% <3.2 to 4.8 mm., >0.1 to 1.2 mm. depending on furnace type. Container glass uses <10 mesh (1.7mm) and >200 mesh. Fibre glass uses limestone flour <200 mesh). Specialty glass allows up to 25% >200 mesh.	Highly variable.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

METALLURGICAL USE

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USES OF PRODUCT
Pig Iron Flux	Normal quarry production, processed to appropriate size. Iron ore is crushed and roasted with limestone and coke in pelletization process.	Typical for open hearth: calcium and magnesium carbonate >95%, 98% calcium carbonate, generally <3.0% magnesium carbonate, silica <1% to <3%, sulfur <0.25%, traces only of phorphorous tolerated. Typical for blast furnace: <1% to <2% silica, <0.1% sulfur and phosphorous (or <0.5% sulfur and only traces of phosphorous, <2% alumina, <4% to <15% magnesia.	Hard, ground fine. Typically 100% passing 5mm size for pelletization, 95% passing 3mm., 90% coarser than 0.15mm., finer than 200 mesh (0.075mm.) totally unacceptable. Blast furnace size specifications range form 2.5 cm. to 15 cm., requiring strong rock that will not decrepitate under heat of furnace.	Various.
Aluminum Production	Details undetermined	High-calcium limestone.	Undetermined	Limestone sintered with leach residues to form insoluble dicalcium silicate with the silica present. Aluminum and soda in residues may then be leached out and returned to the circuit.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

ENVIRONMENTAL APPLICATIONS

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONED	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE
Flue Gas Desulfurization (FGD)	Fine Grinding, 84% passing 45 microns	High calcium carbonate (85 to 95%), low sulfur, maximum 5% acid insolubles, iron content beneficial, magnesium sulphate creates disposal problems (very soluble), maximum 5% MgO.	High micron-range porosity, finely ground (average 0.05 cm.) for greater surface area, 84% paqssing 325 mesh (44 microns). Mico-porosity important.	Sulfur emmissions control by either wet process (stack gasses passed through a wet slurry of lime or limestone); or by dry process (limestone introduced into a fluid bed firing system of a boiler with the resulting CaO content sufficient to absorb the sulfur dioxide as a calcium sulfate material).
Acid Rain Combatant	Fine grinding	High grade limestone	100% passing 0.2 mm. size; consistency of product important.	Addition to surface waters, particularly lakes, to reduce the acidity caused by acid rain. Sprayed or slurried into lakes.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

FILLER MATERIAL

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE
Fillers, Extenders, Whiting	Fine crushing	Chemical purity and inertness. For PCC: 97% calcium carbonate, less than 5% MgO; low silica, iron, alumina and sulfur.	Specific particle size and size distribution. Typically 12 to 22 mm. as bulk fillers andf 0.7 to 10 mm. for fine fillers. May require whiteness and high reflectivity, specific particle shape and surface area, known plastic and rheological characteristics; high adsorption characteristics with regards to oil, ink, and pigments; adequate specific gravity and bulk density, proper pH, favorable compressive strength. For PCC: quality only confirmed through simulated production.	Adds color, stiffness, opacity, incresed electrical conductivity, resistance to heat for many uses such as: in plastics, rubber, paint, paper, putty, ceramic, floor coverings, caulking, sealants, adhesives, joint cement, etc.

MISCELLANEOUS APPLICATIONS

PRODUCT	PROCESSING OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE
Mine Dusting Agent	Crushing, size classification.	Not excessively important.	Light colored. Low on combustible material and silica (<5% combined), Typically < 0.2 mm, will not cohere to form a caked mass when wetted and dried.	Prevents or checks coal dust explosions, light color aids illumination.

TABLE 2-1,Continued USES AND SPECIFICATIONS OF LIMESTONE

MISCELLANEOUS APPLICATIONS, Continued

PRODUCT	PROCESSING OF OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE
Pharmaceutical	Fine grinding.	Extremely fine chemical purity.	Undetermined.	Calcium nutrition for human consumption, potential additive to flour and other foods.
Welding Rod Coatings	Fine grinding.	Uncertain.	Undetermined.	As designated.
Filter Stone	Crushing to size and adequate angularity.	Chemical purity, minimum of soluble sulfate impurities, siliceous impurities acceptable if fine-grained and evenly distributed.	Adequate compressive strength, good moisture absorption, abrasion resistance (low dust formation), typically 3 to 8 cm., consistent size grading, close limitation on fines; minimum pyrite, marcasite, and clays; cherts undesireable, rough surface for anchorage of bacteria.	To form beds of trickling filters over which the liquid portion of sewage is sprayed. The rock serves as a host for organisms which purify the sewage.
Water Treatment	Fine grinding.	High calcium limestone.	Typically 150 mesh (0.15 mm.) to 325 mesh (0.045 mm.).	Coagulent or stabilizer to prevent after-precipitation of calcium carbonate from lime-softened water.

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

LIME-MAKING

PRODUCT	PROCESSING OF OF LIMESTONE	CHEMICAL SPECIFICATIONS OF LIMESTONE	PHYSICAL SPECIFICATIONS OF LIMESTONE	END USE
Lime, Quicklime, Hydrated Lime	Calcining of limestone at temperatures exceeding 898 degrees Centigrade in an atmosphere of carbon dioxide at a pressure of 760mm	High purity, normally a minumum of 97% carbonate content, less than 5% MgO for high calcium limes; overall less than 3% impurities including silica, alumina and iron oxides.	7 cm to 25 cm, absence of fines, limited tendency to produce fines or dust during burning.	See below

Uses for lime are very extensive, including the following:

Flux - Alumina
BOF Steel
Open Hearth Steel
Electric Furnace Steel
Non-Ferrous Metals

Flocculation - Sugar
Ore Flotation
Sewage Treatment
Water Purification
Waste Treatment
Paint Pigments

Neutralization - Citric Acid
Water Treatment
Sewage Treatment
Calcium Phosphates
Metal Pickling Wastes
Explosive Wastes
Agricultural Soils
Acid Mine Drainage
Radioactive Wastes
Uranium Wastes
Chrome Chemicals
Dyestuffs

Solvent - Gelatin
Leather (Dehairing)
Casein Paints
Strawboard

Absorption - Bleaches
Sulfur Dioxide Removal
Sulfite Pulp
Apple Storage

Hydrolization - Pulp Cloth
Lubricating Grease
Organic Chemicals
Ammonia

Raw Material - Rubber
Concrete
Stock feeds
Calcium Cyanamid
Agriculture (Liming)
Synthetic Whiting
Calcium CArbide
Insecticides
Abrasives
Glass

Bonding Agent - Mortars
Plasters
Ashalt Paving
Insulation Materials
Road Soil Stabilization
Calcium Silicate Products
Silica Brick
Stuccos

Dehydration - Air Drying
Petroleum
Other Organic Sovents
Alcohols

Causticization - Caustic Soda
Soda and Sulfate Pulp
Dual Alkali Scrubbing

Lubricant - Oil Welll Muds
Wire Drawing

TABLE 2-1, Continued USES AND SPECIFICATIONS OF LIMESTONE

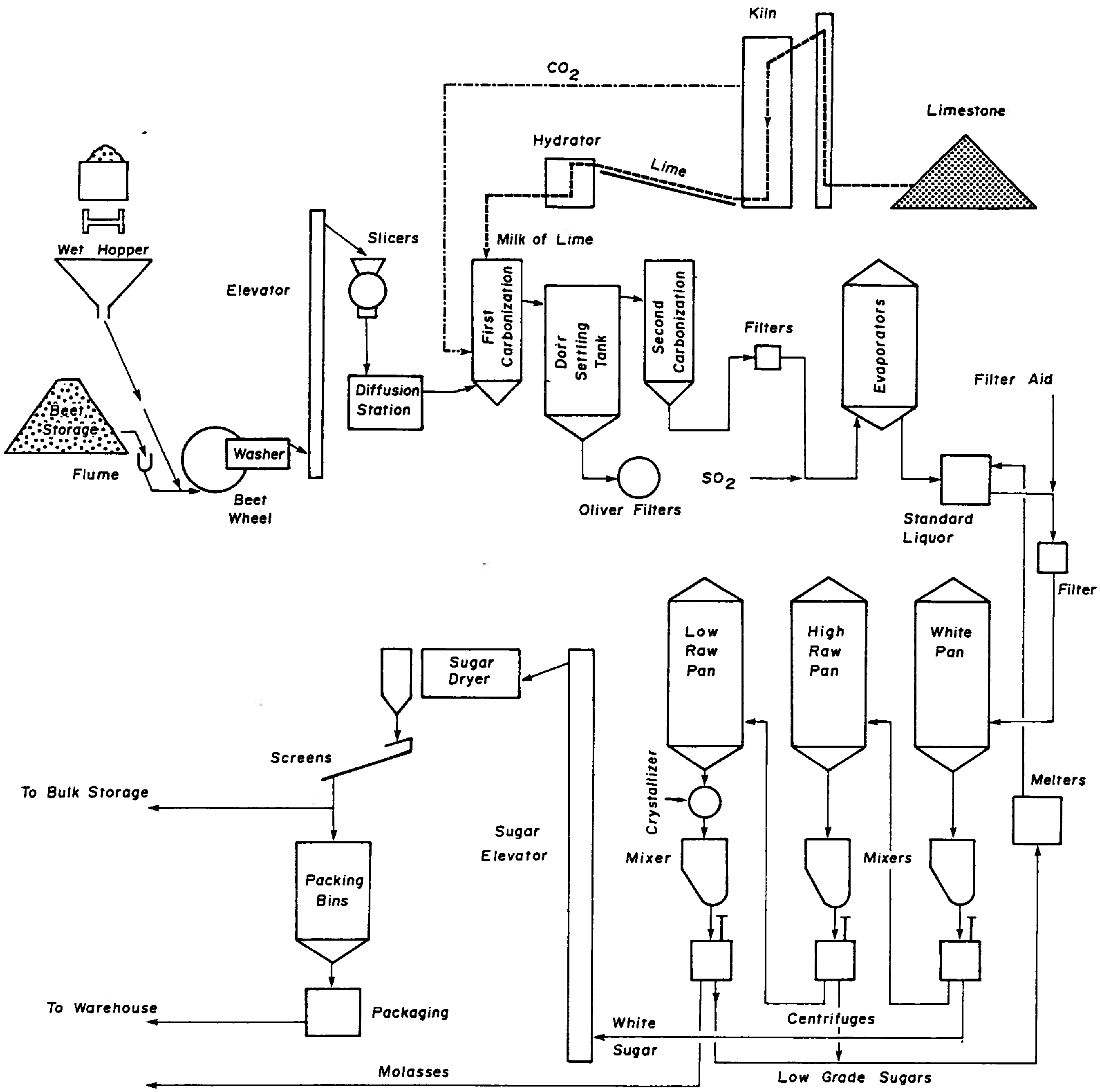

FIGURE 2-1

Sugar Plant Circuitry

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By: Holter Geological Services

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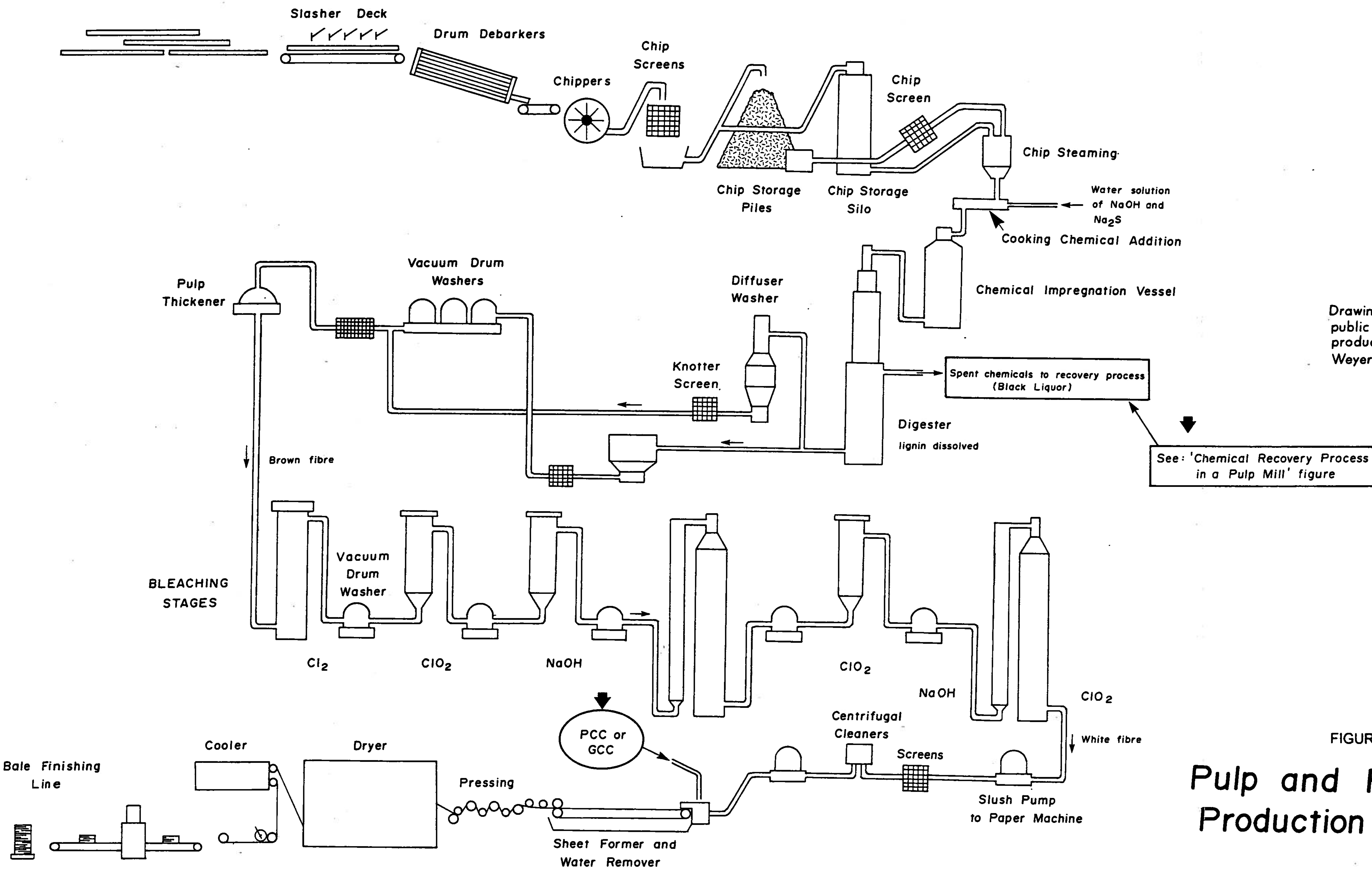

Drawing modified from public information brochure produced by: Weyerhaeuser Canada Ltd.

FIGURE 2-2

Pulp and Fine Paper Production Sequence

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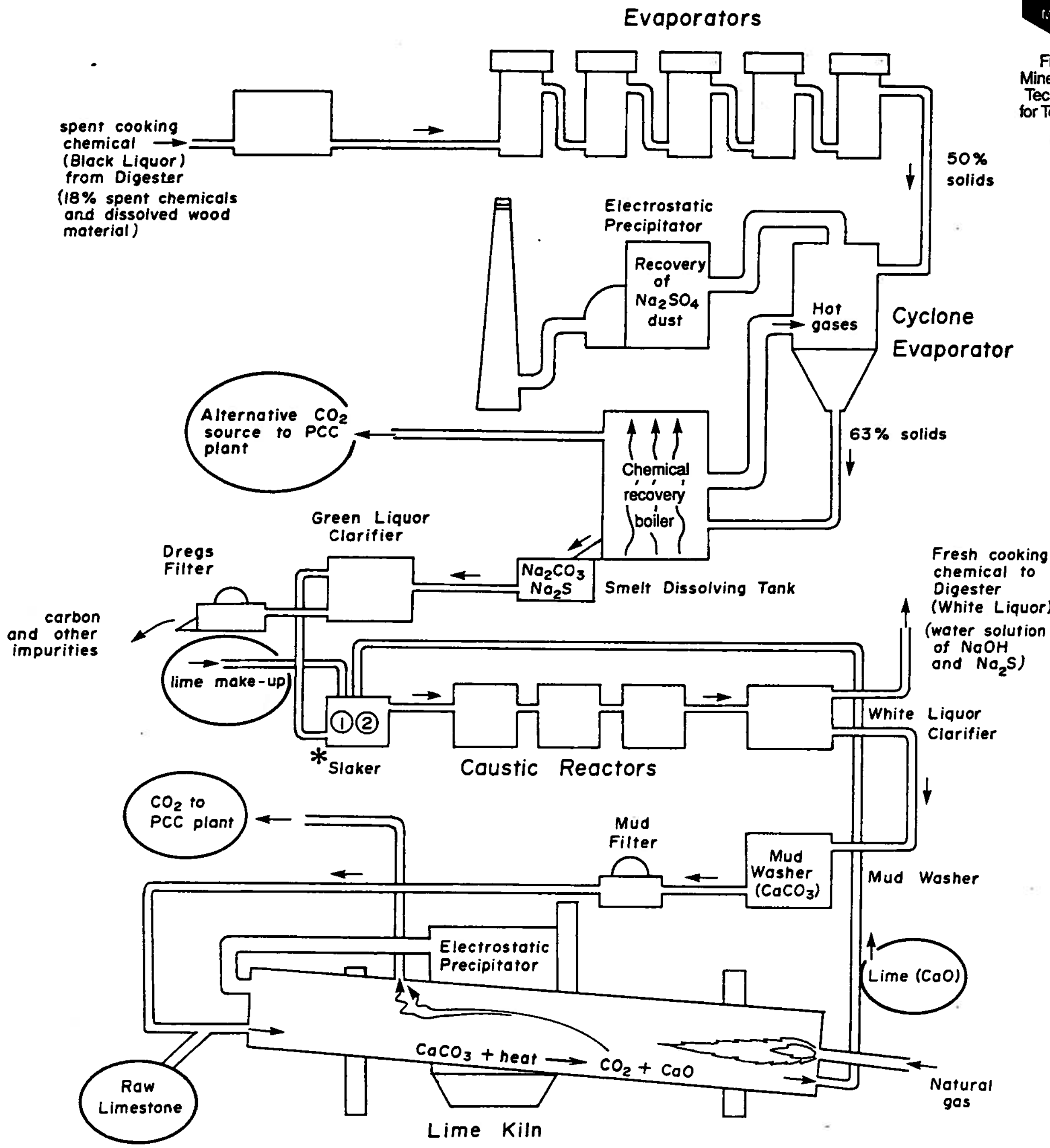

* ① $CaO + H_2O \rightarrow Ca(OH)_2$

② $Ca(OH)_2 + Na_2CO_3 \rightleftharpoons 2NaOH + CaCO_3$

FIGURE 2-3

Chemical Recovery Process in a Pulp Mill

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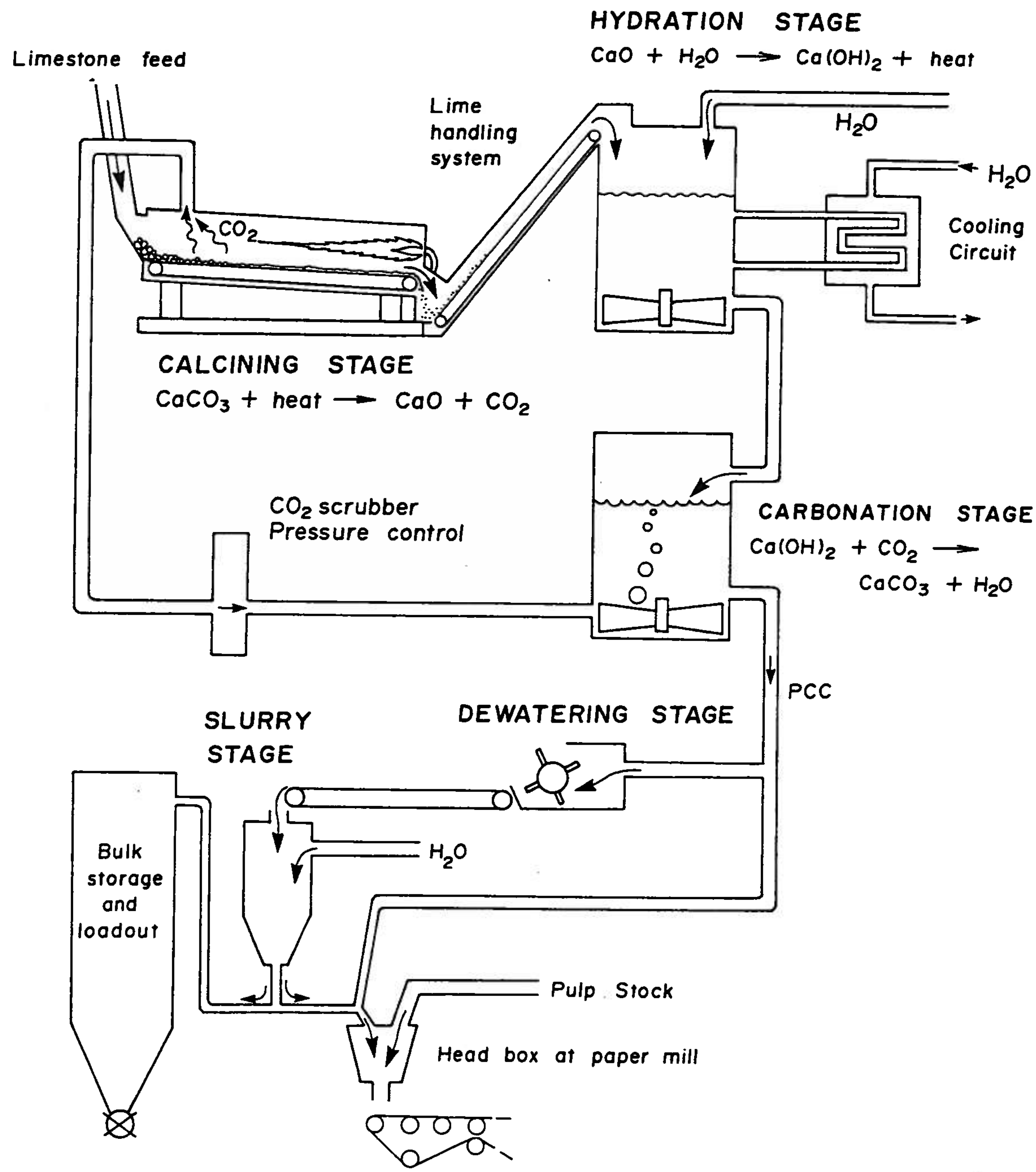

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FIGURE 2-4

Generalized Circuitry for PCC Production

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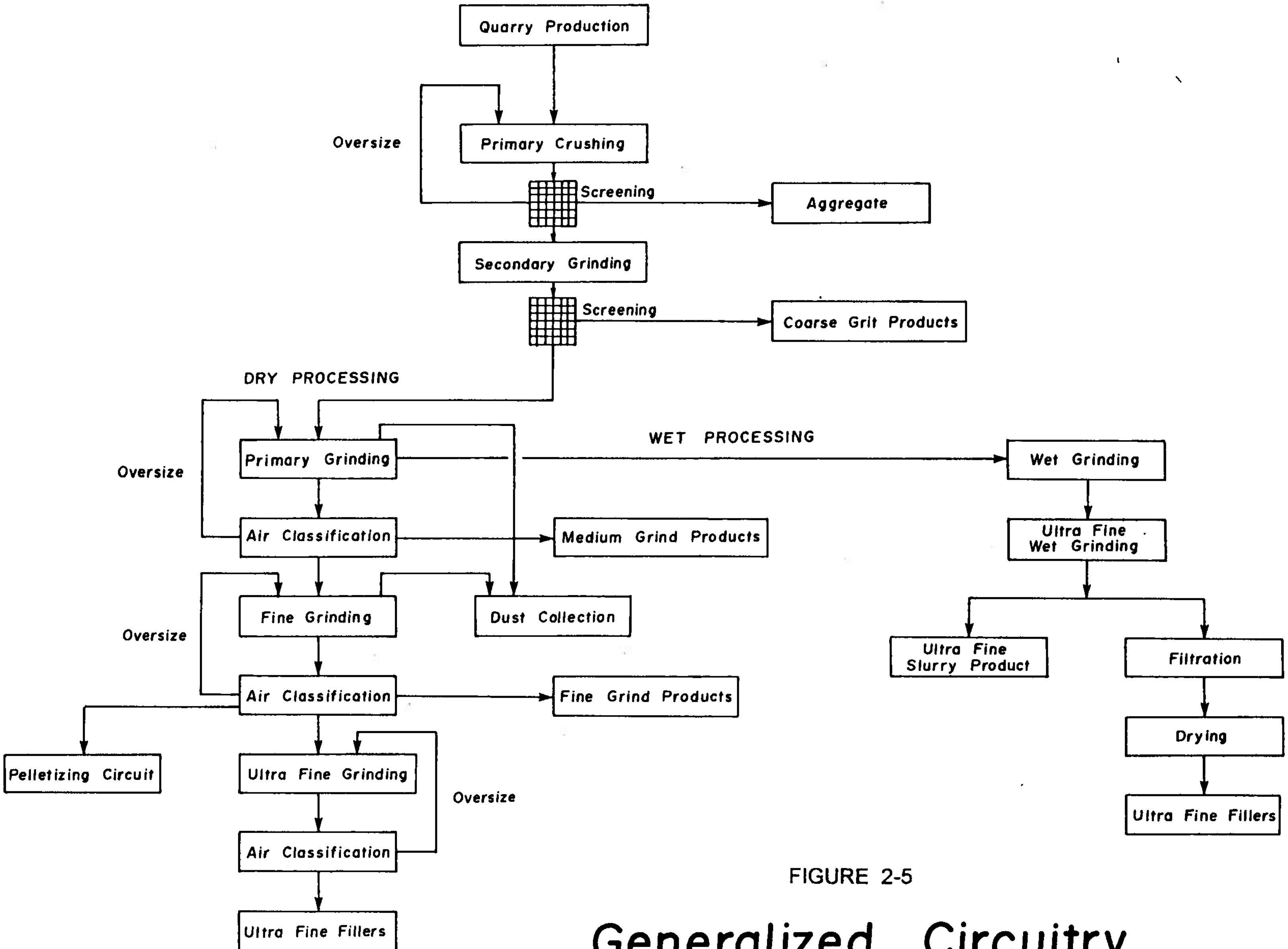

FIGURE 2-5

Generalized Circuitry for GCC Production

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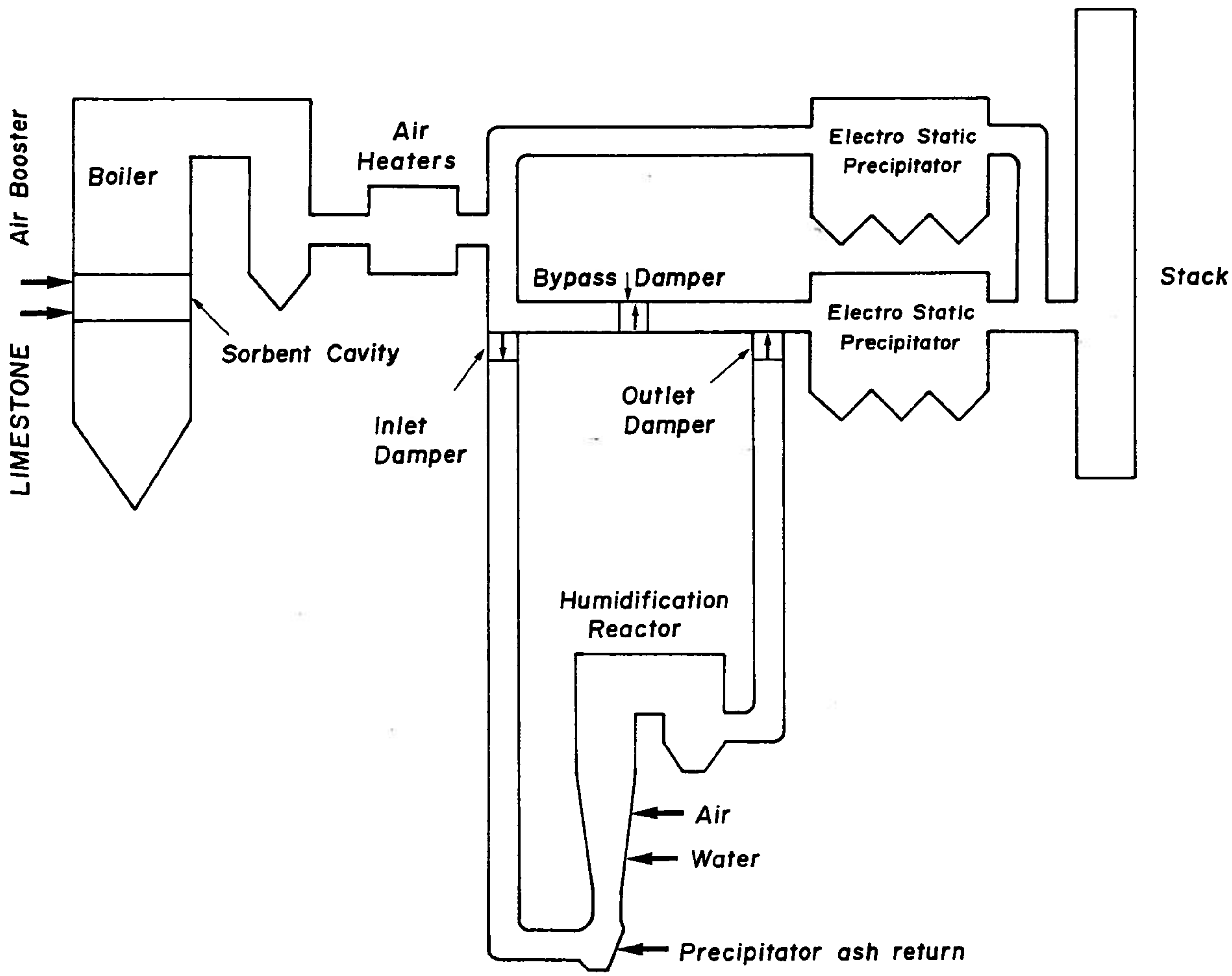

FIGURE 2-6

Sulfur Dioxide Control System
Shand Power Plant

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3. LIMESTONE DEVELOPMENTS IN WESTERN CANADA

Active development of limestone deposits has taken place in British Columbia, Alberta, and Manitoba since the preliminary years of this century. Alberta Economic Development and Trade has indicated that the nonmetallics mineral products industry in Alberta employed over 8,000 people in the province in 1988 and shipments of product during that same year amounted to $571 million. An invaluable guide to the early phases of this industry in the west has been compiled by Goudge (1946). The British Columbia resources have recently been reviewed by Fischl (1992). Manitoba limestones have been studied by Bannatyne (1975) with later contributions by Gunter (1990, 1991). An extensive review of the market potential for Manitoba limestones was prepared by Ash Associates (1992). The limestone resources of Alberta have been investigated by Holter (1976) and subsequent updates have been provided for several localities, most of which are noted elsewhere within this reporting.

