LIMESTONE ON LEYLAND MOUNTAIN NEAR CADOMIN, ALBERTA

by: L. B. Halferdahl

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Research Council of Alberta
Edmonton, Alberta

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RESEARCH COUNCIL

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A knowledge of the composition of some types of rocks is required to learn whether they can be used for certain industrial purposes. This report presents data on the composition of limestone in a stratigraphic interval of almost 300 feet near the top of the Upper Devonian Palliser Formation near the bottom of the southern slope of Leyland Mountain about two miles west of Cadomin, Alberta. The data indicate that it is suitable for the manufacture of cement, calcium building limes, and most chemical limes.

Location, Access, Power, and Fuel

On the afternoon of October 12, 1965, about three hours were spent examining and sampling limestone in unsurveyed territory near Cadomin. Plotting of the location on a map with respect to surveyed land less than a mile away indicates that the limestone examined is in Lsd. 3, Sec. 35, Tp. 46, R. 24, W. 5 Mer., Alberta. Contours on map 83 F/3 West Half, scale 1:50,000, of the National Topographic System place the elevation of the bottom of the limestone deposit at about 6200 feet above sea level; this is about 1250 higher than Cadomin and about 1000 feet higher than the closest existing railway at the confluence of Whitehorse Creek and the McLeod River, about 2-1/2 miles away. Where examined the limestone beds are cut by a small creek which might have to be dammed to provide enough water for drilling.

Cadomin is on the Mountain Park Coal Branch of the Canadian National Railways about 200 miles from Edmonton and about 70 miles southwest of

Edson (Fig. 1). Currently nearly all the freight shipped from Cadomin consists of limestone for the manufacture of cement in Edmonton. It is quarried about two miles south of Cadomin beside the railway to Mountain Park. The railway south of the quarry has not been used for more than 10 years. Lumber is also shipped on the Coal Branch from points closer to Edson. An all-weather gravelled road, Highway 47, runs 60 miles from Cadomin to a point about 5 miles west of Edson on Highway 16, a paved road from Edmonton. Hinton on the main line of the Canadian National Railway and the site of the Northwest Pulp and Paper Company's mill is also about 60 miles from Cadomin via a gravelled road which joins Highway 47 at Robb.

From Cadomin the limestone deposit is reached by travelling about 3 miles south on the road to Mountain Park, thence westerly for about one mile along the north side of Whitehorse Creek, and thence northerly about 1 - 1/2 miles up a tributary of Whitehorse Creek (Fig. 2). The route up Whitehorse Creek and its tributary is along a road bulldozed during the summer of 1965 and passable for a late model car on a dry day in October, 1965.

Electrical power was extended to Cadomin by Calgary Power Limited during 1965. Pipelines carrying oil and natural gas extend west from Edson on rights-of-way not far from those of Highway 16 and the mainline of the Canadian National Railway. B.A. Triad et al. Mt. Park in Lsd. 5, Sec. 36, Tp. 47, R. 22, W. 5th Meridian, and Lovett River in Lsd. 12, Sec. 30, Tp. 46, R. 18, W. 5th Meridian are wells in the