As noted previously, the largest single industrial user of limestone in western Canada is by cement manufacters. Figure 3-1 indicates the distribution of plants and quarries throughout the west. There has clearly been much opportunity for interprovincial movement of semifinshed and processed product. In recent years the volume of production has been relatively level (Figure 3-2) and some modifications of previous output has even taken place. For example, Inland Cement has deactivated plants at Regina and Winnipeg. The same company has largely curtailed the use of rock from its quarry at Mafeking, Manitoba and has also discontinued the processing of clinker from its Edmonton plant at the Regina and Winnipeg facilities. Lafarge Canada has ceased to ship clinker from its plant at Exshaw for grinding at a terminal at Edmonton.

A total of 1.24 million tonnes of limestone was produced on the Prairies in 1992, most of which was manufactured in Alberta. During the same period British Columbia manufactured 1.15 million tonnes of cement. Production statistics are not individually available for Manitoba and Alberta from publicly available files for the last number of years. Data from Statistics Canada is current to the end of 1992 but, since 1989, all production from the Prairie provinces is published as one annual value.

There are currently five lime operations in western Canada (Figure 3-3), four of which are controlled by Continental LIme. In recent years this company acquired the Summit Lime Works operations in the Crowsnest Pass area of Alberta. Western production appears to show a modest increase over the past number of years (Figure 3-4) although published data is only available from Statistics Canada for British Columbia up to the end of 1989 and for Alberta to the end of 1991. No production volumes have been reported by this agency for Manitoba but sales figures would imply that recent annual production is in the range of one million tonnes.

No effort has been made to review the remaining aspects of the limestone rock products industry in western Canada in detail. Many small industrial developments are operational in Manitoba and British Columbia which are not readilly referenced in detail. The rock product production in Alberta is discussed in the ensuing portions of this report.

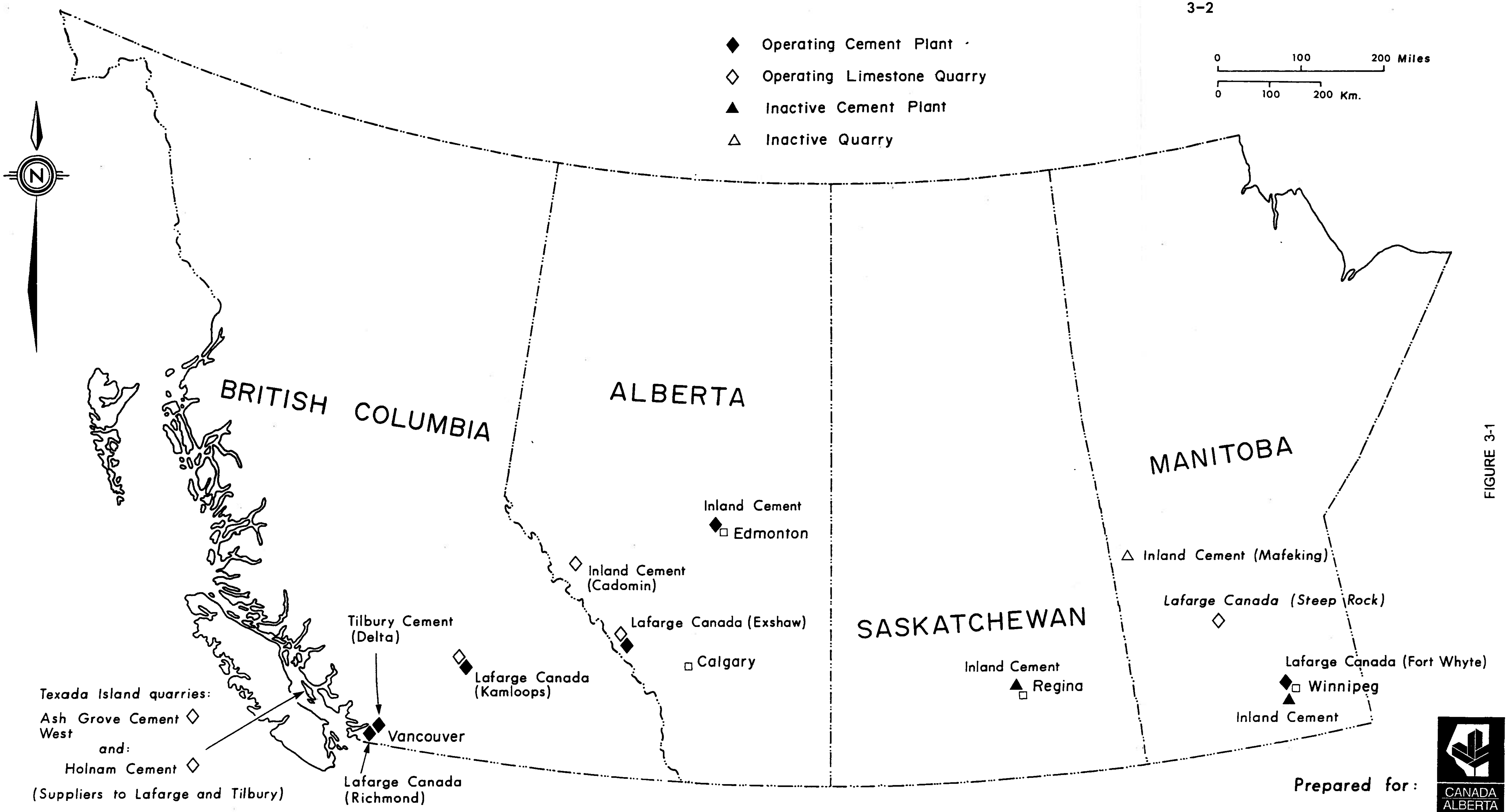

FIGURE 3-1

Cement Operations - Western Canada

2/94

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By: Holter Geological Services

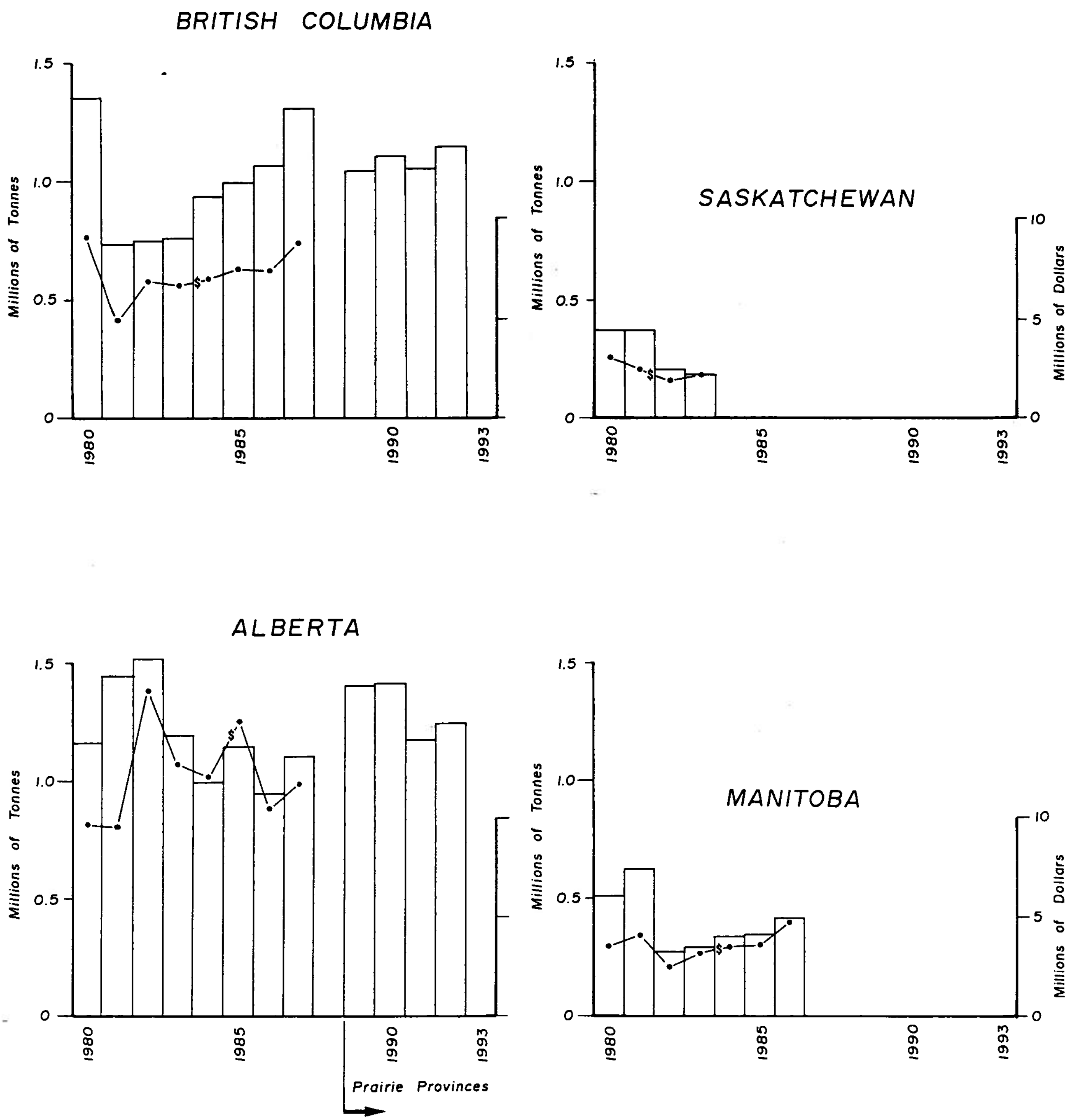

FIGURE 3-2

Cement Production - Western Canada

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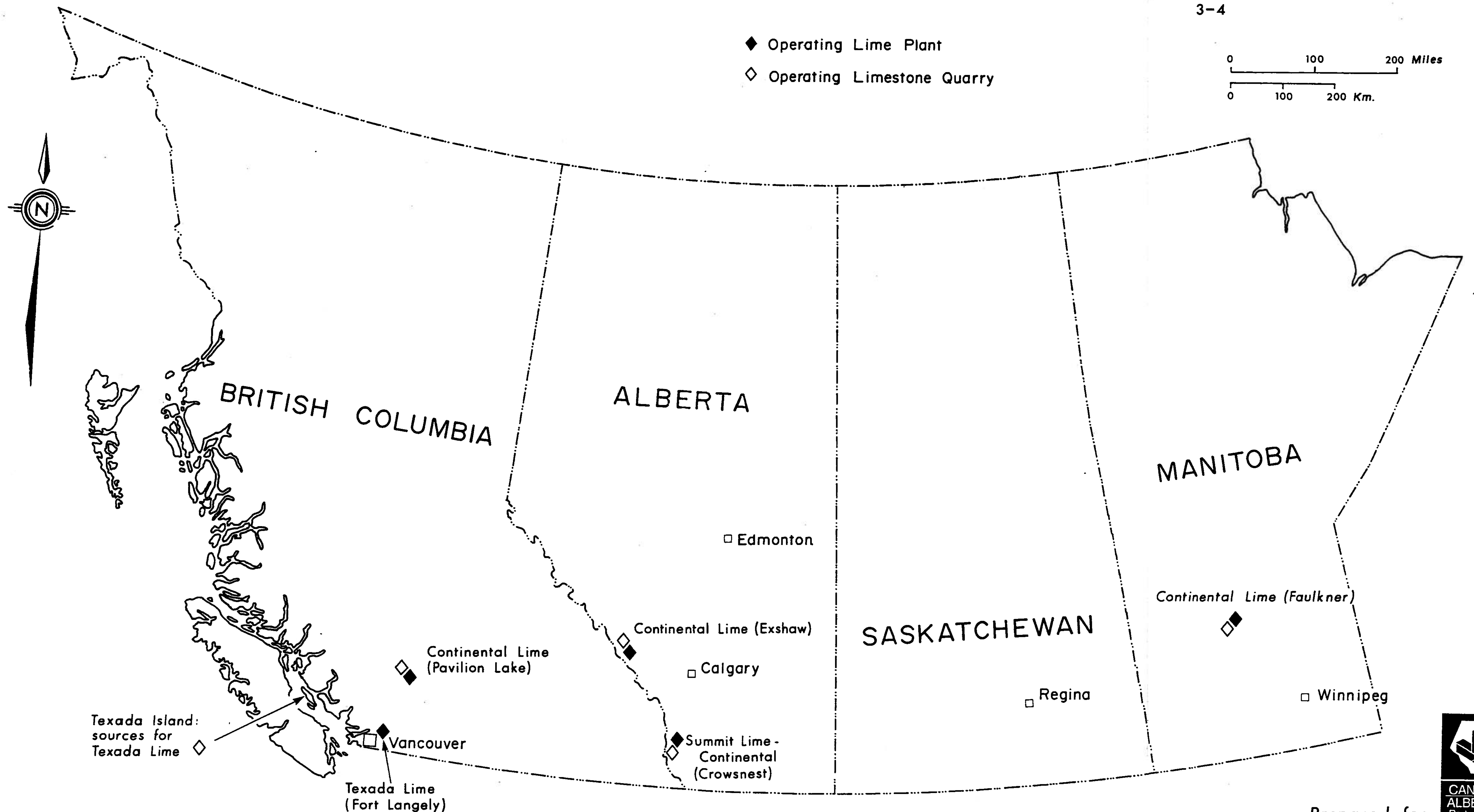

FIGURE 3-3

FIGURE 3-3

Lime Operations - Western Canada

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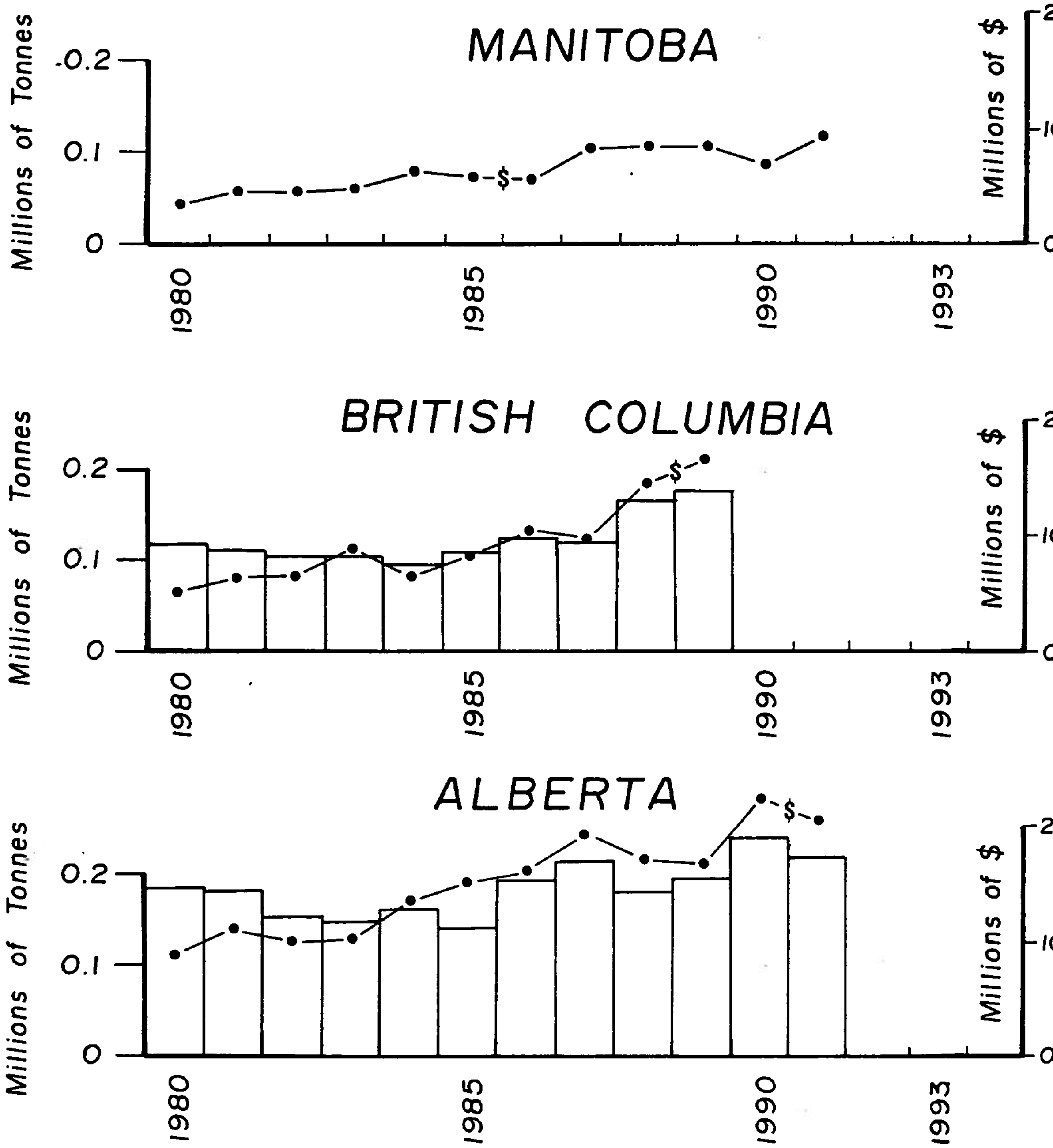

FIGURE 3-4

Lime Production - Western Canada

4. THE ALBERTA LIMESTONE INDUSTRY

Total Alberta limestone production has exceeded 2.0 million tonnes during each of the past 4 years as indicated by figures obtained from the Mineral Tax Division of the Alberta Energy (Figure 4-1).

The two cement manufacturers in Alberta operate quarries located along the Rocky Mountain Front on the western side of the province (Figure 4-2). The plant and quarry of the Lafarge Canada facilities are located at Exshaw within the Bow River Corridor, approximately 80 km. west of Calgary and the site is serviced by Highways 1 and 1A as well as the main line of the Canadian Pacific Railway. Regional corporate offices are located in Calgary. Lafarge has established facilities at Edmonton for grinding of clinker from Exshaw but these are not operating at this time. The quarries of Inland Cement are located at Cadomin along a branch line of the Canadian National Railways and is reached by road from Edmonton via Highways 16, 47, and 48. A unit train delivers rock to the plant in Edmonton three times per week.

The Lafarge quarry yielded slightly more than 1.0 million tonnes of rock for cement-making during each of the past several years (Figure 4-3). Inland cement has shown an average gain of quarry production from about 620,000 tonnes in 1988 to approximately 890,000 tonnes in 1993. This may be due, in part, to a restructuring of manufacturing by the company in western Canada over the past few years. In addition, some production of rock for other purposes may be significantly factored into this increase.

Lime is produced in Alberta at Exshaw and the Crowsnest Pass by Continental Lime along the eastern edge of the Cordillera Region (Figure 4-4). The quarry that supplies the plant near Exshaw is located approximately 10 km. to the west along Highway 1A. The main line of the Canadian Pacific Railways services this facility. The Summit Lime Works (both plant and quarries) is located alongside the Canadian Pacific Railway and Highway 3 within the Crowsnest area.

Limestone from the Continental Exshaw quarry has shown a relatively steady increase in production since at least 1988 (Figure 4-5). During 1993 about 550,000 tonnes is reported to have been mined although, during the previous year, only a total of 151,000 tonnes was reported to be extracted. The Summit operations experienced a relatively large production in 1989 (338,000 tonnes) and fell back to 81,000 tonnes in 1990. Since that year there has been a consistently modest production gain to a total of about 165,000 tonnes in 1993. As previously shown, the combined production of lime from the two plants in 1990 was about 240,000 tonnes, during which time the reported total limestone production was about 375,000 tonnes. Relating the available limestone production figures with the tonnage of lime manufactured during any one year is difficult from publicly-available data due to unknown inventories, deliveries of crushed rock, and other factors.

Two companies are currently involved exclusively in the production of limestone rock products in Alberta (Figure 4-6). Limeco Products operates a facility at Rocky Mountain House in the west central part of the province. A branch line of the Canadian National Railways services the area and Highway 11 passes through the town site. The company has rights to a quarry at Corkscrew Mountain approximately 60 km. to the southwest and this may be reached by a series of secondary highways. Nordegg Lime, with offices in Calgary, operates a quarry at

Nordegg west of Rocky Mountain House on a land parcel presently subleased from Westmin Resources of Vancouver. The site is close to Highway 11 but is not serviced by rail.

Only limited amounts of limestone have been taken from the Corkscrew Mountain quarry in recent years (Figure 4-7) in spite of comparatively high plant production. Much of the limestone has otherwise originated from the Nordegg quarry which normally produces in excess of 35,000 tonnes per year. Nordegg Lime has continued to meet other market needs as they become established.

Some of the major consumers of limestone and lime products in Alberta (other than cement and concrete) are shown in Figure 4-8. These markets have been briefly discussed previously and, apart from variability of quality and quantity parameters, one of the most critical factors in satisfying any market niche is the cost of production and transportation. Quarrying costs will understandably vary depending on the scale of operations and complexities of the setting. For relatively small facilities quarrying is suggested to cost in the vicinity of $2.50 per tonne and almost as much again to pass through a relatively modest processing stage. Rail rates must be negotiated within a particular scenario of volume and distance and are therefore difficult to establish as any kind of average. Trucking charges are probably comparable with rail (with the exception of unit train rates) and might sensibly be set at approximately $0.07 per kilometre-tonne at this time. Expanded market development for Alberta limestone is clearly a complex interplay between several economic parameters.

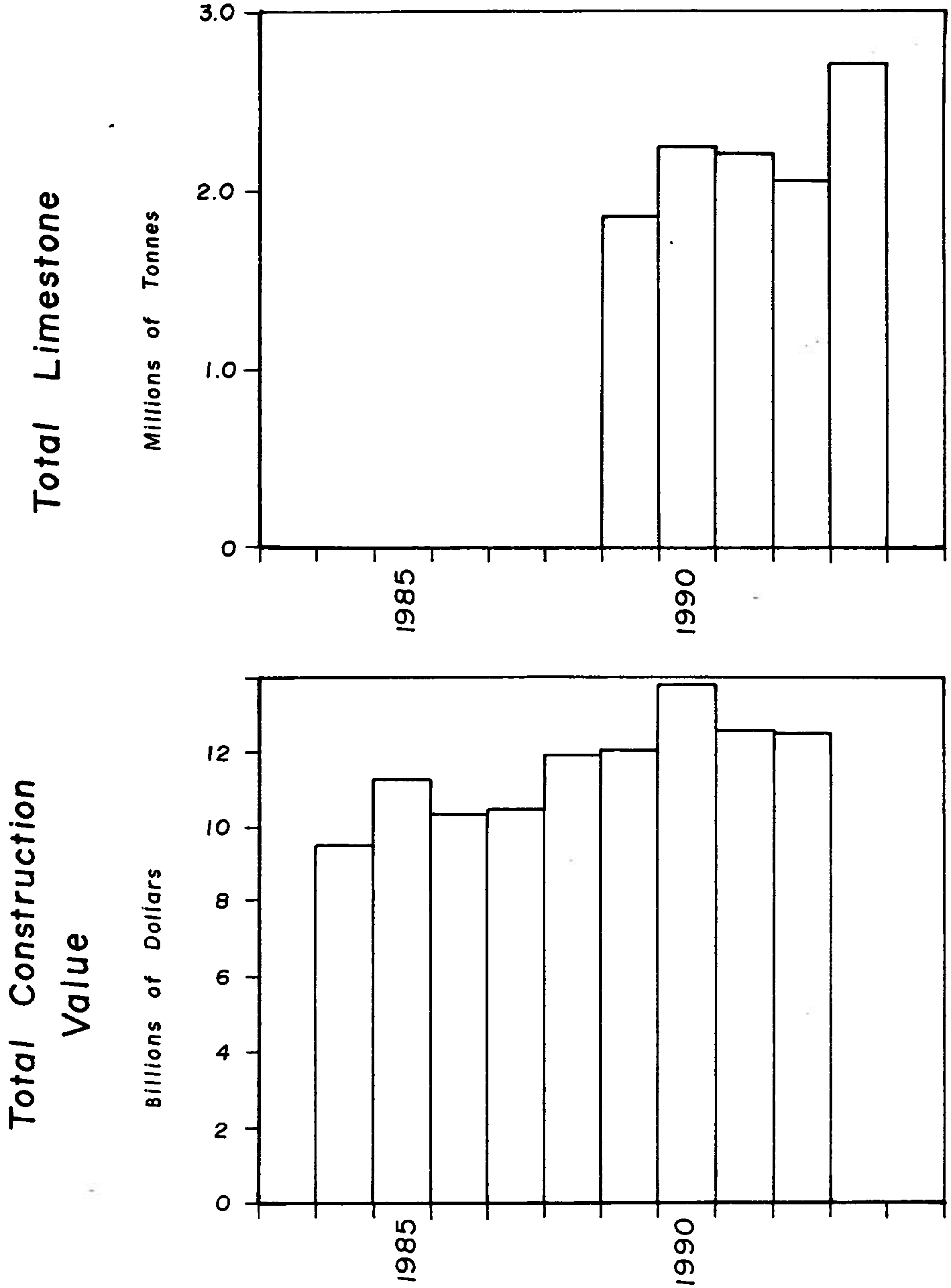

FIGURE 4-1

Alberta Limestone Production

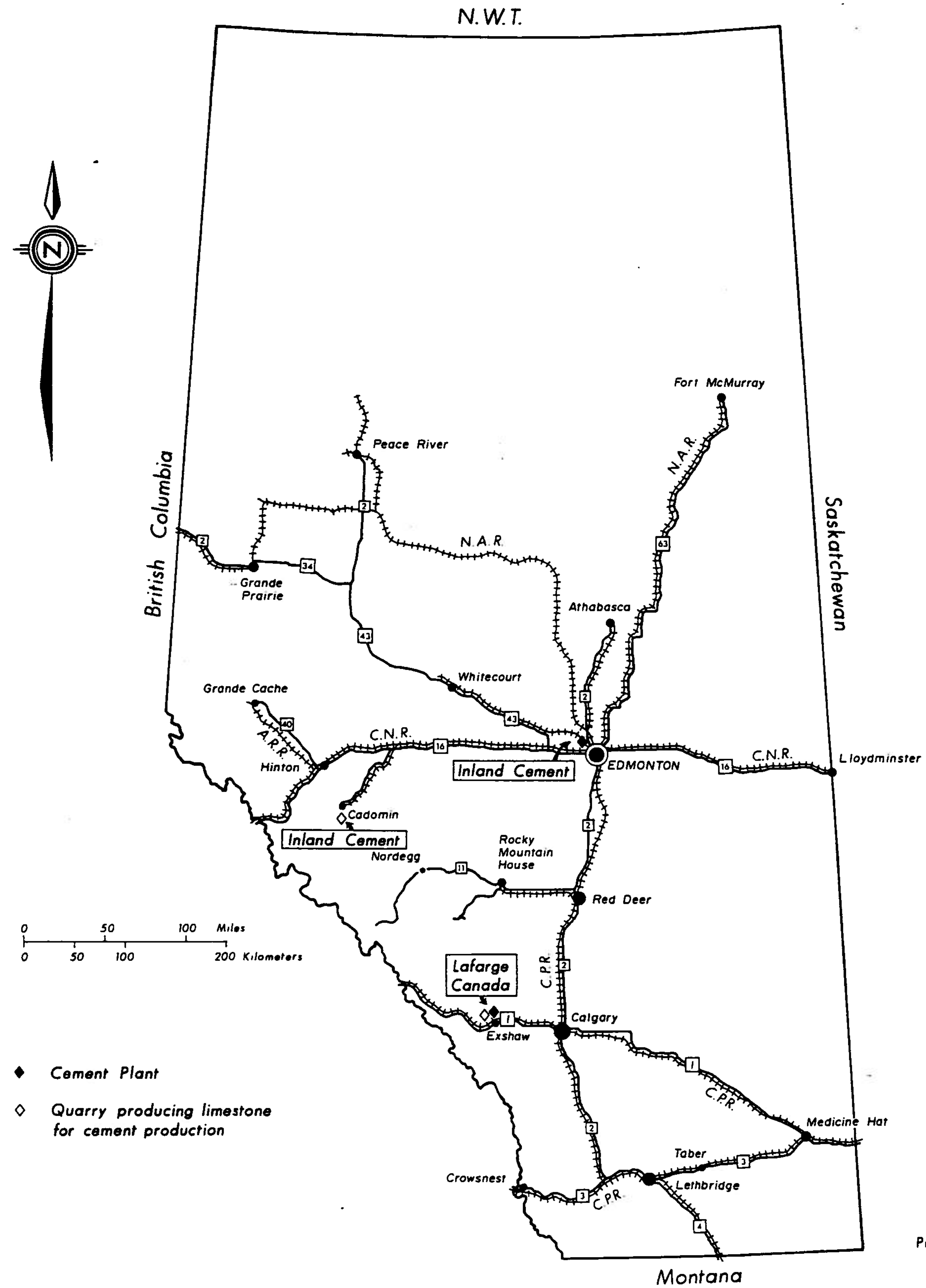

FIGURE 4-2

Alberta Cement Producers

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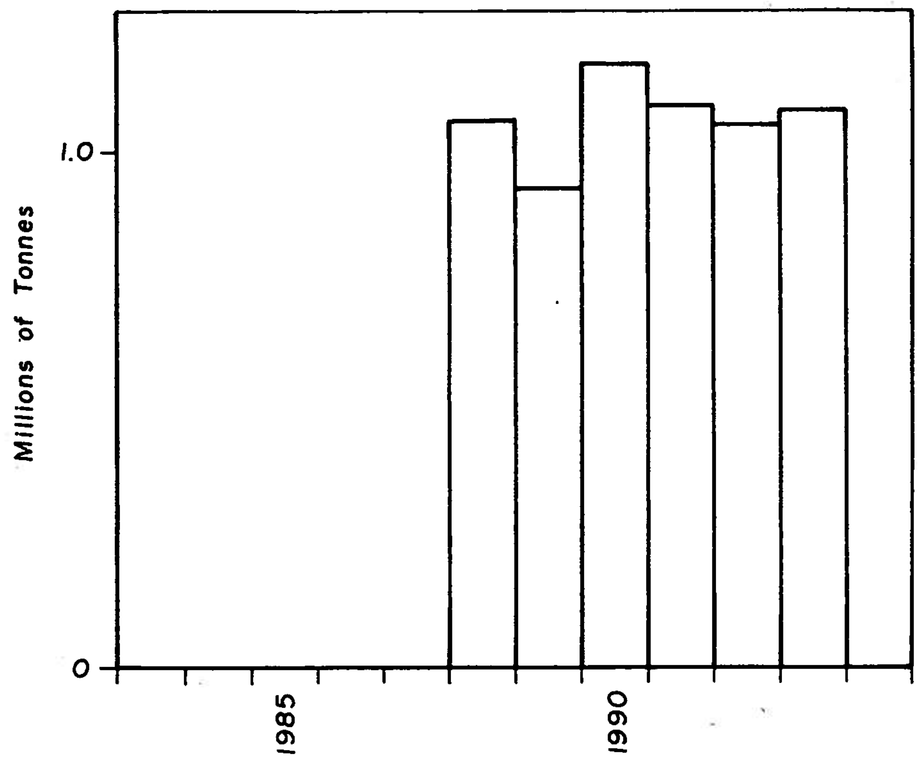
Lafarge Canada



Inland Cement

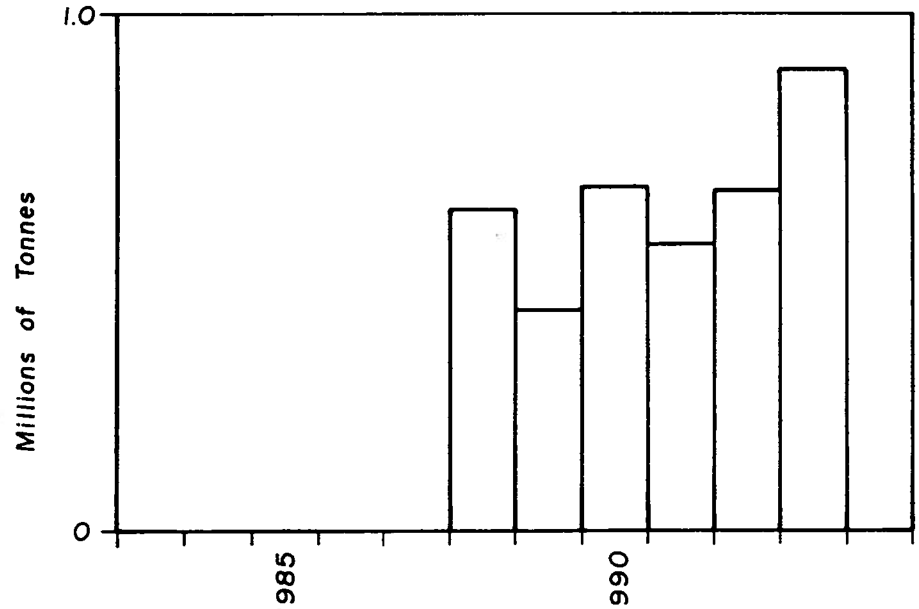


FIGURE 4-3

Alberta Limestone Production

for Cement Manufacturing

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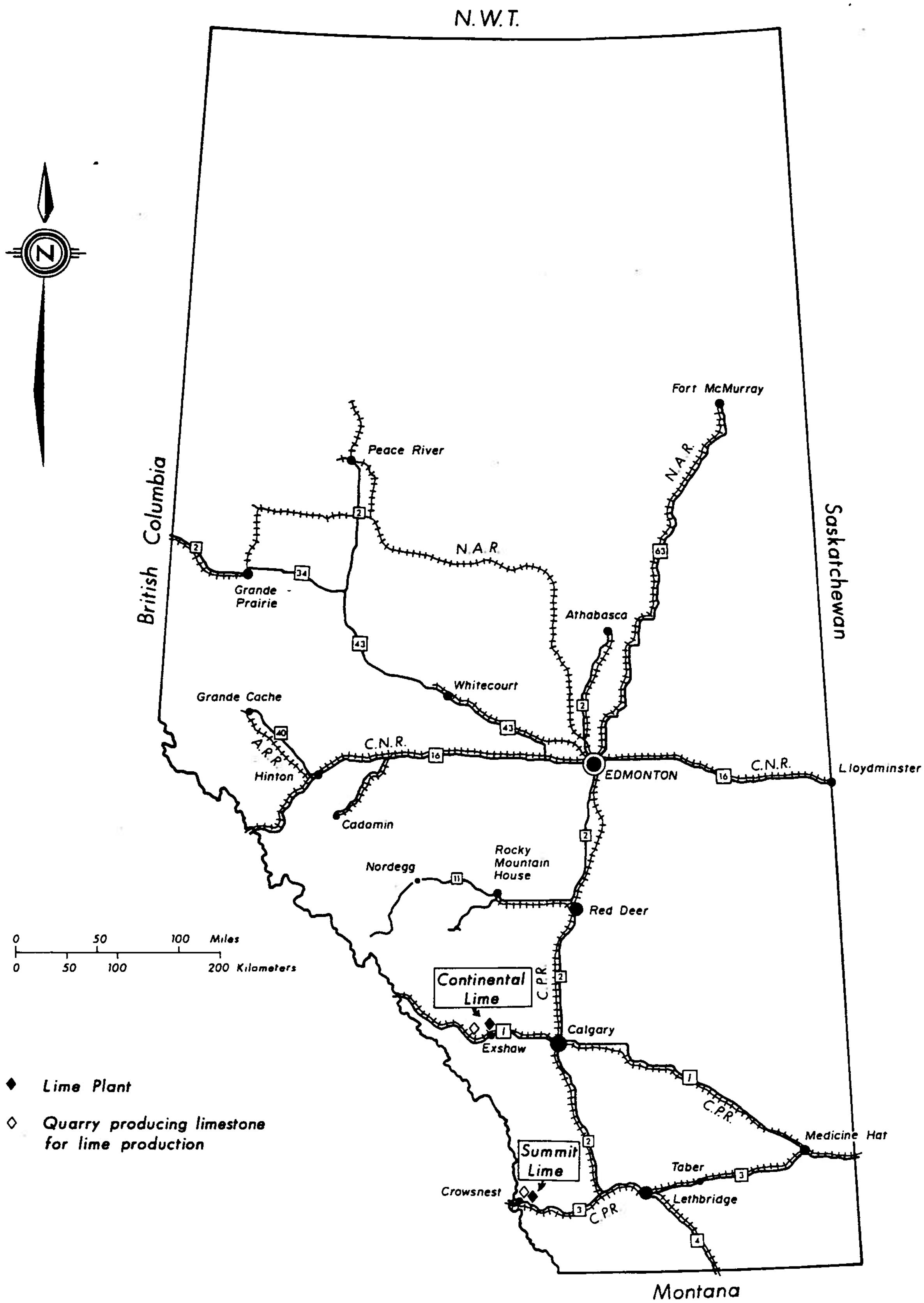

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FIGURE 4-4

Alberta Lime Producers

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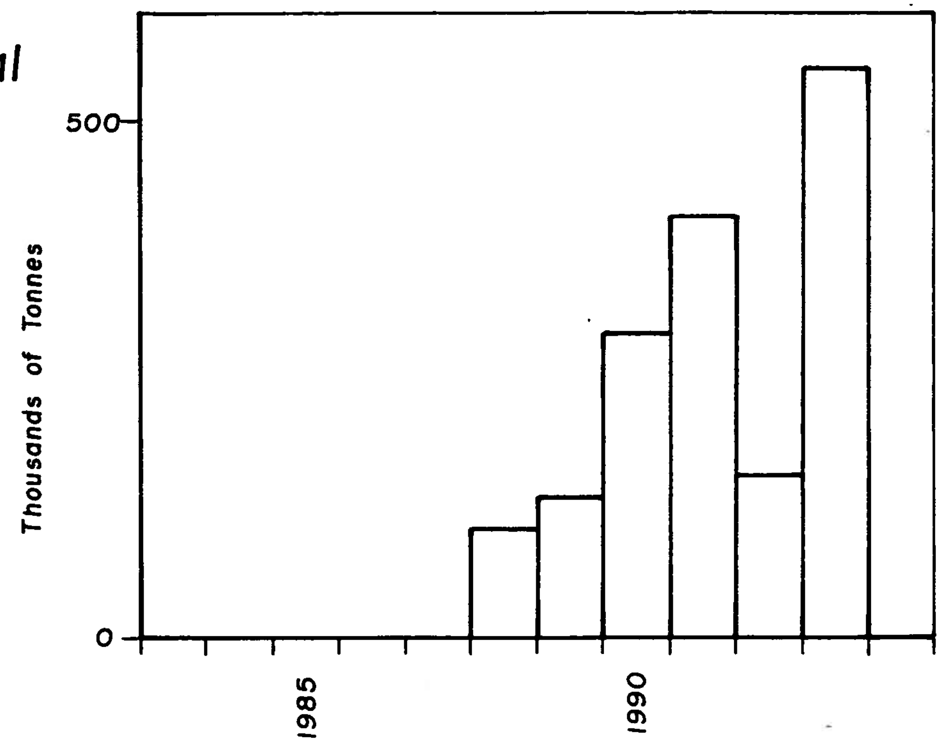
Continental Lime (Exshaw)



Continental Lime (Summit Lime Works)

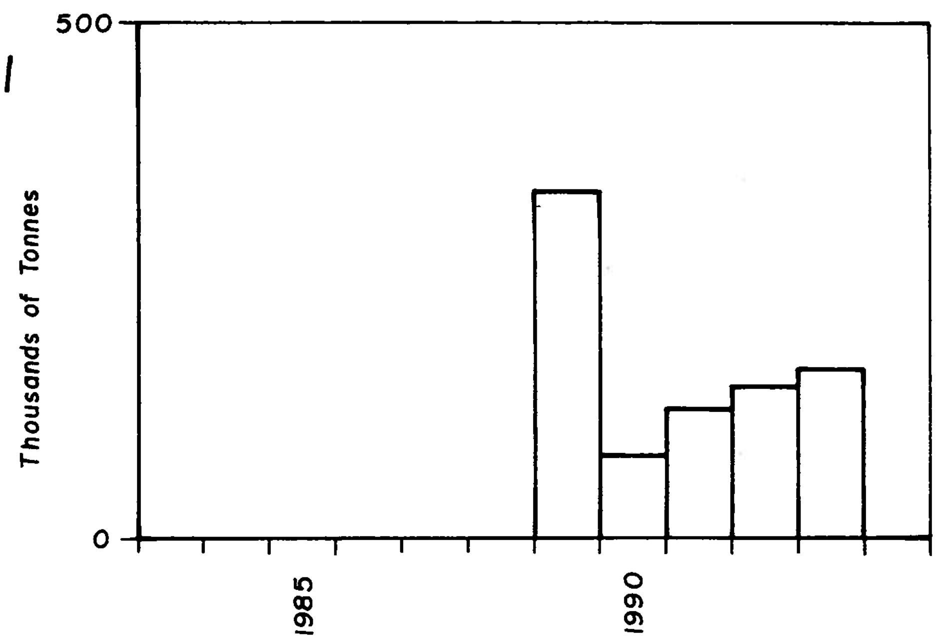


FIGURE 4-5

Alberta Limestone Production

for Lime Manufacturing

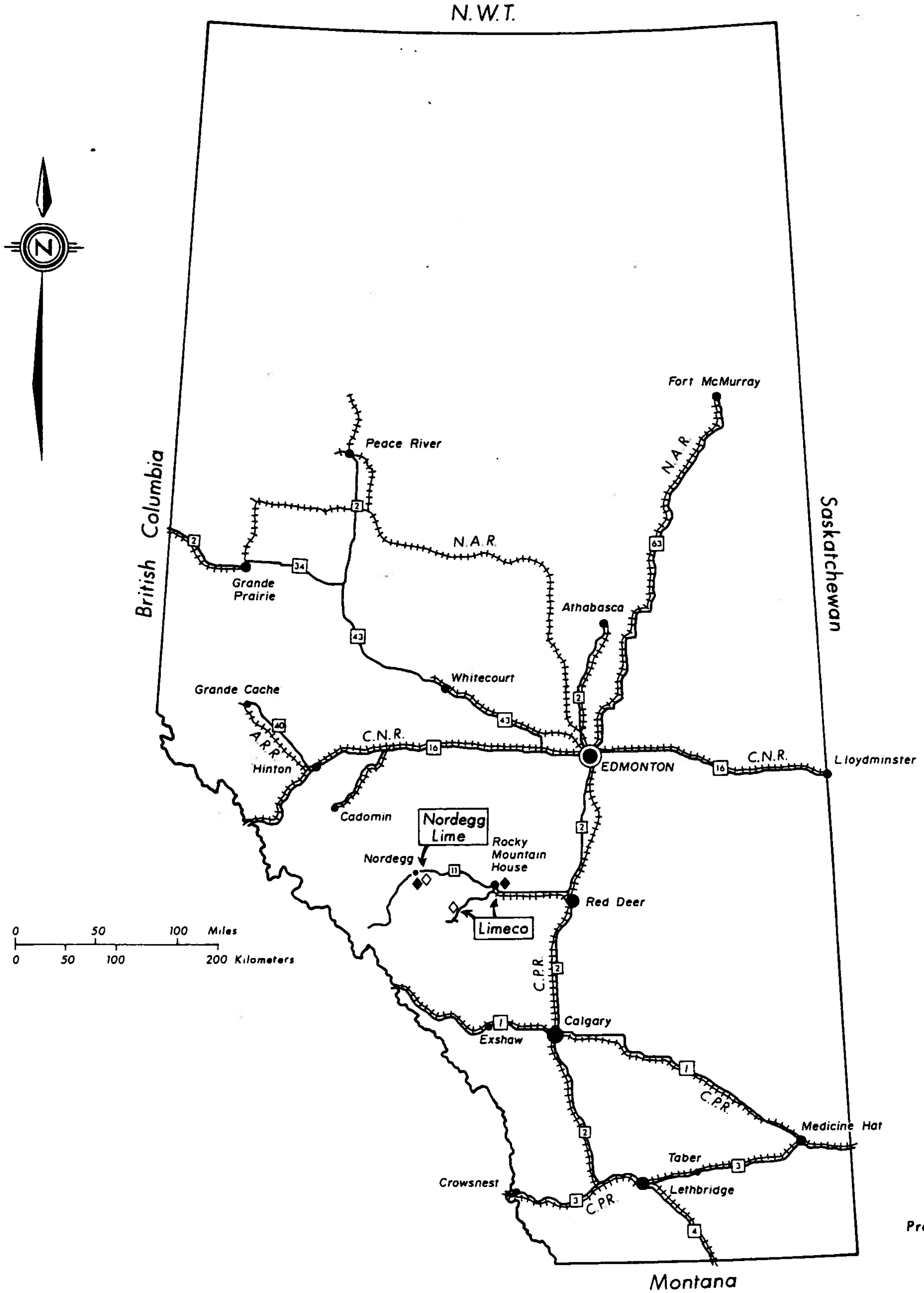


FIGURE 4-6

Alberta Limestone Rock Producers

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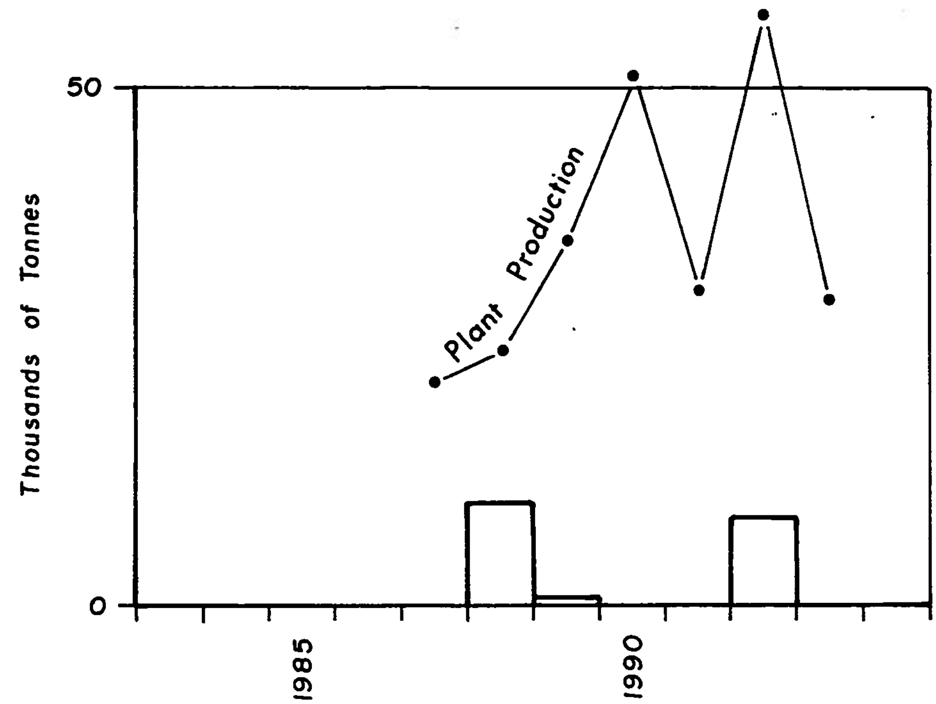
Limeco



Nordegg
Lime

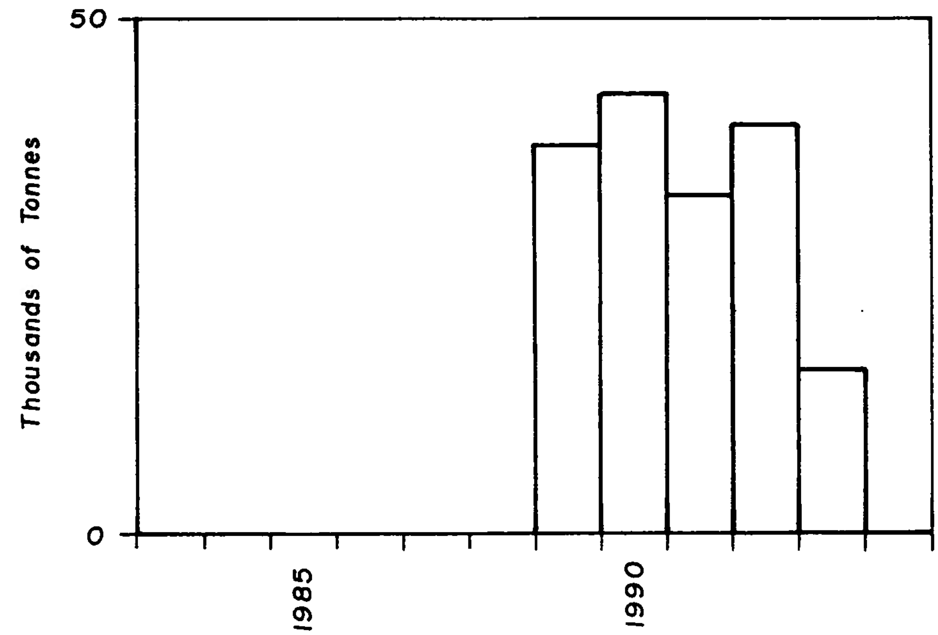


FIGURE 4-7

Alberta Limestone Production

for Processed Rock

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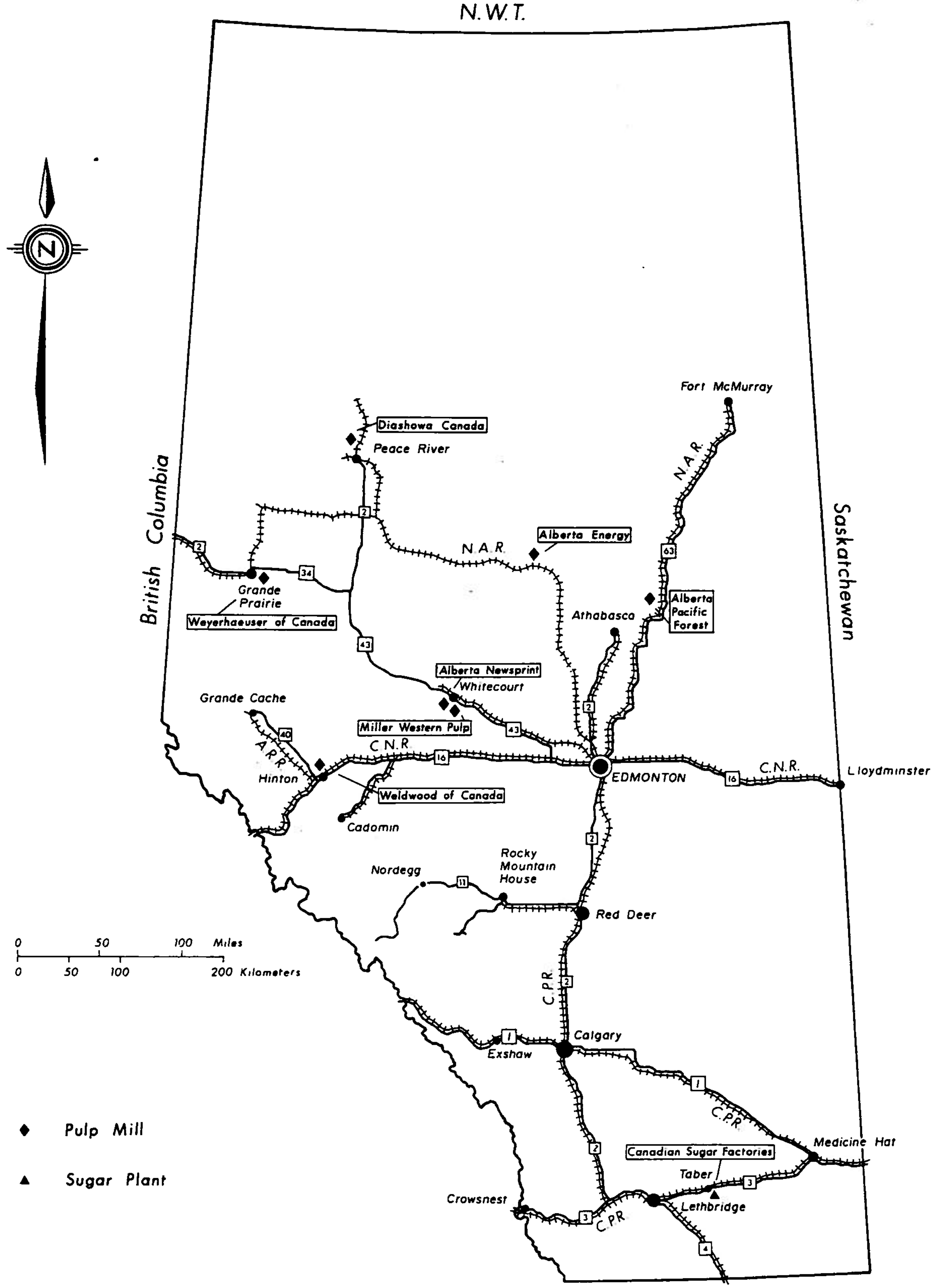

FIGURE 4-8

Major Alberta Limestone and Lime Consumers

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5. GEOLOGICAL SETTINGS OF ALBERTA LIMESTONE DEPOSITS

The distribution of outcrop zones of limestone-bearing formations in Alberta is shown in Figure 5-1. These occur within the Cordilleran and Foothills regions along the western edge of the province, as well as in the northeast along the Athabasca and Clearwater River systems. All commercial production to date is within the Crowsnest Pass, Bow River, David Thompson Highway, and Cadomin regions. In each case the quarries have been developed in either Devonian Palliser Formation or Mississippian Livingstone Formation strata.

The Crowsnest Pass area has been mapped by Norris (1955) and Price (1961). A generalized presentation of geological conditions within the main transportation corridor between Blairmore and the British Columbia border has been reproduced in Figure 5-2. A cross section constructed along an east-west line, immediately south of the Pass, is provided in Figure 5-3 and this indicates the correlative stratigraphic and structural position of the Summit Lime Works quarries. Rock has been removed from almost the entire stratigraphic succession of the Livinstone Formation from beds that dip approximately 30 degrees to the west. A few secondary thrust faults and lateral displacements have been mapped in this area.

Geological conditions in the Bow River Corridor are from Price (1970, see Figure 5-4). The structural style of this region is demonstrated by a cross section across the Corridor (Figure 5-5) which clearly shows typical effects of imbricate thrust faulting and Inner Foothills folding as well as the spectacular influences of glacial erosion. The resultant repetition of stratigraphic units and the presence of prominent cliffs formed by the more resistant stratigraphic units such as the Palliser Formation are readilly apparent. Both the Lafarge operations in the Palliser and the Continental Lime developments in the Livingstone Formation are within west-dipping beds that are readily accessible for favorable quarry management.

The Limeco quarry on Corkscrew Mountain is opened on the west flank of a relatively gentle anticline with moderate local bedding dips (Figure 5-6). A secondary thrust fault has created an uplifted displacement of the western limb of the Corkscrew Mountain anticline at this location. The geological mapping, as well as the section provided in Figure 5-7, have been derived from Ollerenshaw (1968). Current production is from the Mississippian Pekisko strata.

Geological mapping of the Nordegg area was carried out by Douglas (1956) and the main structure influencing the Nordegg Lime quarry is the so-called Brazeau Anticline (Figure 5-8). A secondary thrust fault, a bifurcation from the Brazeau Thrust, has breached and offset the anticline along its axis. The west flank of the fold, along which the quarry occurs, is relatively undisturbed and beds dip towards the west at relatively low angles (see Figure 5-9). Rock is recovered from limestone beds assigned to the Mississippian Livingstone Formation.

The Inland Cement quarry is located along the main front of the Nikanassin Range within Devonian Palliser strata (Figure 5-10). Geological mapping in this area was first published by MacKay in 1929. The main fault in this region is the Nikanassin Thrust and the development of an associated splay, the Fiddle River Thrust, has resulted in the occurrence of a second belt of Palliser outcropping less than two kilometres south of the prominent cliff faces of the formation at the mountain front (Figure 5-11). A secondary quarry has been opened in these southern exposures of the limestone.

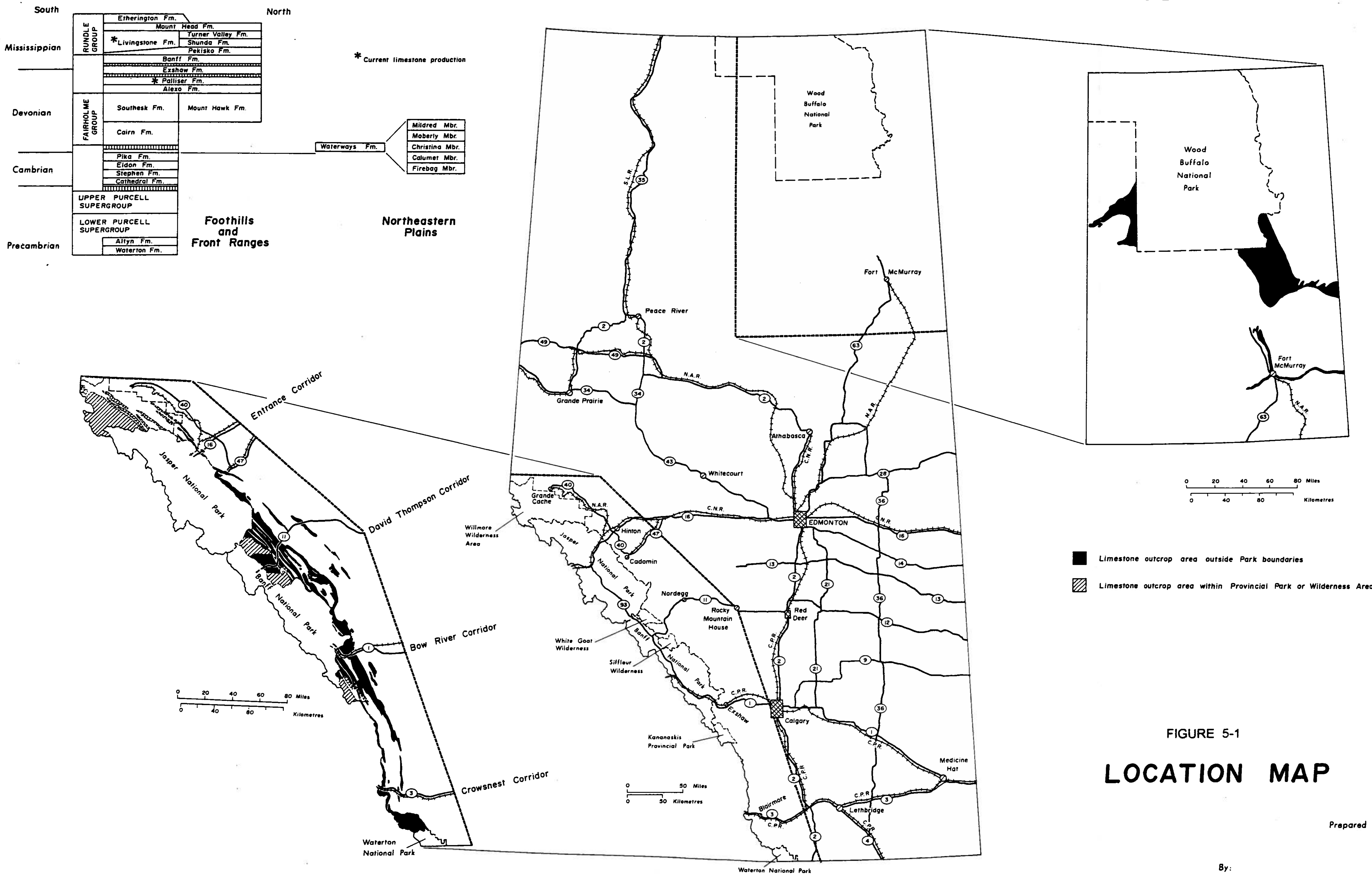

FIGURE 5-1

LOCATION MAP

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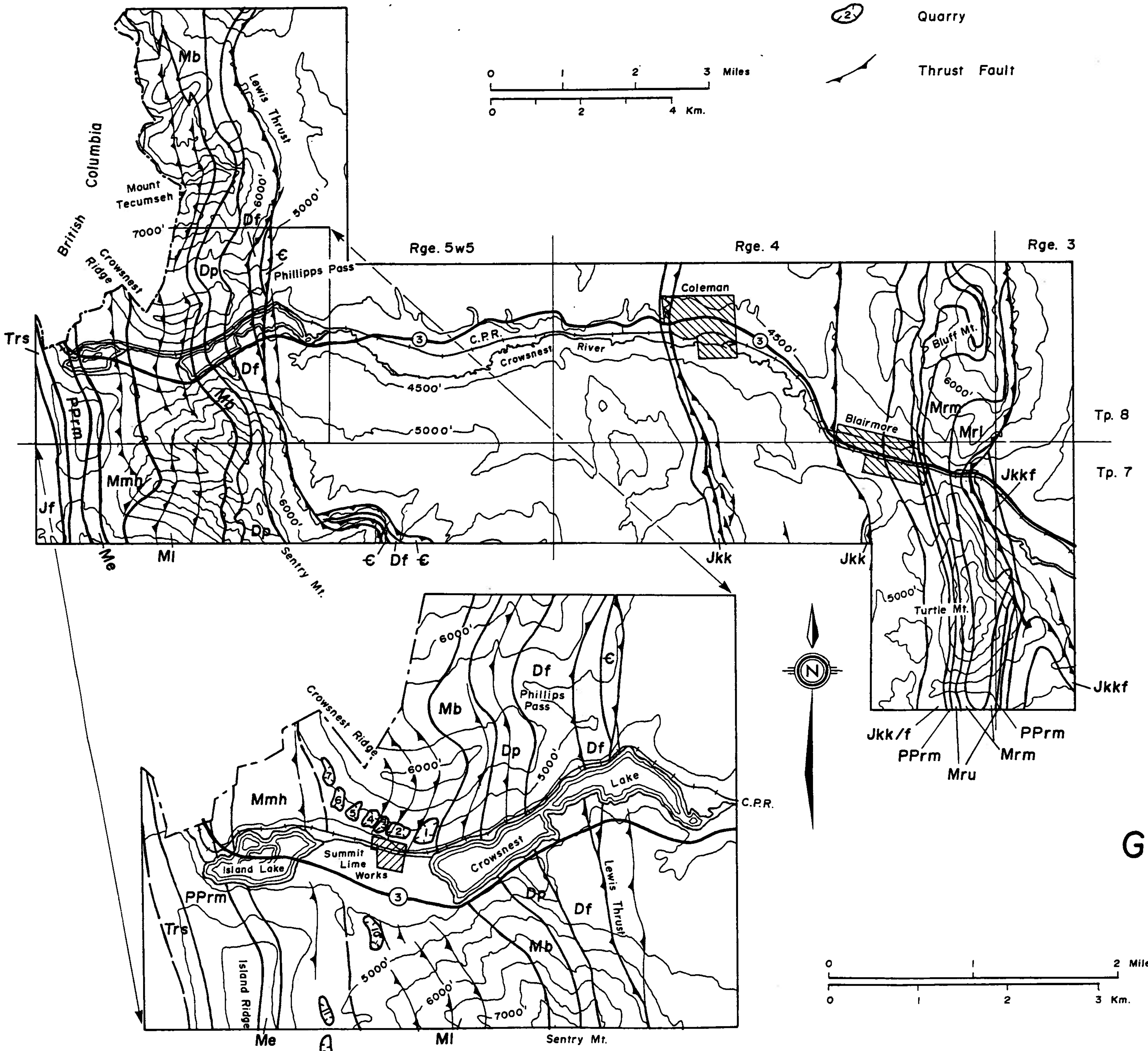

Jkk/f	Jurassic/Cretaceous Kootenay Fm., Jurassic Fernie Group
Trs	Triassic Spray River Fm.
PPrm	Pennsylvanian and Permian Rocky Mountain Fm.
Me	Mississippian Rundle Group / Etherington Fm.
Mmh	Mississippian Mount Head Fm.
Ml	Mississippian Livingstone Fm.
Mb	Mississippian Banff Fm.
Dp	Devonian Palliser Fm.
Df	Devonian Fairholme Group and Alexo Fm.
€	Cambrian Flathead / Elko Fm.

FIGURE 5-2

Geology of the Crowsnest Corridor

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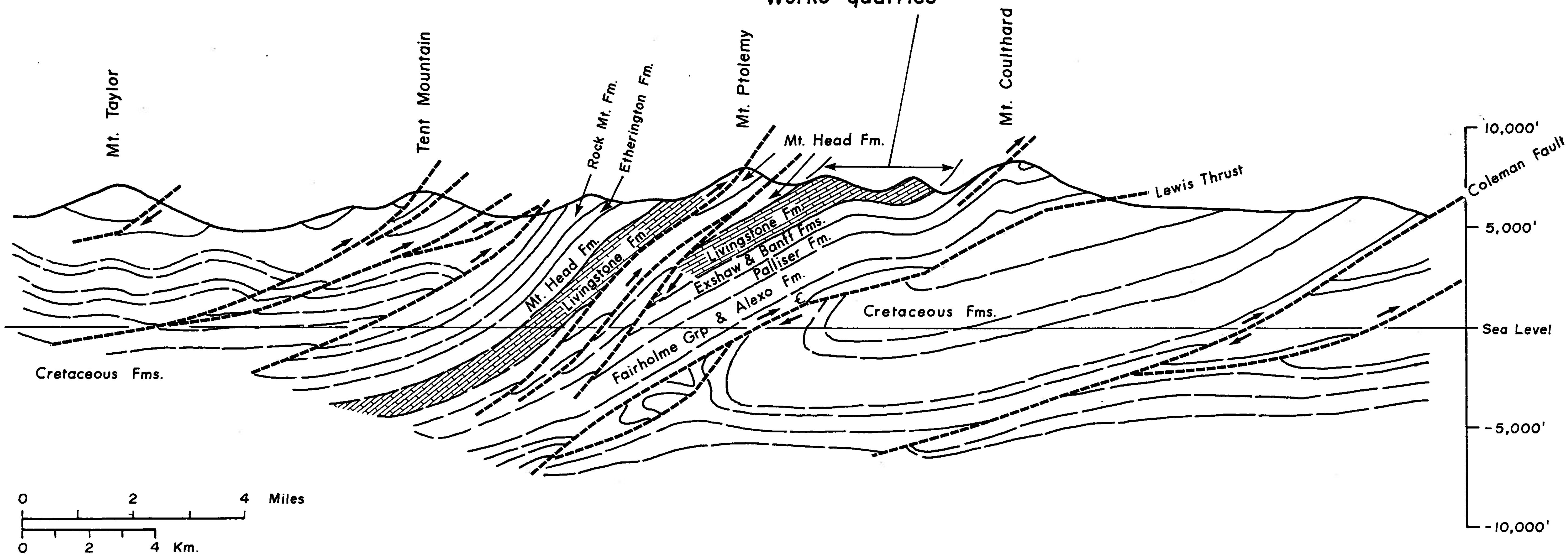

FIGURE 5-3

Cross Section adjacent to the Crowsnest Corridor

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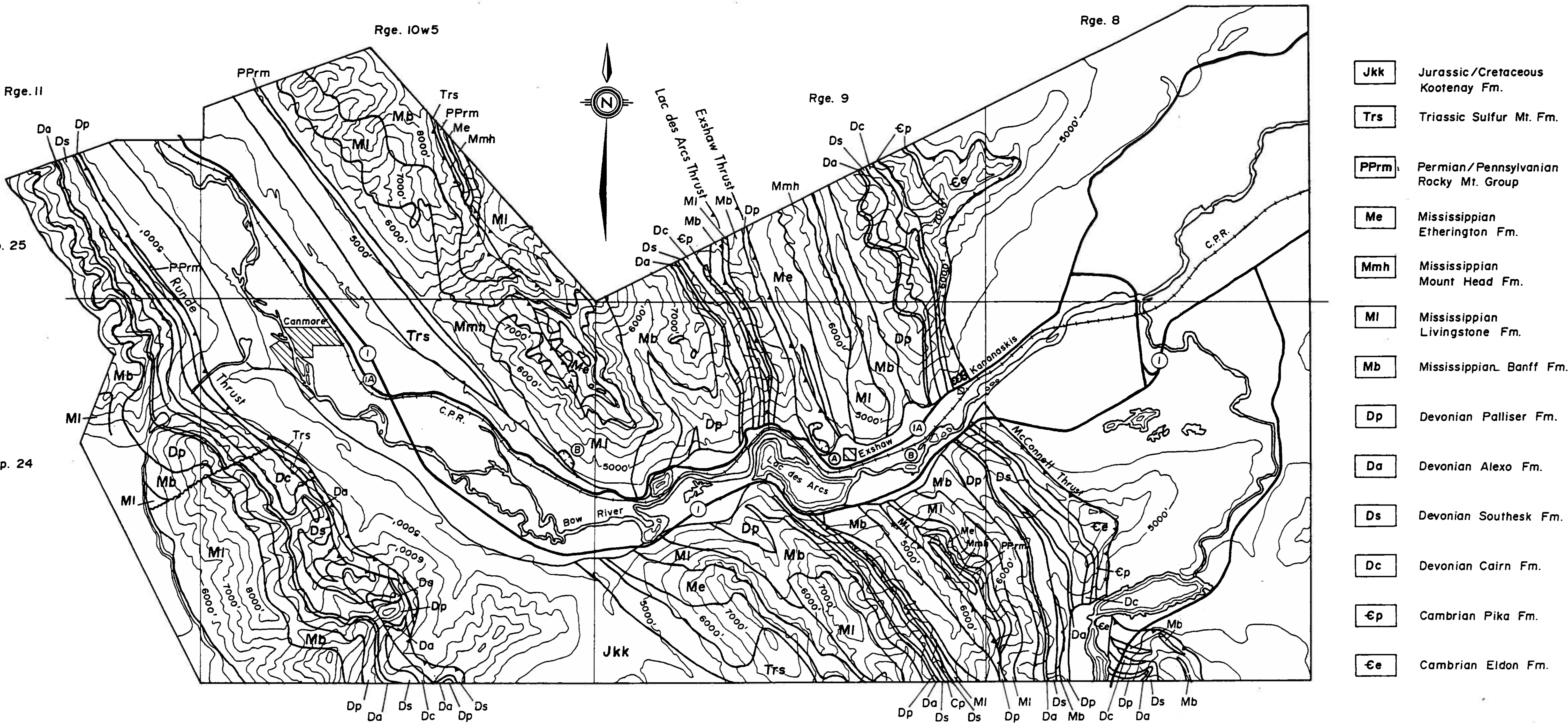

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0 1 2 3 Miles

0 1 2 3 4 Km.

(A) Lafarge Canada Inc.

(B) Continental Lime Ltd.

Quarry

Thrust fault

FIGURE 5-4

Geology of the Bow Corridor

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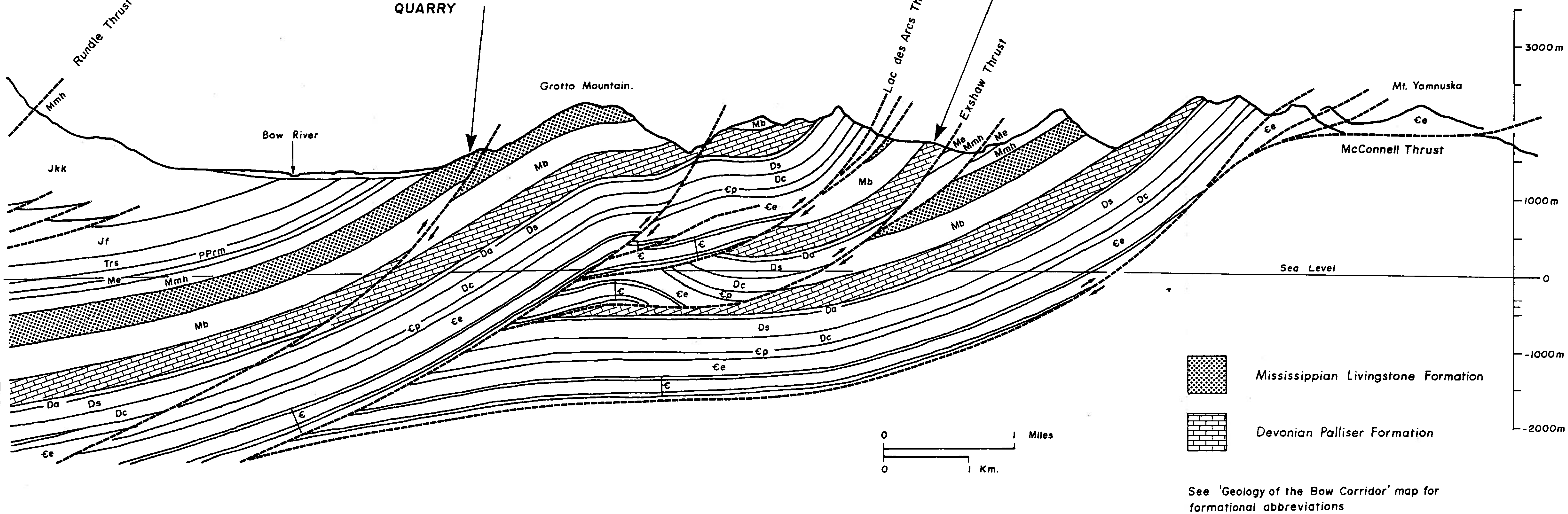

FIGURE 5-5

Cross Section Across The Bow River Corridor

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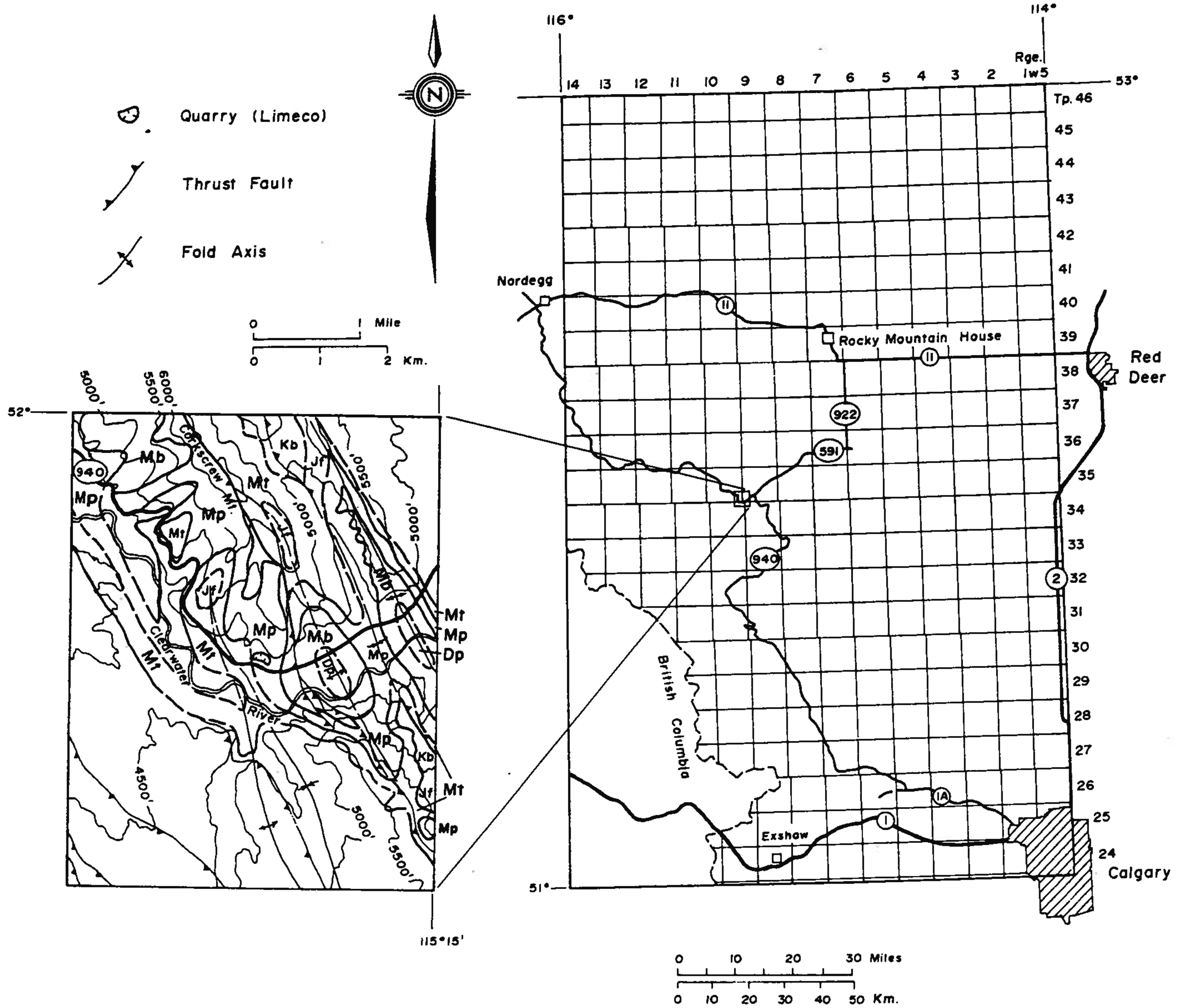
FIGURE 5-5



LOWER CRETACEOUS

| Kb | Blairmore Group |

JURASSIC

| Jf | Fernie Group |

MISSISSIPPIAN

Mt	Turner Valley and Mount Head Fms.
Mp	Pekisko and Shunda Fms.
Mb	Banff and Exshaw Fms.

DEVONIAN

| Dp | Palliser Fm. |

FIGURE 5-6

Geology of the Corkscrew Mountain Area

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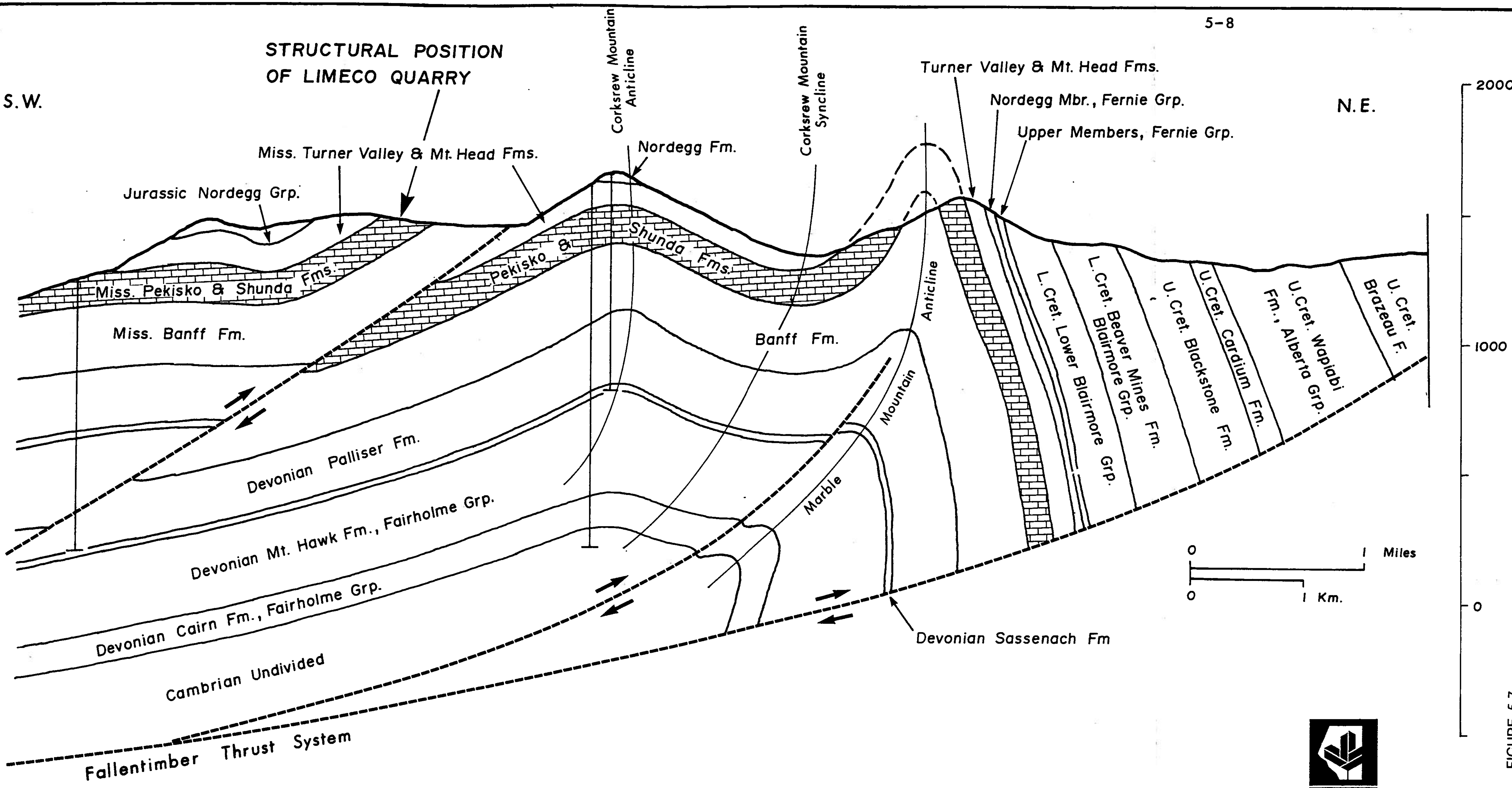

FIGURE 5-7

Cross Section of the Corkscrew Mountain Area

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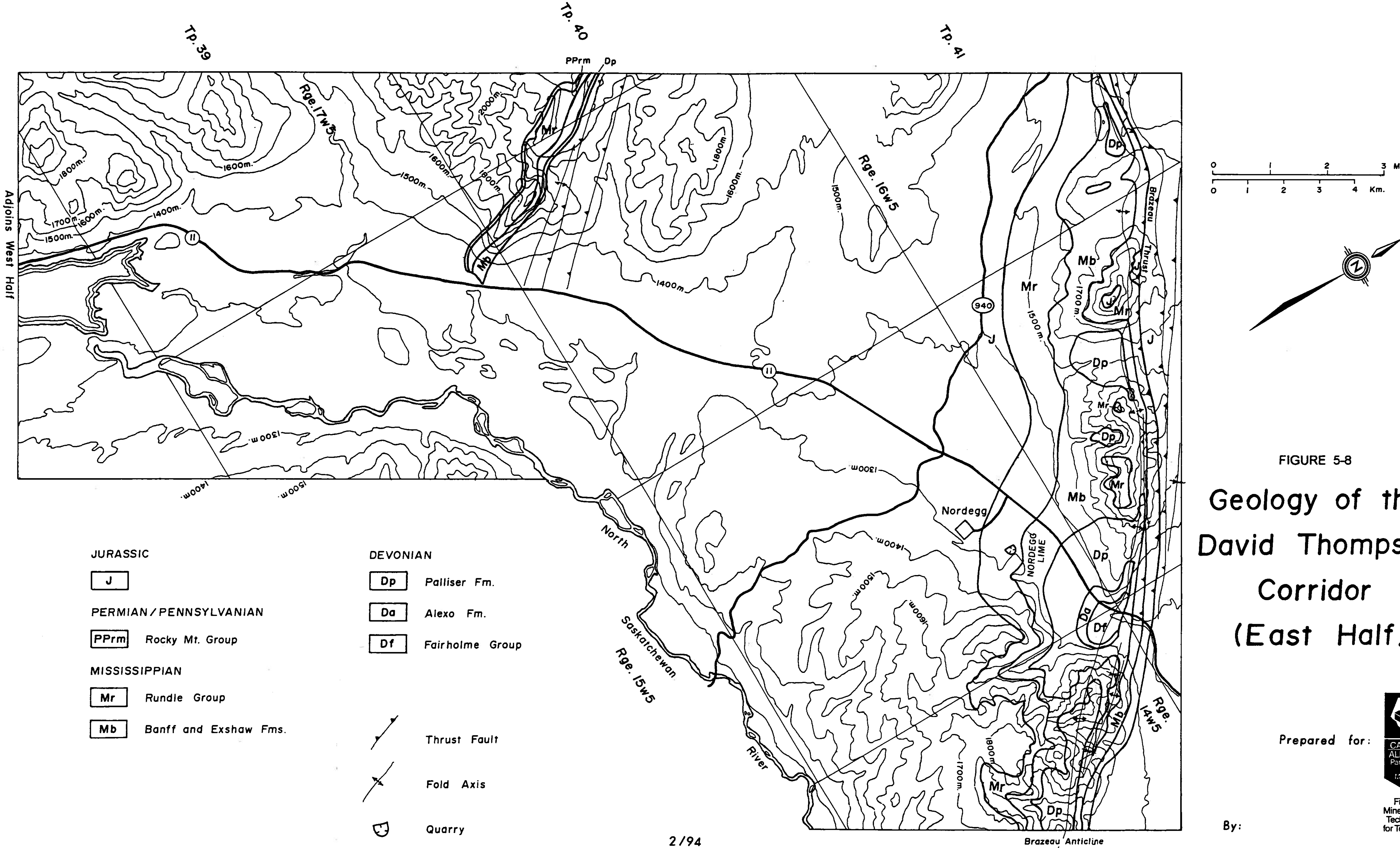

FIGURE 5-8

Geology of the David Thompson Corridor (East Half)

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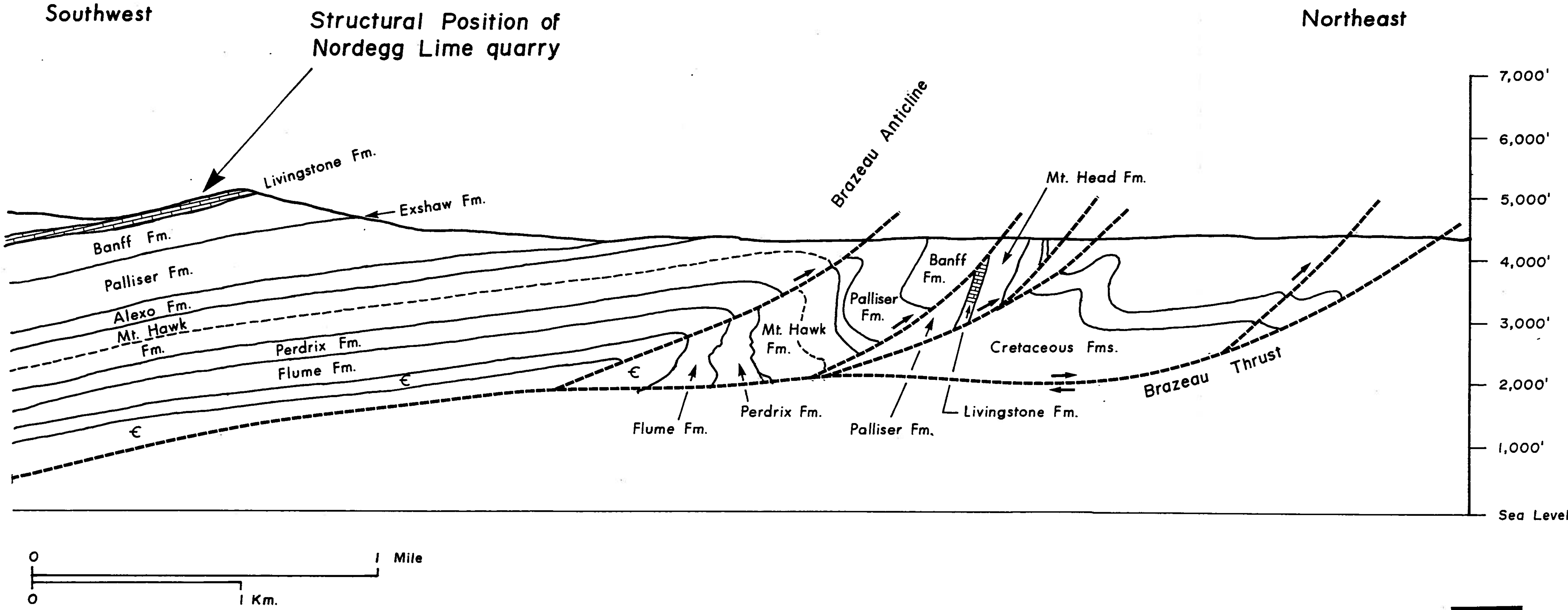

FIGURE 5-9

Cross Section of the Nordegg Area

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Minerals

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FIGURE 5-9

2/94

By:

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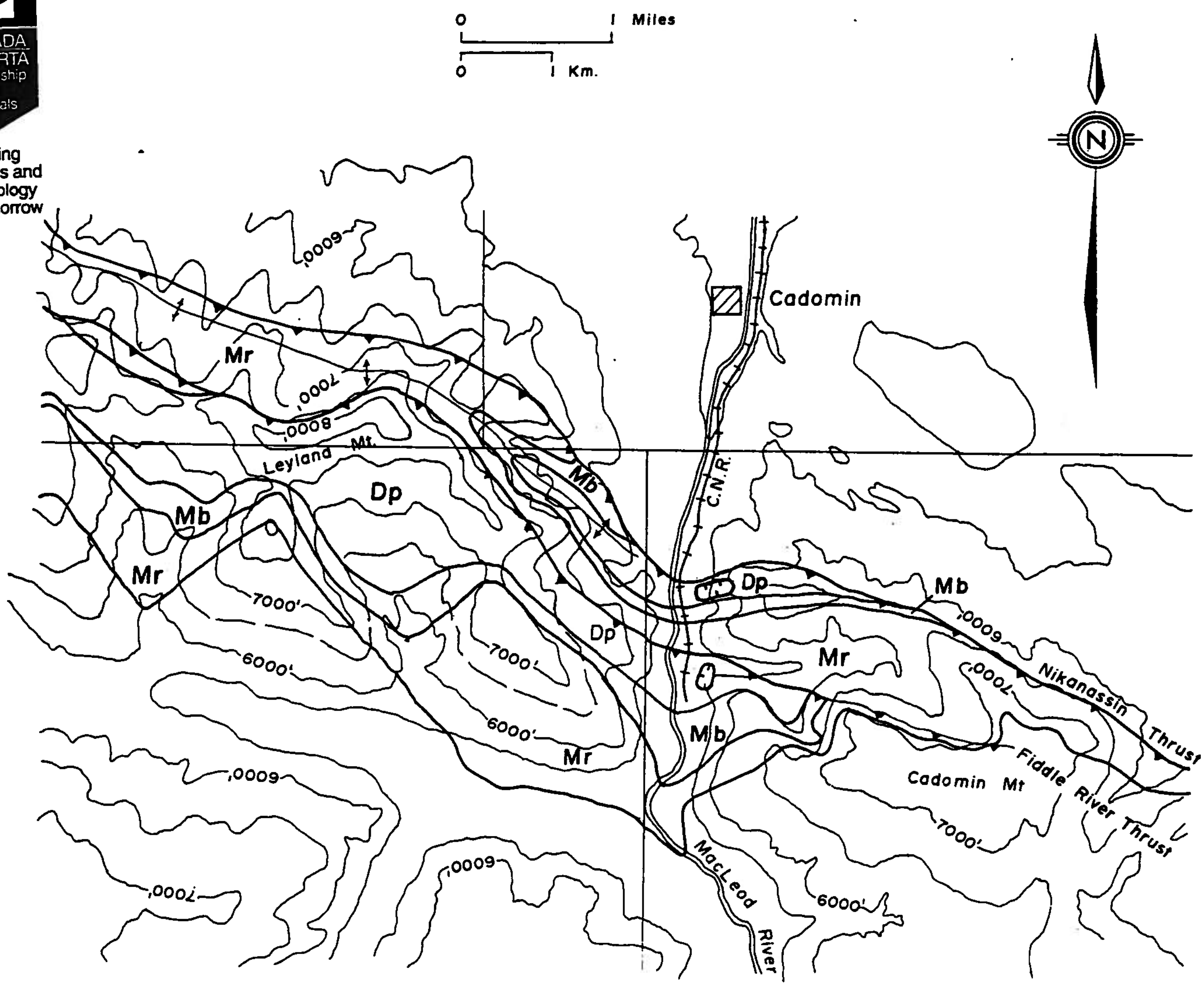

MISSISSIPPIAN

Mr — Rundle Group

Mb — Banff and Exshaw Fms.

DEVONIAN

Dp — Palliser Fm.

Quarry (Inland Cement)

Thrust Fault

Fold Axis

FIGURE 5-10

Geology of the Cadomin Area

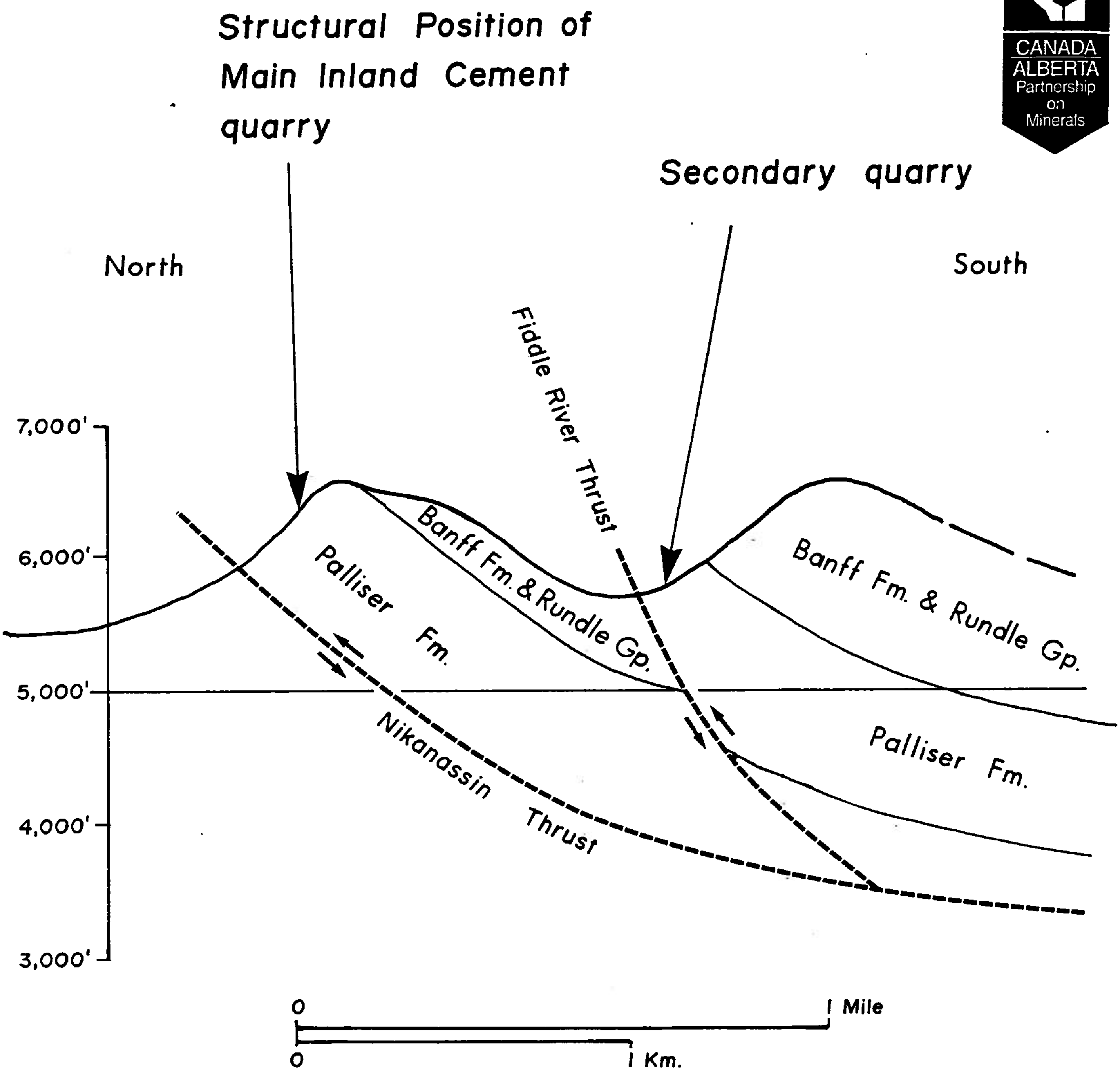

FIGURE 5-11

Cross Section of the Cadomin Area

2/94

6. ALBERTA LIMESTONE OPERATORS

A. SUMMIT LIME WORKS

The Summit Lime Works has a long history of operations as testified by the extensive development of quarries in the area (see Figure 6-1). All but three have been opened in strata of the Missippian Livingstone Formation, the exceptions being quarries 8, 11 and 12 which were established within the Missippian Mount Head Formation. Goudge (1946) includes extensive data on the early efforts at this site. The facilities were recently upgraded with the construction of new vertical kilns. Ownership and management has been assumed by Continental Lime.

Price (1961 has characterized the beds as being comprised of light grey skeletal calcarenites and calcarenitic limestones, cherty limestones, and dolomites.

Only limited information is available to the writer on the details of quarry and plant operations, products manufactured, and distribution to markets. The site was not visited in recent months and time constraints on the reporting has not allowed for solicited information to be returned by Continental Lime to date. Additional investigations of the area in more recent years have been reported on by MacDonald and Hamilton (1981).

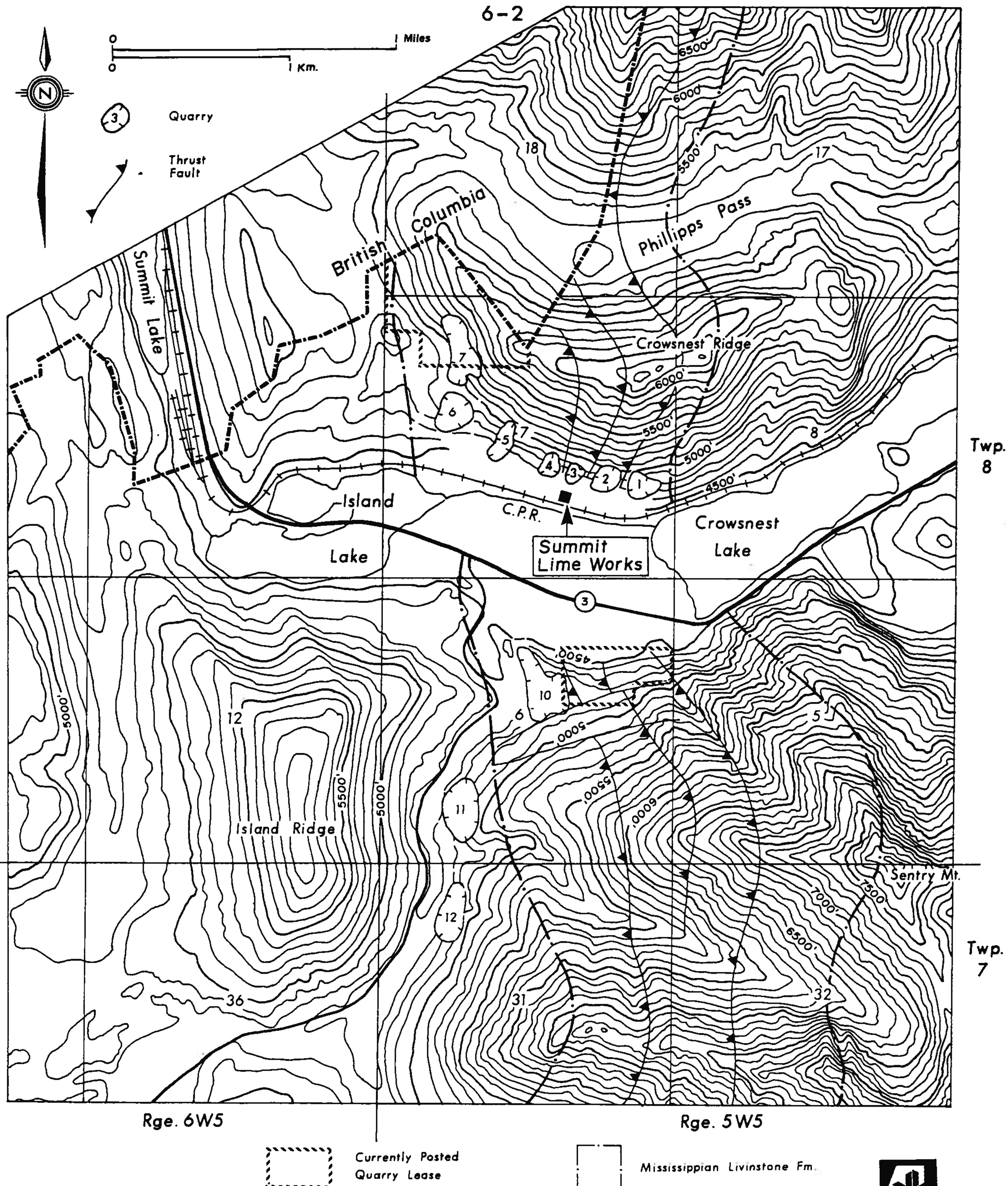

FIGURE 6-1

Area of Summit Lime Works Operations

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B. LAFARGE CANADA OPERATIONS

Quarry operations at Exshaw began as early as about 1907 and various modifications and upgradings of facilities over the years have resulted in approximately one million tonnes of rock now being mined per year with an annual cement production capacity of 1.2 million tonnes. The local topography and general site conditions are shown in Figure 6-2.

Rock is extracted from the Palliser Formation from five of the seven different litholo-chemical units locally represented. The general layout of the quarry as documented in 1991 is shown in Figure 6-3 and one cross section at the north end of the quarry (Figure 6-4, Section 5 of Lafarge) aptly demonstrates the stratigraphy and structural controls. The entire Formation is about 250 metres thick in the area and is typically composed of light to dark grey, medium to masssive bedded, finely crystalline limestone, mottled in part by dolomite. The limestone strata are interbedded in places with grey and brown grey, finely crystalline dolomite. Detailed stratigraphy of the the entire succession exposed at the quarry is provided in Table 6-1.

Lafarge geological staff recognize three structural blocks within the quarry, including:

a.) The Front Mountain where beds strike 135 degrees and have an average dip of about 45 degrees to the west.

b.) The Saddle, which is bound longitudinally by two transverse faults (F1 and F2). Movement of the Saddle has been to the north relative to the adjoining blocks. These faults intersect a major imbricate thrust fault (F3, indicated in the accompanying section) where transverse displacement has been decreased as a result of the interaction of the structures.

c.) The Back Mountain with slightly higher angle bedding dips (up to 50 degrees) and strike azimuths of about 140 degrees.

Documentation of the stratigraphy at the site is on the basis of 6 testholes drilled in 1951, 10 holes between 1971 to 1973, 16 in 1983, and 3 during 1985. This represents over 9,000 metres of drilling and the recovery of approximately 8,000 metres of core for analytical work of intervals that were normally established to represent 10-foot core sections.

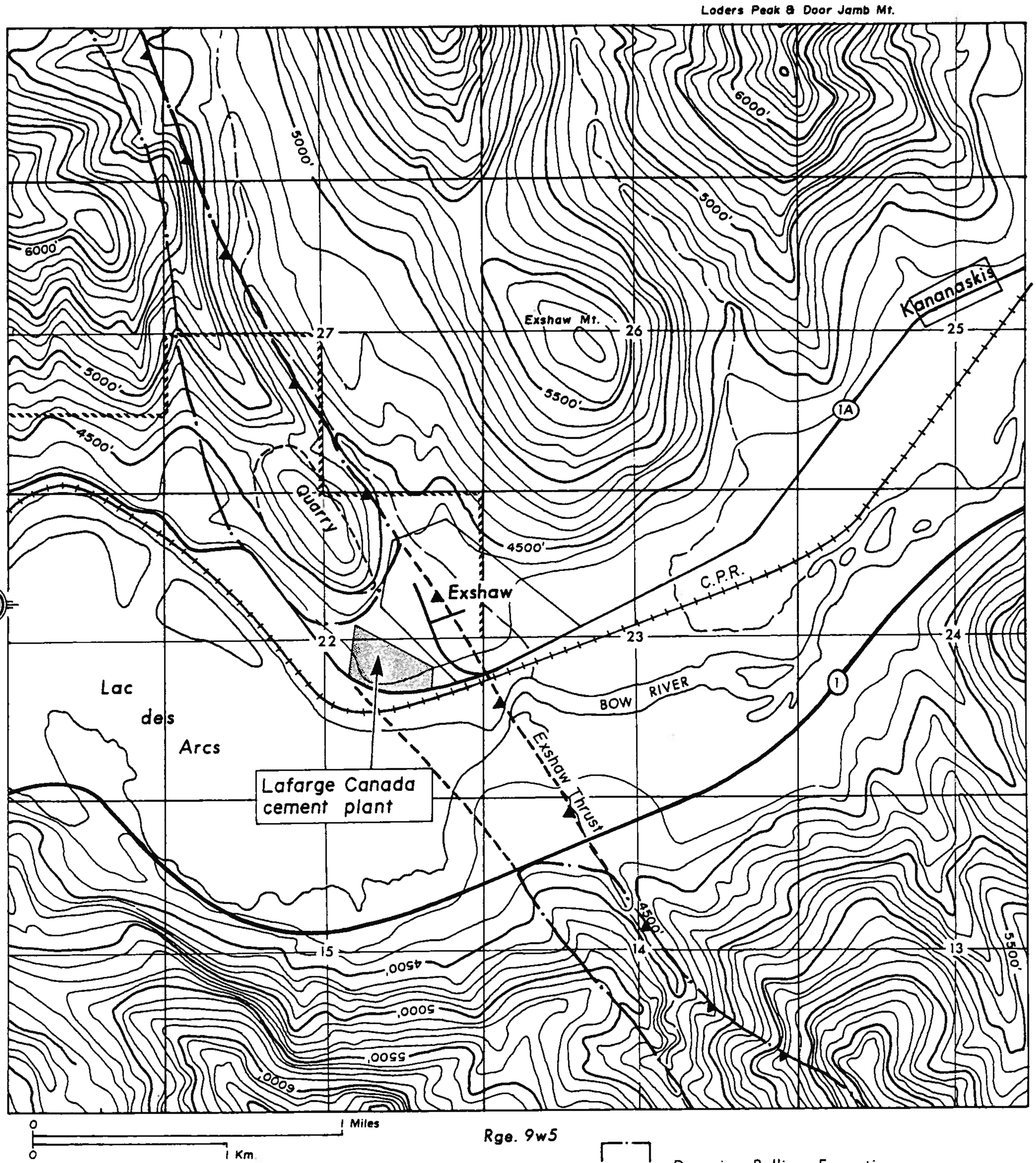
Currently rock units A, B, C, and D are mined in all three blocks of the quarry. Rock types B (low magnesium) and C (variable magnesium content) constitute the main production beds. Rock type A is a high magnesium material and is wasted. It is necessary to remove this rock to ensure a setback for the highwall. The Saddle area includes low magnesium type D rock and this is the main unit mined here, along with some type B strata.

The quarry benches have been developed parallel to the north-south strike of the beds and working faces are at right angles to this orientation. Bench heights have been established at 11 metres. Two drills are on site but only one, a rotary DM45E Ingersoll-Rand, is utlilized for preblast drilling. Vertical blast holes are drilled on a 6 metre by 6 metre grid to depths that ensure a level pit floor. The 20 cm. diameter holes are loaded with 1 inch, continuous length Prima-flex and detonations of sets are simultaneous.

Rock Unit	Estimated Thickness (metres)	Description	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	Cl-
A	?	Light brownish grey, dolomitic limestone interbedded with sandy clay beds, vugs and cavities filled with calcite crystals.	1.93	0.36	0.20	45.44	7.24	0.07	0.14	0.020	0.020
B	30	Light to dark grey, dense, weakly layered, rarely shows mottled texture.	1.09	0.33	0.15	53.11	1.52	0.07	0.15	0.020	0.014
C	98	Bluish grey mottled limestone with variable bed thickness and MgO content. MgO is mainly concentrated in lense-shaped units. Some fractures filled with calcite or red clay.	1.16	0.33	0.16	50.64	3.42	0.07	0.15	0.016	0.017
D	45	Dense, weakly layered high-calcium limestone, extremely homogeneous.	1.03	0.26	0.13	53.43	1.31	0.06	0.12	0.015	0.014
E	30	Bluish grey mottled dolomitic limestone, this unit is very compact.	1.31	0.30	0.15	48.80	5.04	0.08	0.15	0.018	0.018
F	15	High calcium limestone.					1.75				
G	30	Dolomitic limestone interbedded with shaly limestone layers.					12				

TABLE 6-1 Analyses of Rock Units in the Lafarge Canada Quarry, Exshaw

Currently Posted Quarry Lease



Devonian Palliser Formation

FIGURE 6-2

Area of Lafarge Canada Operations

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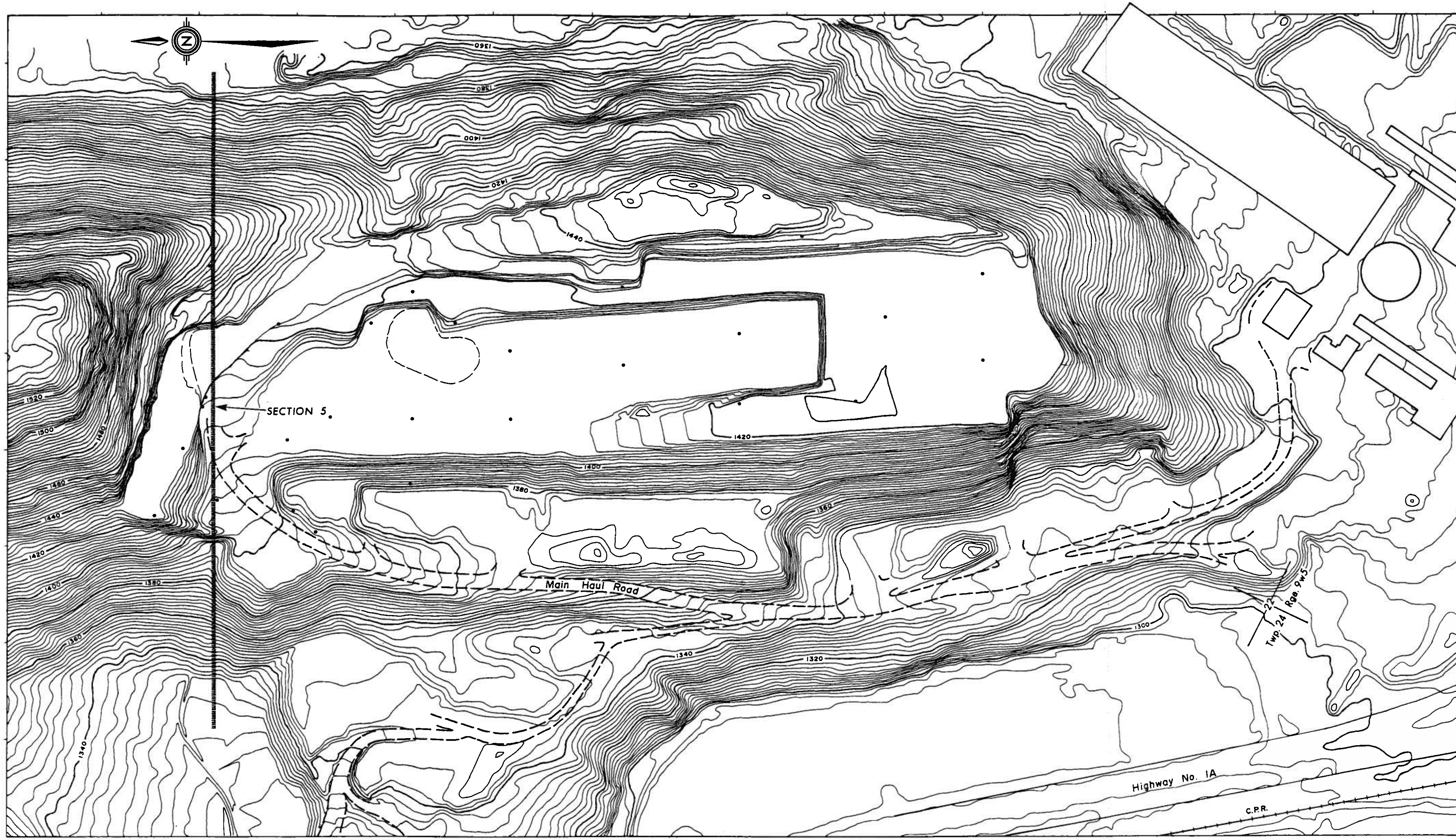

0 100 200 Metres

Contour Interval: 2 metres

• Testhole

Quarry details as of May, 1991

FIGURE 6-3

Lafarge Canada Quarry Layout

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FIGURE 6-3

SECTION 5

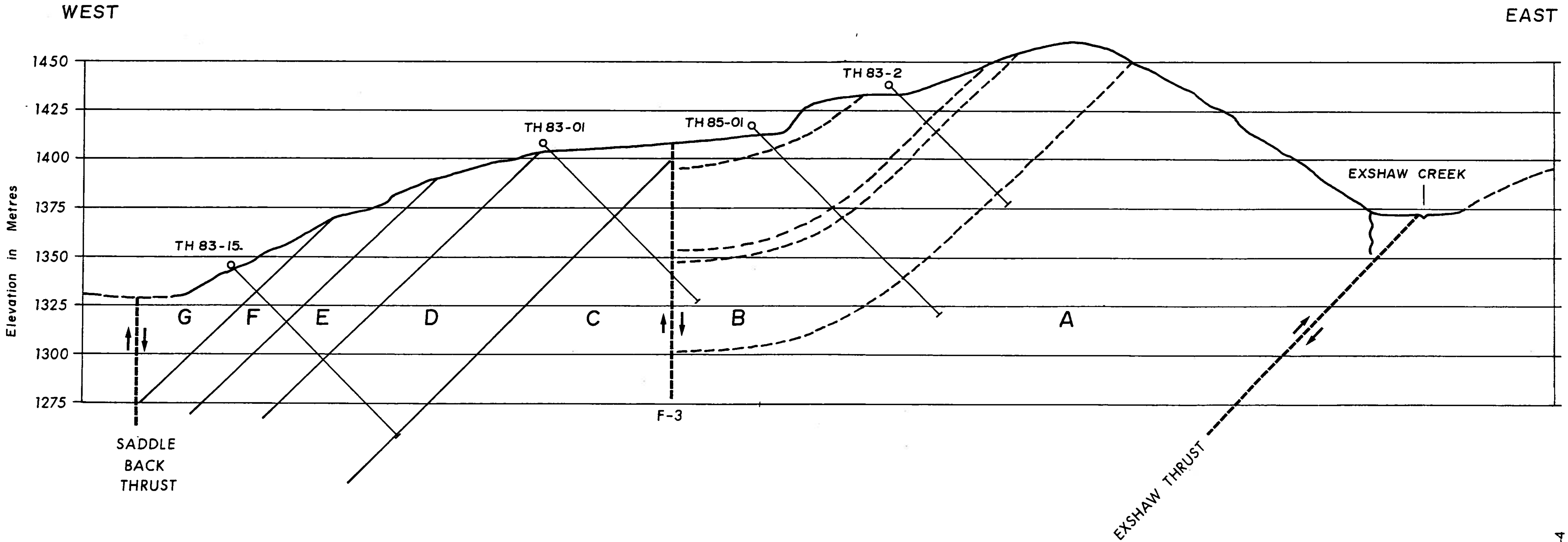

FIGURE 6-4

Cross Section through the Lafarge Quarry

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FIGURE 6-4

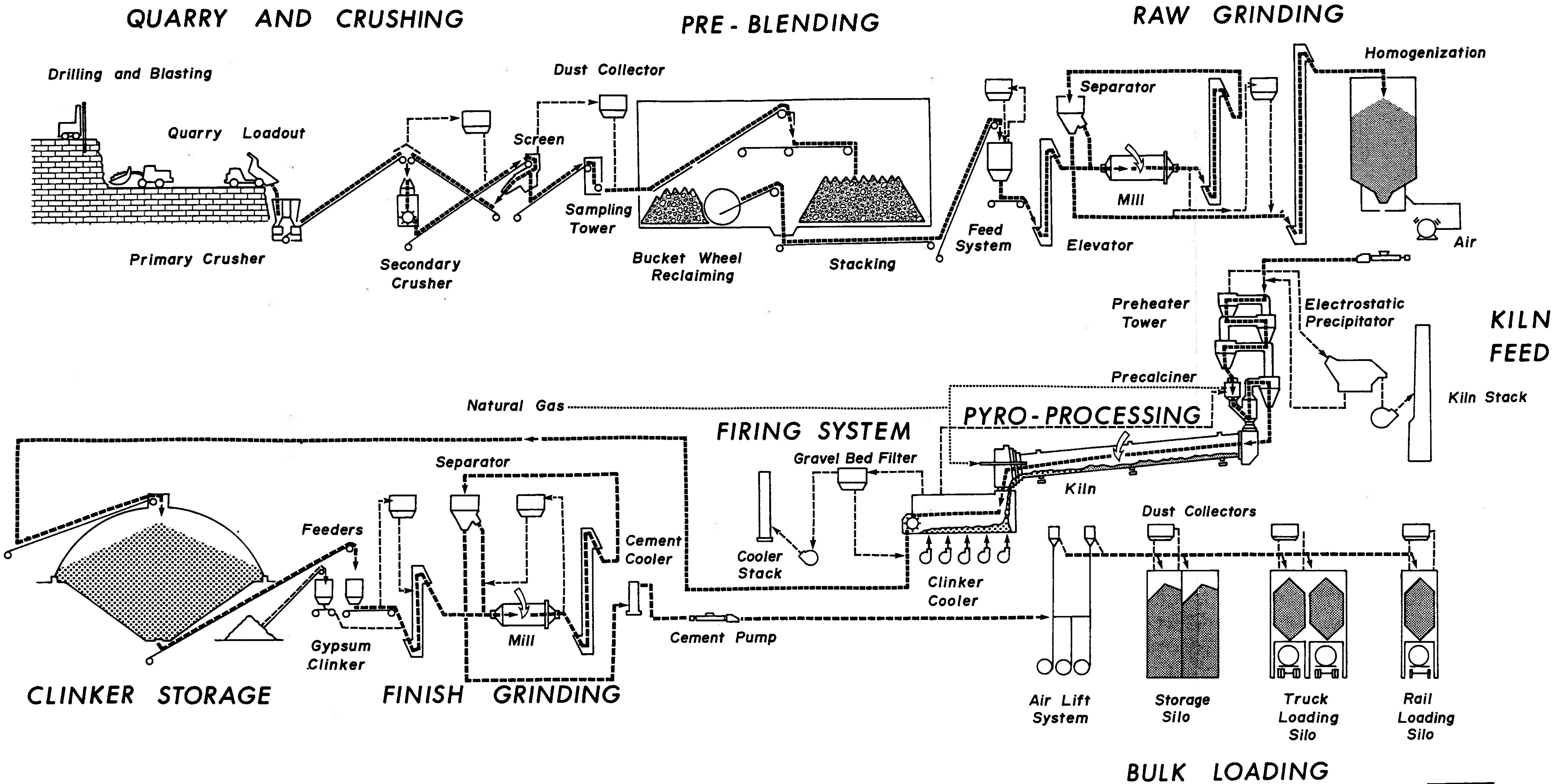

FIGURE 6-5

FIGURE 6-5

Circuitry of the Lafarge Canada Cement Plant

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C. CONTINENTAL LIME (EXSHAW) OPERATIONS

The quarry for supplying the Continental Lime operations is within beds of the Mississippian Livingston Formation at the base of Grotto Mountain (Figure 6-6). The site is approximately 12 km. west of the plant at Exshaw. The strata have a northwest strike and dip to the southwest at about 40 degrees. Chemical analyses of the quarried rock are very consistent, normally exceeding 98 percent calcium carbonate (Table 6-2). The exploited bed is about 30 metres thick and is underlain as well as overlain by strata with relatively high silica values. The quarry has been subdivided into 25 different operational levels.

The predecessors of the present plant provide a history of operations that go back as far as the 1880's. The current operations achieved its full developmental status in 1978 and has been under Continental Lime ownership since the late 1980's. The flow sheet for the plant is provided in Figure 6-7 and a clear presentation of the workings of the plant has been prepared by Edwards (1991). His description follows with only minor changes.

The rock is trucked to the plant, crushed and screened into various mesh sizes, and temporarilly stored. The fines (about 43 percent of the total) are not passed through the kiln as they tend to clog the system. The screened rock (2 by 3/4 inches) is fed by conveyors to one of two preheaters. The preheaters raise the temperature of the rock to 370 degrees Centigrade. Fans, each with a six hundred horsepower rating, purge the carbon dioxide emanations. These gases are 99 percent dust free. A given mass of material passes the preheater in about one and one half hours.

The rock is fed to the kilns, where calcination takes place. Each kiln has a capacity of about 11.52 tonnes per hour at temperatures between 1425 and 1480 degrees Centigrade (at the combustion end) at a rotation of 75 to 84 r.p.m. The lime is tested by testing kiln samples to ensure that no unburned core is present. It takes about two hours for rock to pass through the kiln and be completely calcined.

A controller within the plant can regulate the temperature of the preheater and the kiln as well as the amount of input. He can also direct the product to be hydrated or pulverized. If the former condition is desired quicklime is first fed to a cooler system. After an hour and a half the quicklime is hydrated, then pulverized or loaded directly into railcars, trucks or bags.

The hydrated lime is produced by adding 20 percent water by volume to the quicklime and air-separated to 200 mesh to produce a dry white powder. A 104 tonne per day bagger packages the hydrated lime. The pulverized product is passed through a cyclone system and packaged with a 90 tonne per day bagger.

A limestone rock products plant was started up in 1977 and uses much of the discards from the material that cannot be supplied to the lime plant. The aggregate is heated to 120 degrees Centigrade, passed through five screens and four air separators before being loaded directly into railcars, trucks or bagged. This material is used for a variety of purposes including animal feed additives, fertilizer carriers, and roofing manufacture.

A listing of available products from the Continental plant includes:

Quicklime: Kiln Run (57.15mm minus)
Crushed (6.35mm minus)
Pulverized "Sno White" brand
Pebbled (50.80mm by 19.05mm and 19.05mm by 6.36mm)

Hydrated (Type N) Agricultural/Chemical Grade

Calcium Carbonate: No. 325
Glassrock
Minus 30, plus 60
Poultry Grit
Feed grit
Aglime
"0" Grind

Rock: 121.50mm minus (1/2" minus)
19.1mm by 6.5mm (3/4' by 1/4")
56.5mm by 9.5mm (2 1/4" by 3/8")

Overall, the biggest user of lime is the steel industry, where it is used to balance the pH of the furnaces. Other uses include water and environmental waste treatment, non-ferrous metallurgy, alkalies, pulp and paper, sugar refining, and soil stabilization. Few details of marketing and distribution are available for the Continental Lime operations due to the fact that responses were not received from project questionaires.

	Percent
CaO	55.1
MgO	0.4
SiO_2	0.7
Pb	0.008
R_2O_3	0.2
L.O.I.	43.4
$CaCO_3$	98.34
$MgCO_3$	0.84

(from Holter and Hamilton, 1989)

TABLE 6-2 Analysis of Typical Quarry Rock, Continental Lime, Exshaw

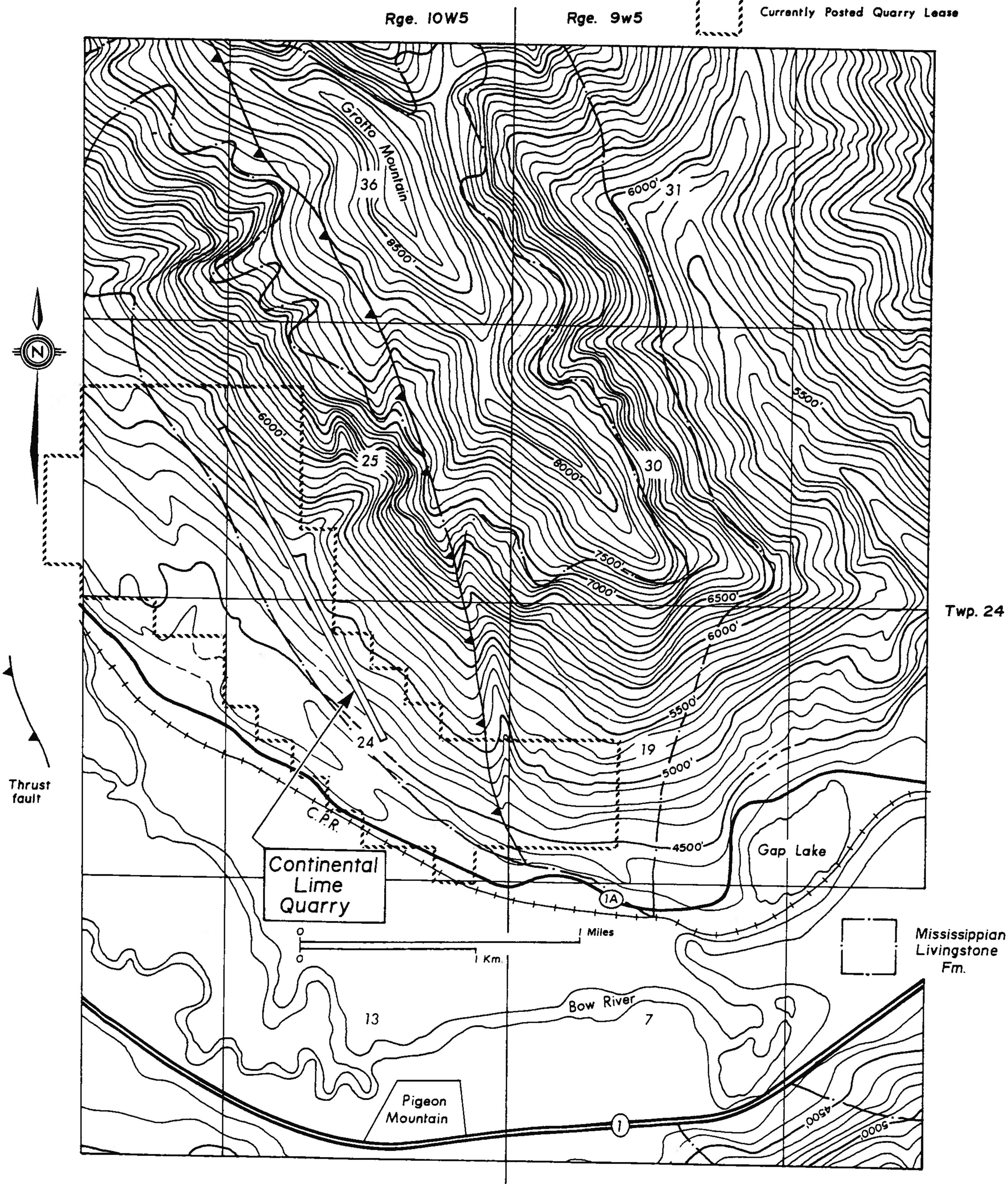

FIGURE 6-6

Area of Continental Lime Quarry

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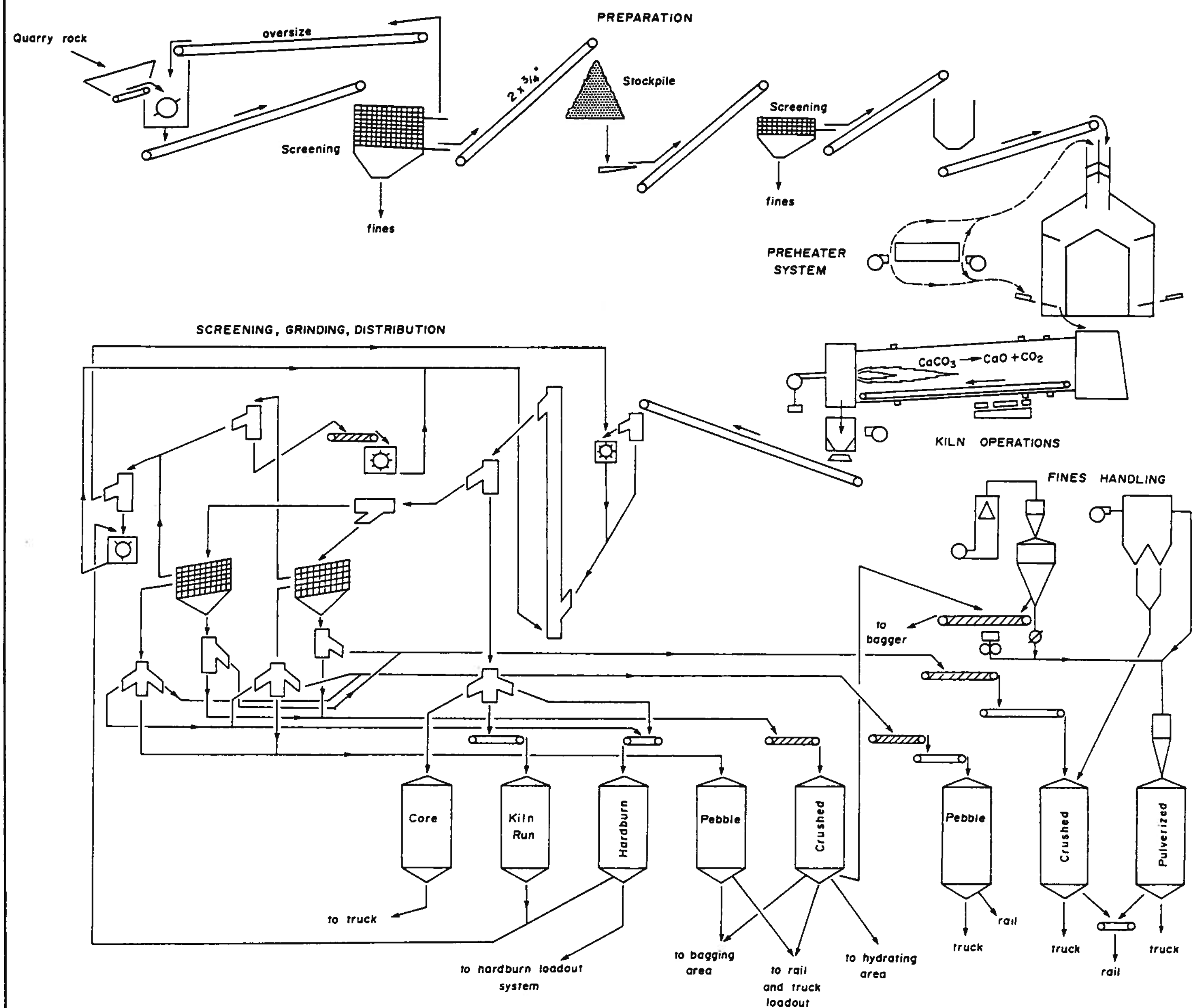

FIGURE 6-7

Continental Lime Circuitry

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D. LIMECO PRODUCTS OPERATIONS

A small quarry has been developed by Limeco products within limestone beds of the Mississippian Pekisko Formation at a location near the base of Corkscrew Mountain, southwest of Rocky Mountain House and adjacent to the Clearwater River Figure 6-8). The quarry strata occur along the western flank of the Corkscrew Anticline where they have a strike of 325 degrees and dip to the southwest at 40 degrees. The beds are comprised of light, grey-weathering, erosionally resistant, coarse-grained, crinoidal limestones. Included with this lithologic assemblage are calcarenites, oolites and local pisolites (Ollerenshaw, 1968). A considerable amount of the underlying Banff Formation has been exposed in developing the quarry and these units include thin-bedded, silty and argillaceous limestone, calcareous siltstone, dolomite, and minor crinoidal limestone.

A study of the deposit by Erdmer in 1986 established that at least one million tonnes of limestone were available for extraction at that time. The exploitable beds are at least 45 metres thick and, in the western portion of the existing quarry an exposed area of approximately one hectare ensures a large block of reserves for further development (see Figure 6-9). Relatively small tonnages have been removed from the quarry in recent years.

Drilling and blasting is carried out under contract and loadout on to trucks is accomplished by front end loader. The flow of materials throught the plant is given in Figure 6-10 and production includes fine grind limestone, ultra fine grind, glass rock (20 mesh), glass rock (40 mesh), poultry grit, and granular limestone (pelletized).

Volumes of individual product are not available but the following figures represent the total plant production for the last seven years:

1987	21,848 tonnes
1988	30,023
1989	35,426
1990	51,532
1991	30,362
1992	57,176
1993	29,593

Bulk loading ffrom the storage silos is directly to trucks with pneumatic or closed box units. Bag loading is by forklifts directly on to flatdeck or covered semi-trailers. Approximately 88 percent of product is handled as bulk material and 12 percent is bagged.

Shipments are to destinations in central and northern Alberta, as well as to Saskatchewan. Small volumes are directed to British Columbia and the United States.

	Percent		
	Quarry Sample	At Crusher	Powder
$CaCO_3$	98.25	96.48	95.41
SiO_2		0.49	0.98
Fe_2O_3		0.09	0.10
Al_2O_3		0.19	0.23
R_2O_3	0.21		
Loss on Ignition	43.26	43.62	43.39
pH		8.30	8.45
Acid Insolubles	0.19		
CaO	55.04	54.05	53.45
MgO	0.68	0.91	1.24

TABLE 6-3 Analyses of Limestone from Limeco Products Quarry

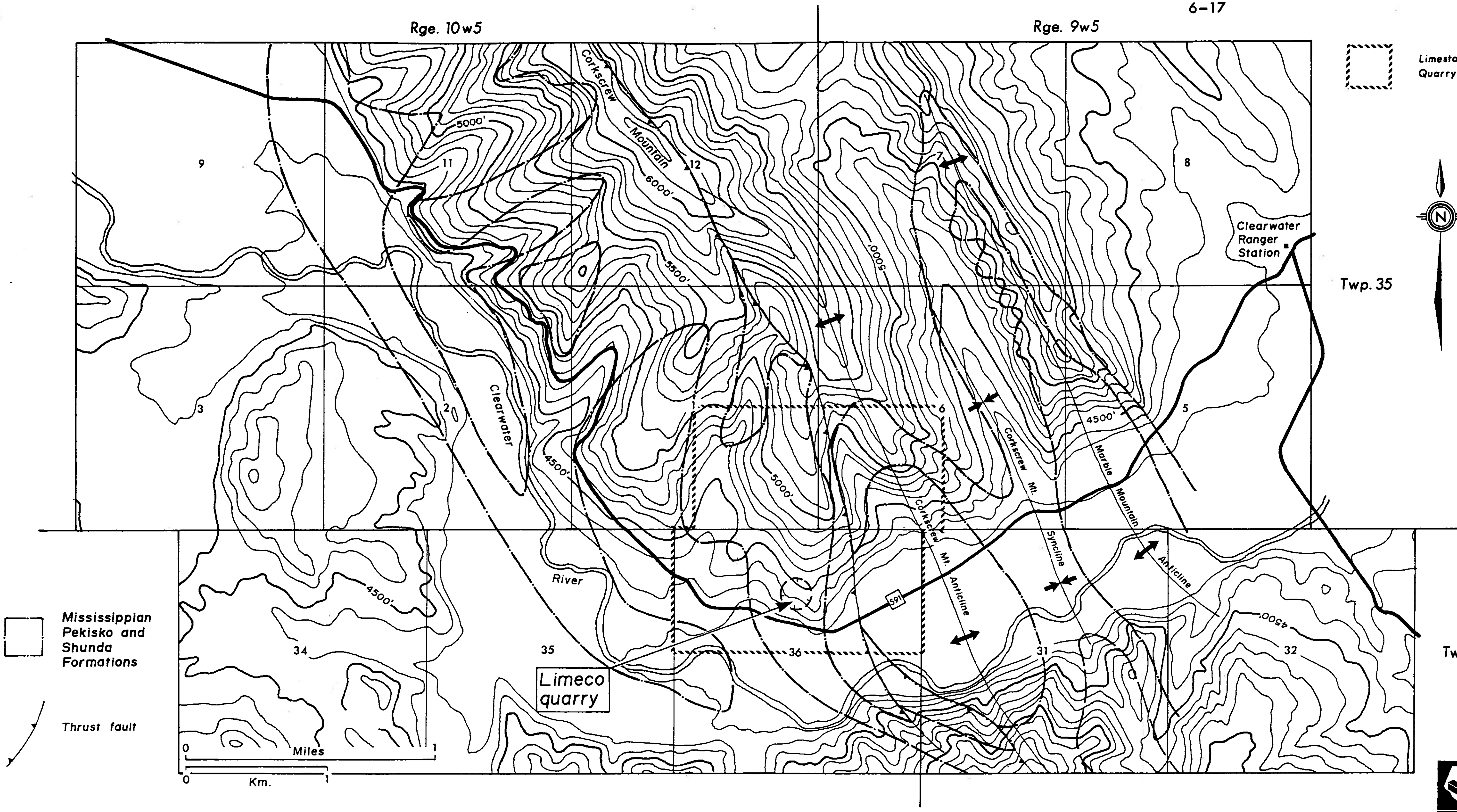

FIGURE 6-8

Area of Limeco Products Quarry

After Erdmer, 1986

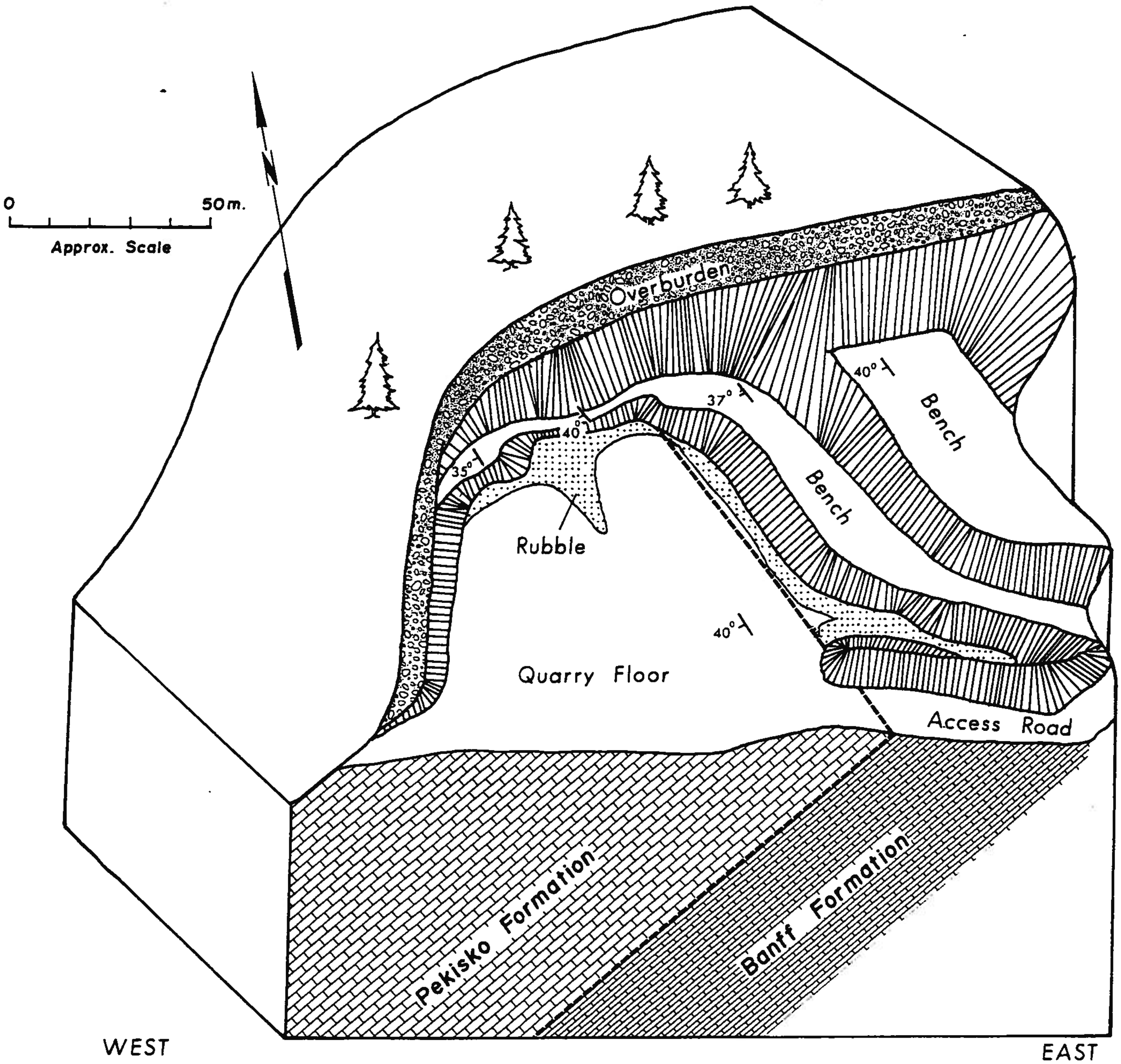

FIGURE 6-9

Block Diagram of Limeco Quarry

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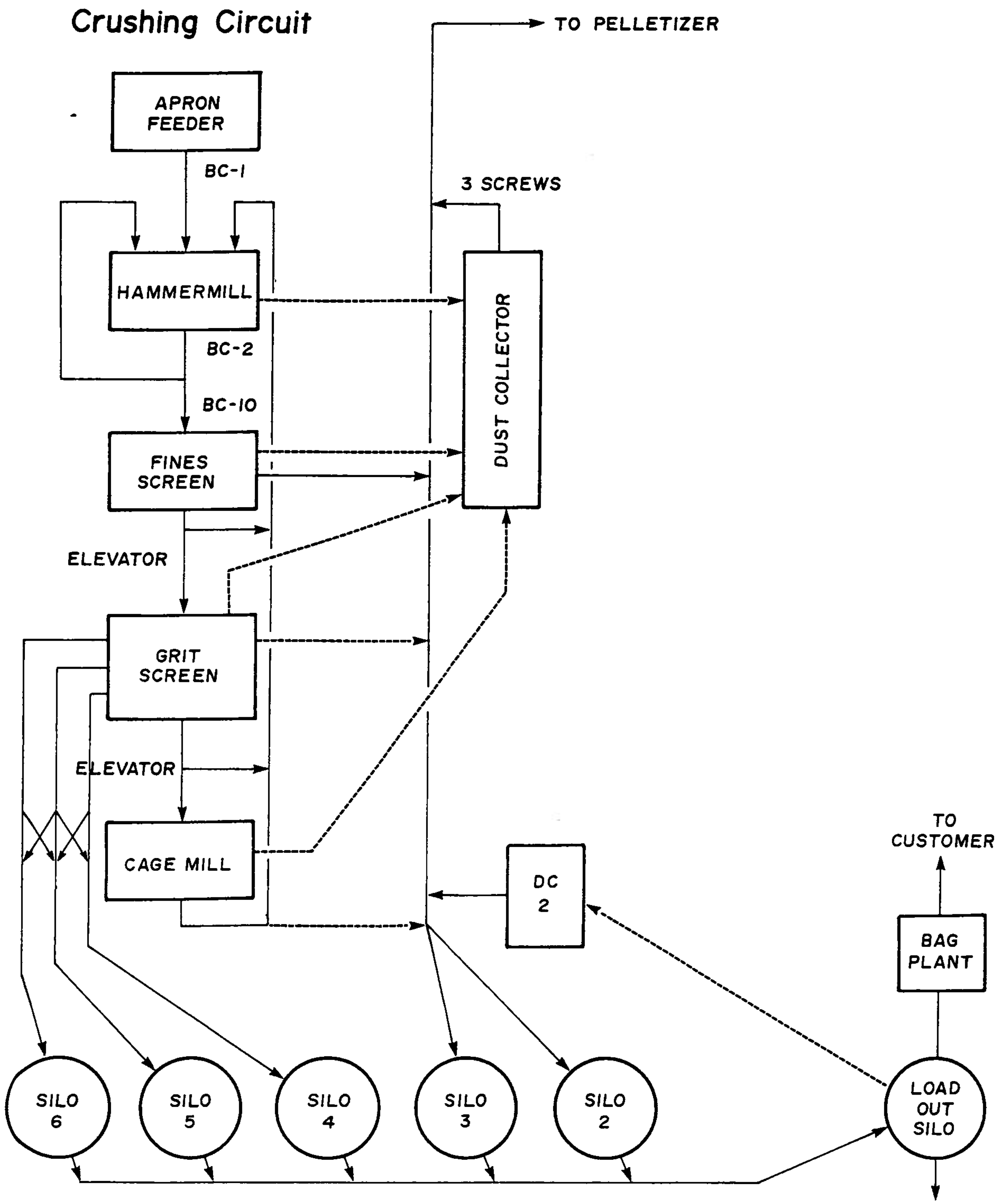

FIGURE 6-10

Limeco Products Circuitry

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E. NORDEGG LIME OPERATIONS

The quarry at Nordegg was orginally opened to provide railway ballast for the branch line of the Canadian National Railways which serviced the local coal mine (Figure 6-11). The rail line is no longer operational and the quarry rights were assumed by Western Minerals several years ago. This company was the predecessor of Westmin Resources, who now hold the leases. Nordegg Lime operates the quarry at the present time and production is from lowermost strata of the Mississippian Rundle Group within the Livingston Formation. Douglas (1956) describes the Livingstone as being massive-bedded, cliff-forming, and grey weathering. The rock is a medium to coarsely crystalline, crinoidal limestone with a local formational thickness of approximately 33 metres.

The site is located on the west flank of the Brazeau Anticline and local bedding dips are less than 15 degrees. There appear to be no major faults affecting the deposit. Investigations by Matthews (1960) established from quarry face studies and two core holes drilled in 1952, that there are three major beds immediately above the underlying Banff Formation. The uppermost unit (Bed A) is comprised of grey-weathering, dark grey to black, massive, coarse-grained limestone with a maximum thickness of about 20 metres. Due to erosion this bed is estimated to average less than half this thickness at this locality. A succession of dolomitic limestone strata, 15 to 18 metres thick, occur immediately below Bed A. Below this is Bed B which is stratigraphically very similar to Bed A.

Recent production has almost exclusively come from Bed A. Typical analyses of all three beds are provided in Table 6-3.

Matthews estimated that Bed A reserves should be in excess of 7 million tonnes.

Current production by Nordegg Lime involves drilling, blasting, and loadout directly from the face to the adjacent plant operations that crush and size the rock according to committed market requirements (see Figure 6-13). The material has seen use as rip rap, feedstock to the LImeco plant, and use in the sugar industry to date.

	Percent	
	3" by 4 1/2"	Glass Rock
$CaCO_3$	97.87	96.9
SiO_2	0.34	0.5
R_2O_3	0.07	0.1
Loss on Ignition		43.9
CaO	54.83	54.3
MgO	0.79	1.1
CO_2	43.90	

Abrasion Resistance (by Los Angeles Machine test, following ASTM C-131 Grinding A (10-40mm) specifications:

24.5% loss

TABLE 6-4 Analysis of Rock Products from Bed A, Nordegg Lime Quarry

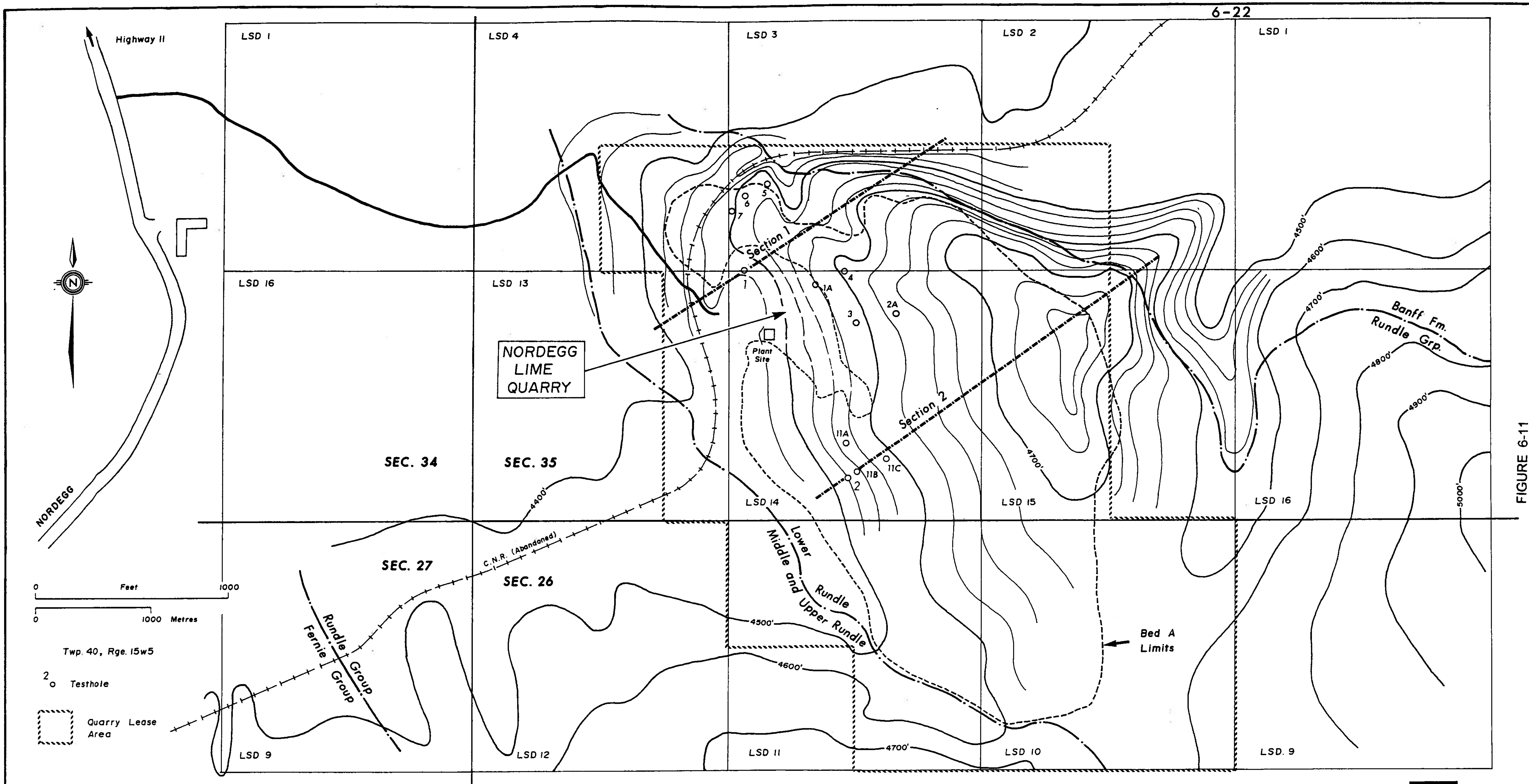

FIGURE 6-11

Area of Nordegg Lime Quarry

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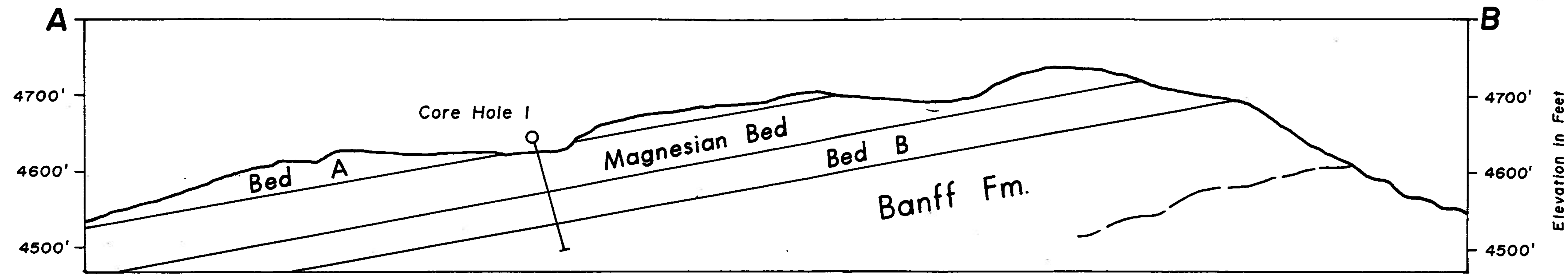
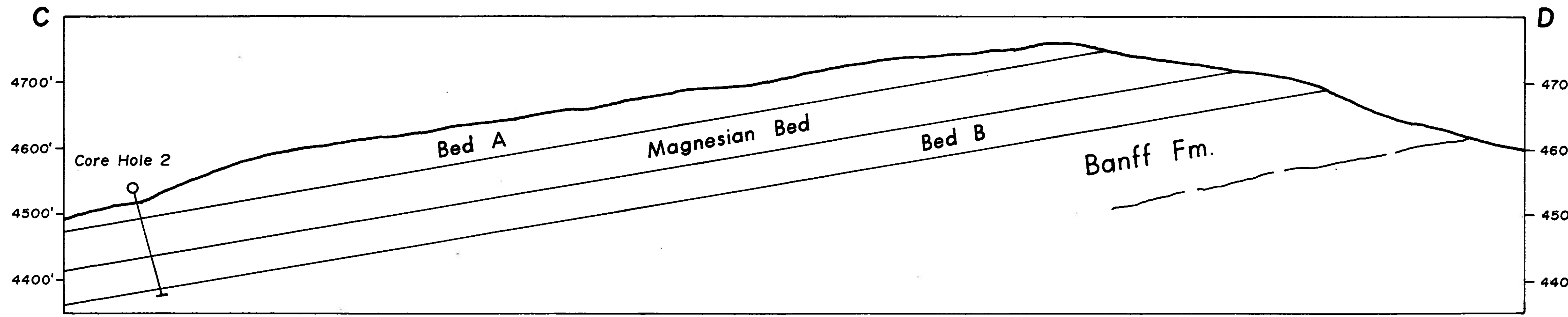


Section 1



Section 2

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FIGURE 6-12

Cross Sections of Nordegg Lime Quarry

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FIGURE 6-12

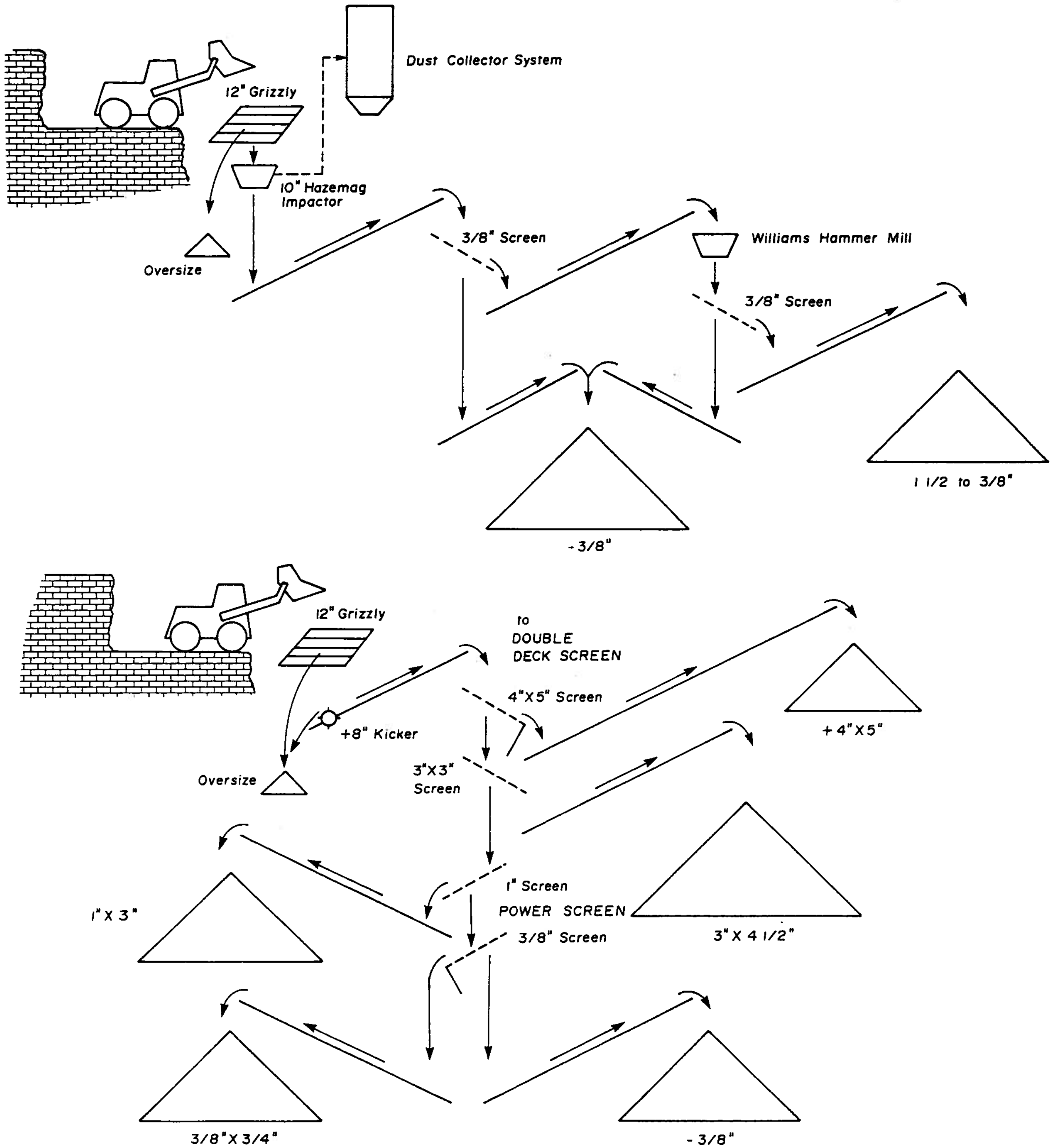

FIGURE 6-13

Nordegg Lime Circuitry

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F. INLAND CEMENT OPERATIONS

Inland Cement is unique as an Alberta limestone products manufacturer in at least one respect. The operation is the only one in the province with the quarry well removed from the plant. The facilities at Edmonton for cement-making have been in operation since 1955 and the source of limestone has been derived during that time from quarries in the Front Ranges at Cadomin, 270 kilometres to the west (Figure 6-14).

Limestone at Cadomin is quarried from the Devonian Palliser Formation which is comprised of thick-bedded, grey, fine-grained rock interbedded with dolomitic and cherty successions. The strata have been severely thrust upwards along the Nikanassin Thrust and subsequent erosion has resulted in prominent cliff faces formed by the resistant Palliser (Figure 6-15). A secondary fault, the Fiddle River Thrust, has repeated the formation further to the south in the MacLeod River valley making it possible for Inland Cement to have separate access to essentially the same rock in close proximity to the main quarry. The Devonian beds in this area dip to the west at approximately 40 degrees.

According to internal company reports five principle carbonate beds are recognized in the quarry and these are summarized in Figure 6-16. The lowermost bed, within 9 metres of the top of the the Fernie, is designated the Lower Dolomite and achieves an average thickness of approximately 6 metres. The strata above these are termed the Lower Limestone, which are about 100 metres thick. The overlying Middle Dolomite is in the range of 10 metres thick. Above this is the Middle Limestone unit which averages approximately 40 metres in thickness. At the top of this succession is the Upper Dolomite which has a variable thickness due to erosional influences but may not exceed much more than 30 metres. Several narrow horizons of high magnesia content are recorded but none appear to be laterally persistent. The quarry produces material which is typically in excess of 92 percent calcium carbonate and the magnesium carbonate contents are controlled to less than 5 percent in product shipments to the Edmonton plant. Rock has also been supplied to other sources for uses such as for rip rap.

Reserves have been calculated to exceed 70 million tonnes. In excess of 20 testholes have been drilled in the quarry area to identify stratigraphic, structural, quality, and reserve components.

Upgrading of the quarry operations in the early 1980's resulted in the development of a new ore raise and layout of production at a higher elevation on the mountain (Figure 6-17). After drilling and blasting the loading of rock is carried out by an O & K hydraulic shovel on to 32 tonne Caterpillar trucks. The benches are typically 18 metres in height and are orientated normal to the strike of the beds. The rock is dumped at the orepass at the upper quarry floor where it falls at a steep angle 270 metres to an underground Allis Chalmers 54-inch gyrator crusher. Crushed material, of less than 15 cm. diameter, can be stored in two 15,000 tonne underground storage bins and conveyed from there to a high volume, computerized rail car loading facility at valley bottom elevation. Three 80 car units (each car with a capacity of 91 tonne) are delivered to Edmonton each week.

At the Edmonton facility the limestone is stored in a 40,000 tonne capacity outdoor stockpile. The material is drawn from the pile by an underground slot discharge/plow reclaimer.

Clay from an onsite source is mixed with the limestone and these are blended by means of a radial arm stacker, then stockpiled in a 44,000 tonne storage dome (refer to Figure 6-18). This preblend is reclaimed, mixed with sand and iron oxide from additive silos and fed to a 200 tonne per hour roller mill where it is ground into kiln feed. Kiln waste gases are used for drying material in the roller mill. The kiln is currently fired by natural gas and discarded vehicle tires.

The roller mill product is then transported by bucket elevator to an impact flow meter and air-lifted to the Fuller four-stage preheat tower. From the preheater the calcined feed passes into the Fuller rotary kiln where clinker is formed. The clinker is cooled by a Fuller grate cooler and is then transported by Almund pan conveyor to clinker storage silos. From the storage silos the clinker is proportioned with gypsum and limestone and ground with three 4,500 horsepower, 75 tonne per hour Aerofall mills and one 900 horsepower, 20 tonne per hour Allis Chalmers mill. The finished product is conveyed by Fuller/Kinyon systems to the cement storage silos.

The entire circuitry is monitored and controlled through a central control room by means of a network of computers and sensors interconnected by a high speed fibre optic system.

Distribution of product is handled as both bulk and bagged shipments by rail or truck.

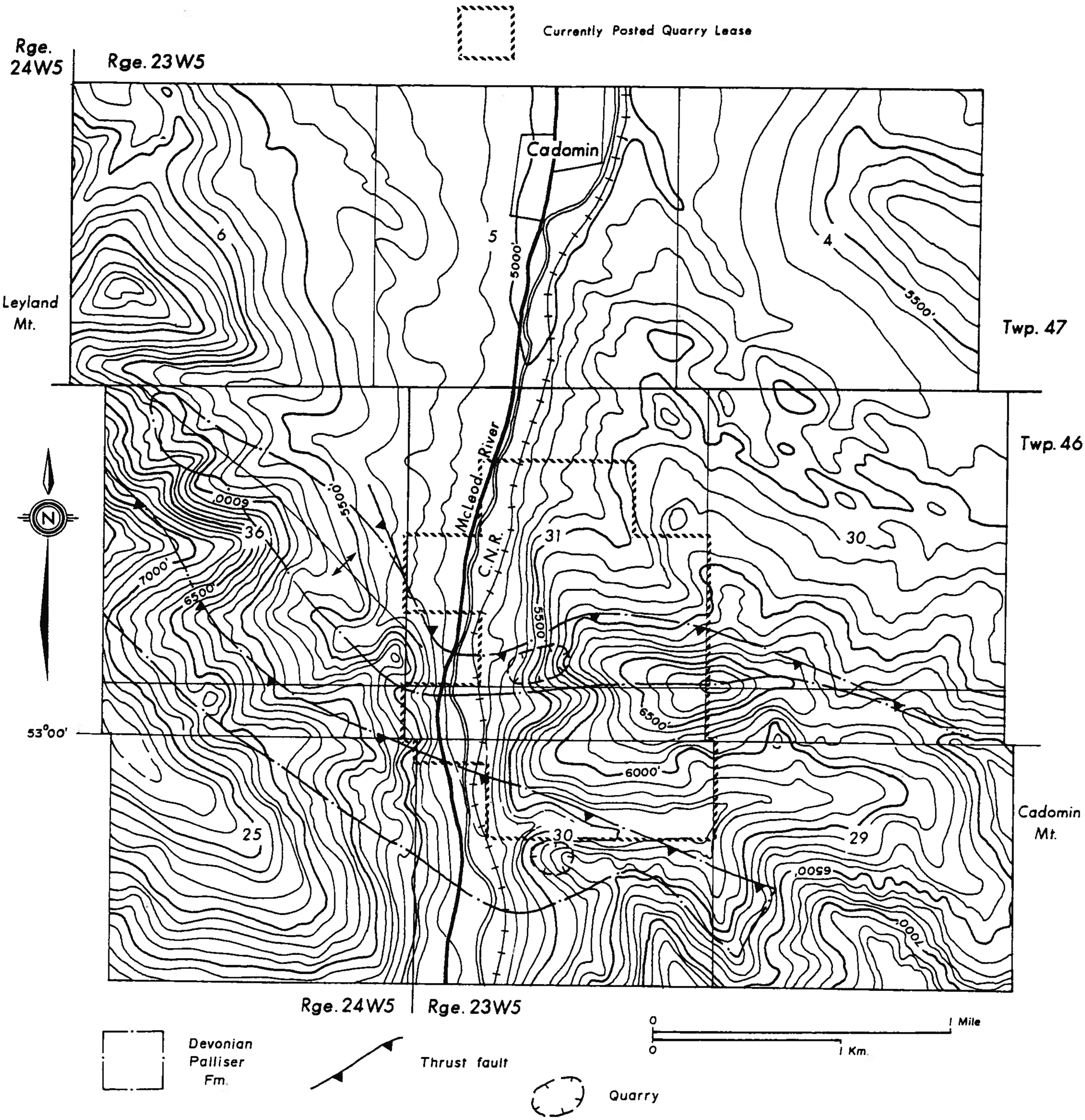

FIGURE 6-14

Area of the Inland Cement Quarry

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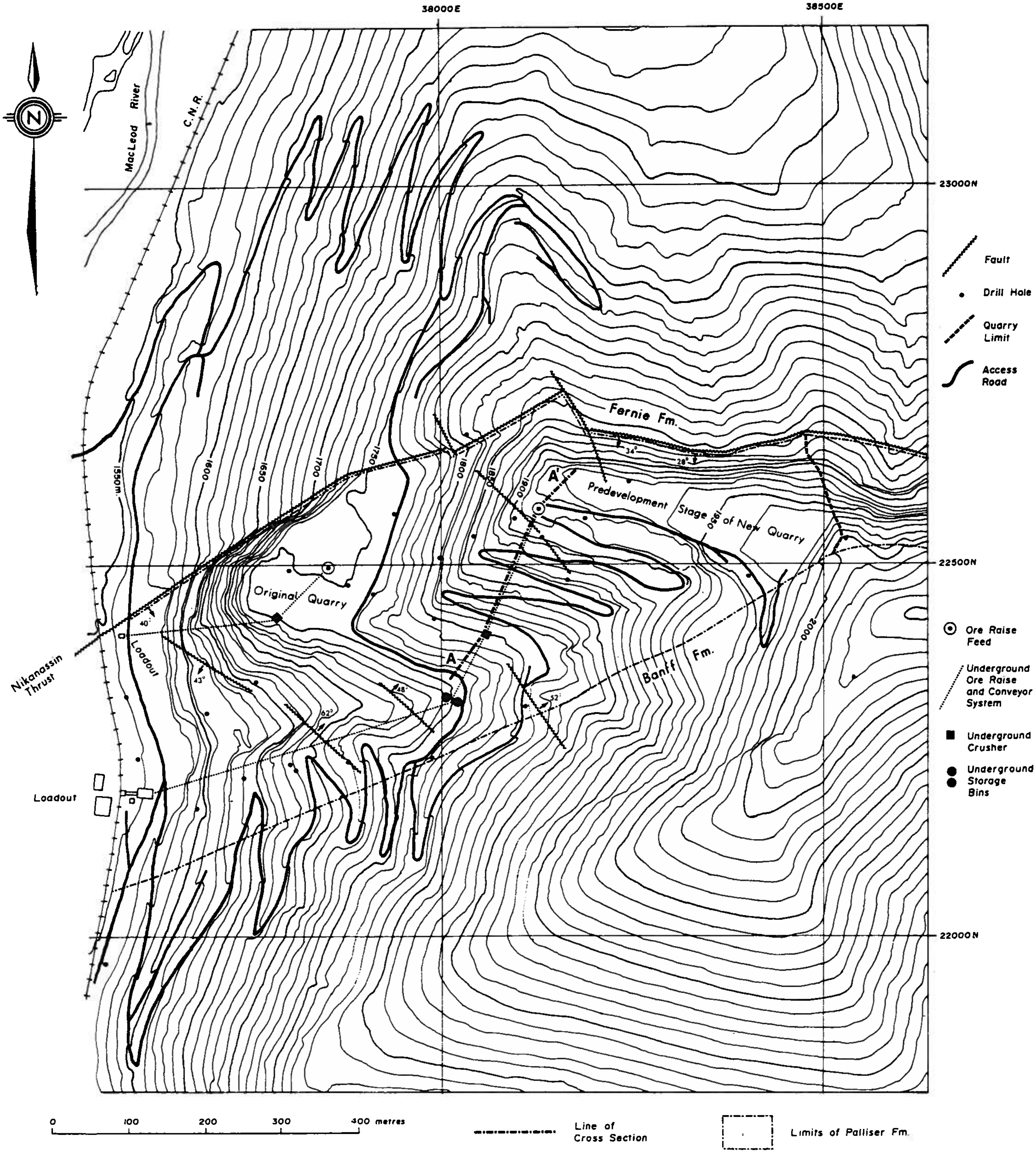

Prepared for:

FIGURE 6-15

Layout of the Inland Cement Quarry

(c. 1980)

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By:

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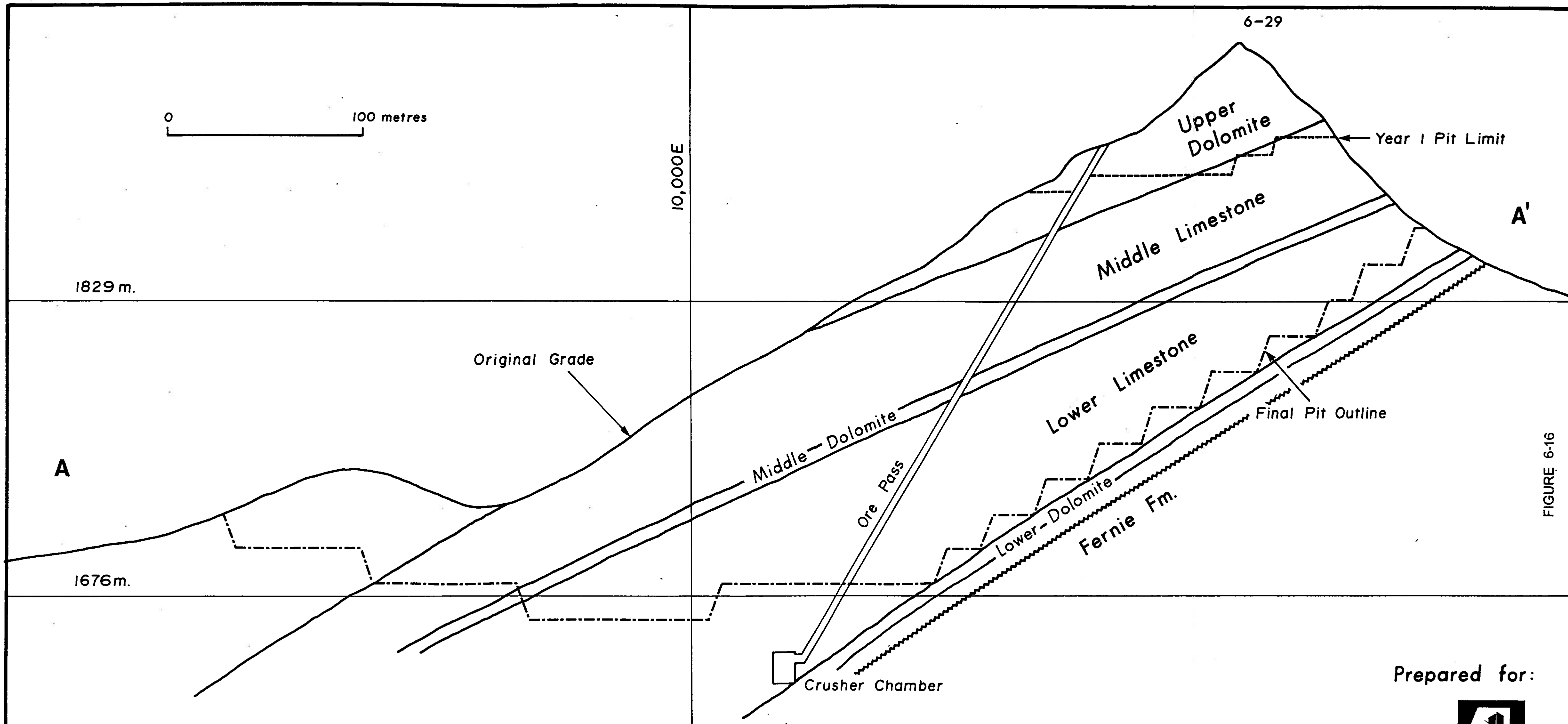

FIGURE 6-16

Cross Section of the Inland Cement Quarry

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Note: Not to scale

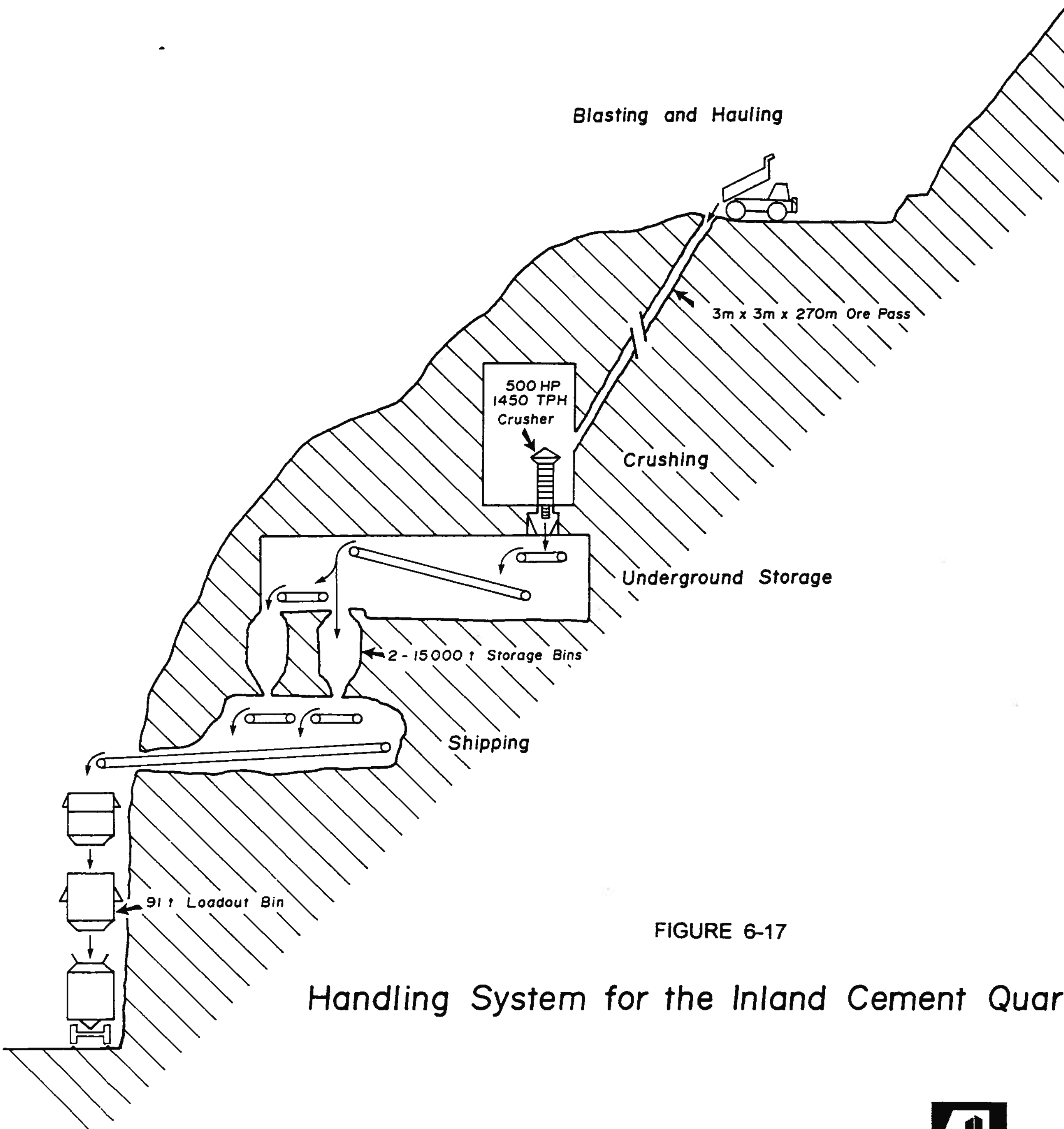

FIGURE 6-17

Handling System for the Inland Cement Quarry

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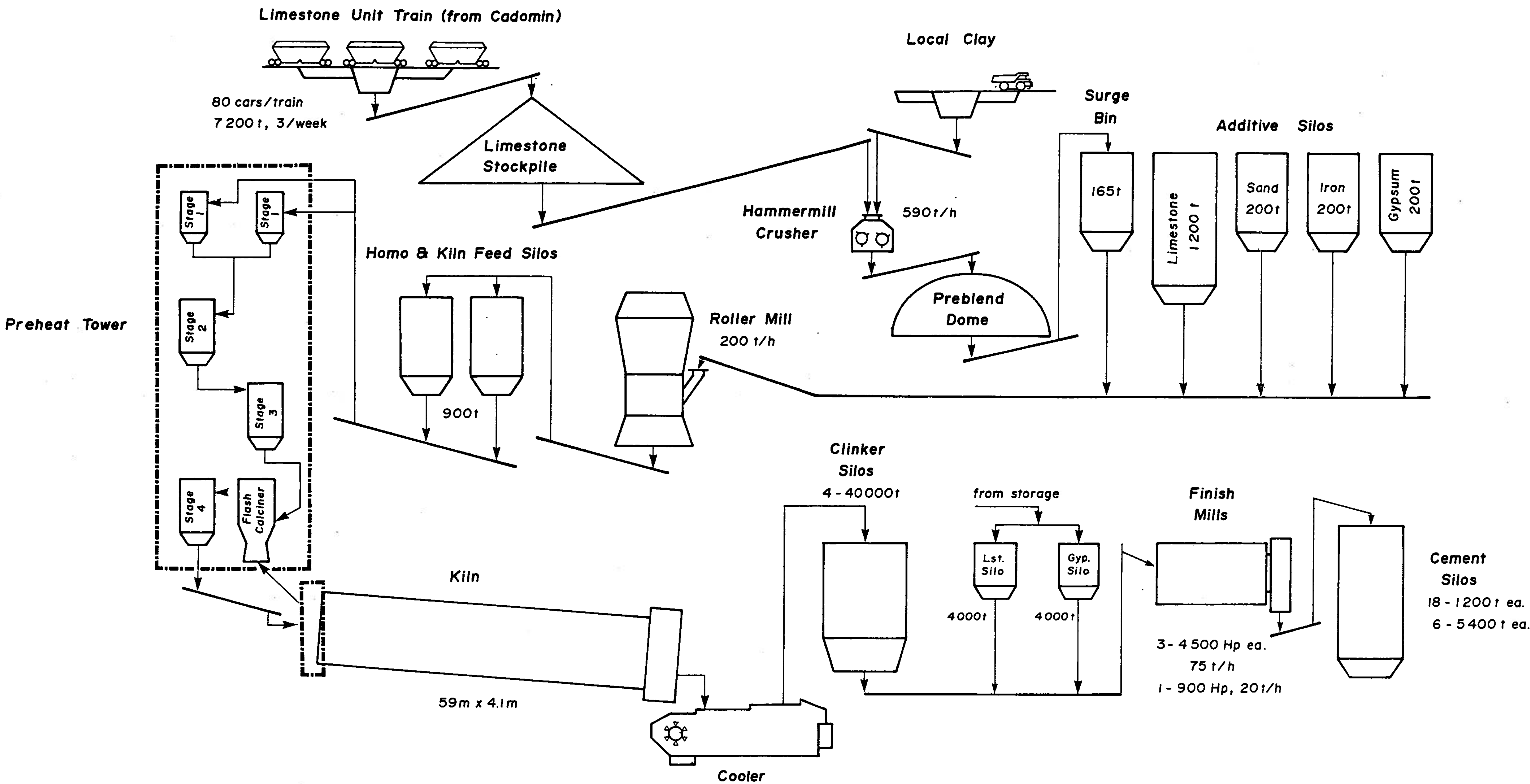

FIGURE 6-18

Inland Cement Plant Circuitry

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FIGURE 6-18

7. FUTURE DEVELOPMENT POSSIBILITIES

The development of new or altered limestone operations in Alberta will be largely dependent upon the extent to which current reserves of rock at existing facilities can be maintained. The quarries serving the cement plants of Lafarge and Inland Cement appear to be well endowed with adequate material for the future. This is somewhat less the case for the Summit LIme Works where a considerable amount of the local resources of high quality rock has been depleted. Little information is available for the Continental Exshaw operations but it would appear that the current beds exploited there have a finite limit to their reserves. The quarries of Limeco and Nordegg Lime are not likely to be close to being depleted in the near future unless production from them is drastically scaled upwards. Undeveloped resources are available in the province and this has been the subject of study for such agencies as the Alberta Geological Survey for some time.

Any future developments in the useage of Alberta limestone will also be subject to changes in local demand. The increased consumption of limestone in newly constructed pulp and paper facilities in recent years is a case in point. Equally important is the probability that manufacturing plants will be developed that require larger volumes of the mineral as population grows and specialty markets come into existence.

Additional optimism for an upswing in demand for limestone is to be found in new technologies that require its availablity. For example, employing the product for alleviating environmental concerns (such as for flue gas desulfurization applications) may become more prevalent as such technologies are more proven, as well as required by regulatory law.

8. CONCLUSIONS

Alberta has a mature and stable limestone industry based on development of high quality deposits strategically located with regards to infrastructure and access to markets. The industry is highly competitive and much of the success of any operation will continue to be in its ability to recognize industry needs and develop customers accordingly.

The cement industry is well established across western Canada and transportation of this Alberta product outside the province is limited by the extent to which such costs must be applied to shipments into areas where competitive operations are already in existence. Fewer producing companies are involved in the lime industry in the west and a somewhat different competitive climate applies to this industry as a result. Both the single lime producer in Alberta (Continental) and at least one of the cement companies (Inland Cement) have shown themselves to be interested in vigorously pursuing the limestone rock products market. This accordingly places higher pressure on smaller producers, such as Limeco and Nordegg LIme, unless their operational overheads are maintained at lower levels to keep them fully competitive.

Limestone production in Alberta is probably at an optimum level of development at this time. Sufficient excess production capacity exists to more than enable the cement industry to respond to any upturns in demand. It is assumed that this might not be completely the case for the lime industry within Alberta but neighboring production in British Columbia and Manitoba potentially provides a leveling effect on meeting fluctuating demand levels. The rock products produced by Limeco appear to address a special market niche and these operations have enjoyed reasonable stability. Nordegg Lime has a very acceptable rock product and quarry setting but must contend with limitations of truck transportation only and a relatively unsophisticated processing system.

The following conclusions can be made with specific reference to the original mandate of this study (see Introduction):

1. Each producing site has been reviewed in an effort to identify the geology, limestone quality, and reserve parameters of the quarries. The available data base for this purpose has proven to be adequate. Plant operations and products manufactured are documented to a reasonable degree although volumes of cement and lime products produced by Alberta manufacturers are not readilly available in all cases.

2. At this time there are only limited cases where excess shipping distances of current product could see replacement by materials from closer undeveloped limestone resources. However, it is anticipated that further expansion of the the pulp and paper industry could justify the opening of new quarries further north along the mountain front in Alberta. Similarly, any requirements fro limestone for flue gas desulfurization in northeastern Alberta could lead to further evaluation of Devonian deposits in the Fort McMurray area.

3. Identification of current markets not satisfied by in-province production involves specialized products such as fillers, extenders, and whitners. In order to meet these demands it is necessary that any such local production utilize the highest

grades of Alberta limestones and that more sophisticated techniques be applied (such as ultra fine grinding and size classification) in order to successfully meet this market requirement.

4. The upgrading of current processing technologies is coupled with the replacement of imports of specialty products into the province, as noted above. Contact with some companies has identified unused byproducts (commonly, undersized materials) but no obvious market application was forthcoming from this review. Further independent studies of this problem might be considered.

9. RECOMMENDATIONS

The future of the Alberta limestone industry is highly dependent on a combined application of strong marketing skills and technical development. Marketing will continue to be handled competitively and aspects of technical advancement will largely be up to each producing company to address. The areas of effort that remain viable in order to encourage growth of the industry are more likely to be in terms of resource survey work and general information development. In the former case a good deal of effort has already been undertaken by the Alberta Geological Survey to identify potential sites for new development, although further field studies can no doubt be justified. One example of this need might be to further investigate resources in the Fort McMurray area in anticipation of limestone use in proposed utility operations in that area. Another possibility might involve new developments in northwest Alberta to meet local demands for such applications as soil ameliorization and mine dusting. Studies of limestone resources in this area have been undertaken by MacDonald and Hamilton (1979).

Information development, particularly by government agencies, might be approached in a variey of ways This study has relied heavilly on responses from operational producers whereas continued marketing studies might better research the consumers and potential users on a province-wide scale. This aspect of study could not be undertaken for this report, largely due to time and budget restaints. Continued efforts to identify the current consumption of limestone in the province in greater detail has merit both in terms of clarifying the status of its current use as well as to recognize the possible substitutions that can be made for materials originating from outside Alberta. In this latter case the manufacture of ultra fine grind product is at least one item that might be investigated. Expanded use of limestone in the province may very well occur in the area of its application as a filler, whitener, or extender.

The development of precipitated calcium carbonate has proven to be innovative and has profound implications for the paper industry. Further research might be justified to determine whether or not this end product can find further use in this expanding field of use.

10. REFERENCES

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