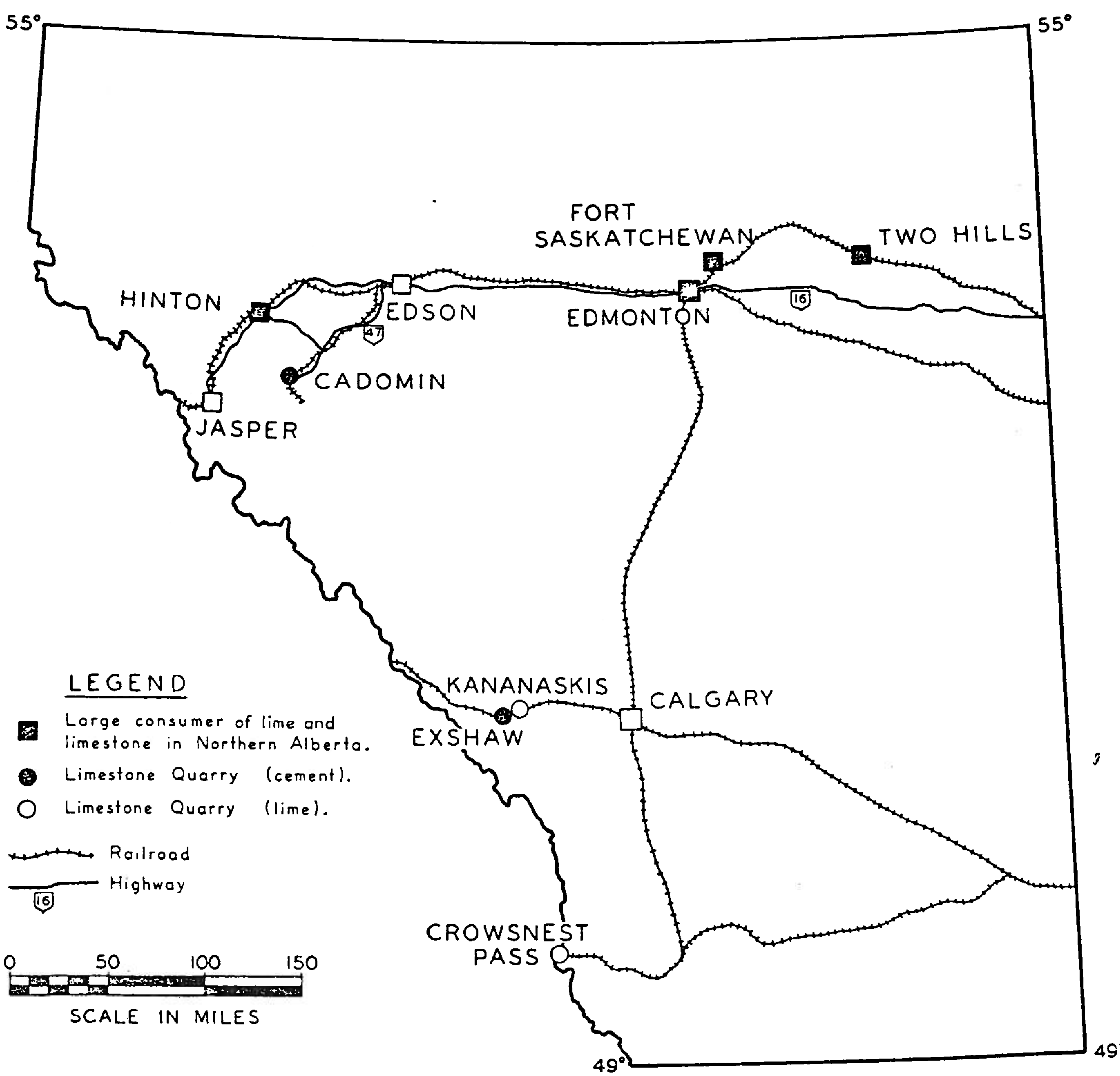


Fig. 1. Part of Alberta showing currently operated limestone quarries and locations of large users of lime and limestone in northern Alberta.

vicinity with commercial quantities of gas. Estimated reserves of coal at Cadomin, Mountain Park, and Luscar exceed 5,000,000 tons. Coal mining ceased at these mines by 1957 and at others somewhat further away along the Coal Branch by 1959.

Previous Work

Most of the early geological work in the Cadomin area was undertaken because of interest in the coal deposits there. Later B. R. MacKay (1929) mapped the area at a scale of 1:63,360. His maps show two folded bands of Upper Devonian Palliser, Mississippian Banff, and Mississippian Rundle Formations consisting mostly of limestone crossing the road and railway between one and three miles south of Cadomin. There these rocks, which trend between west and northwest, have been repeated by faulting.

M. F. Goudge (1945) examined and sampled limestones from these bands along the railway. His observations show that some of this limestone is high calcium, while some is mottled with magnesian material, and some is cherty. He collected and had analyzed three samples of calcium limestone which, although not stated so by him, came from the Palliser Formation.

Sample	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total	S	CaO	MgO
24	0.98	0.23	0.29	0.02	92.45	5.90	99.87	0.02	51.78	2.82
25	1.14	0.24	0.22	0.02	96.00	1.83	99.45	tr	53.77	0.87
25A	0.98	0.22	0.22	0.01	95.03	3.01	99.55	0.02	53.22	1.44

24. Mottled Palliser limestone one mile south of Cadomin from 300 feet along the track excluding cherty beds.
25. Unmottled Palliser limestone overlying the above from 200 feet along the track.
25A. Unmottled Palliser limestone in ridge on the north side of Cadomin Creek.

It is apparent from Goudge's observations that more than 110 feet near the top of the Palliser Formation at this locality may be described as high calcium limestone. High calcium limestone contains more than 95 per cent $CaCO_3$ and less than 3 per cent $MgCO_3$; calcium limestone contains 90 per cent $CaCO_3$ and from 3 to 10 per cent $MgCO_3$; magnesium limestone contains less than 90 per cent $CaCO_3$ and more than 10 per cent $MgCO_3$. Some underlying parts of the Palliser Formation are calcium limestones and magnesium limestones. At the time of Goudge's examination[1] lime was being made one mile south of Cadomin by Mike Errico, from limestone in the northerly band of the Palliser Formation.

[1] Goudge (1945) does not state when he examined and sampled these rocks, but it was probably between 1930 and 1935.

In 1954, Inland Cement Company Limited began quarrying limestone from the first band of Palliser Formation south of Cadomin for a cement plant in Edmonton. Limestone is currently quarried at the top of the mountain, dropped through an inclined chute to an underground crusher, and moved by a conveyor belt to loading bins above the railway. From 1960 to 1965 another quarry was operated in the second band but has now been abandoned. Although much of the material quarried has compositions within the ranges of Goudge's analyses, it is not confined to the high calcium limestone at the top of the Palliser Formation, and so must be blended where necessary or even discarded to ensure that its content of MgO is low enough for the final cement product to contain less than 4 or 5 per cent MgO.

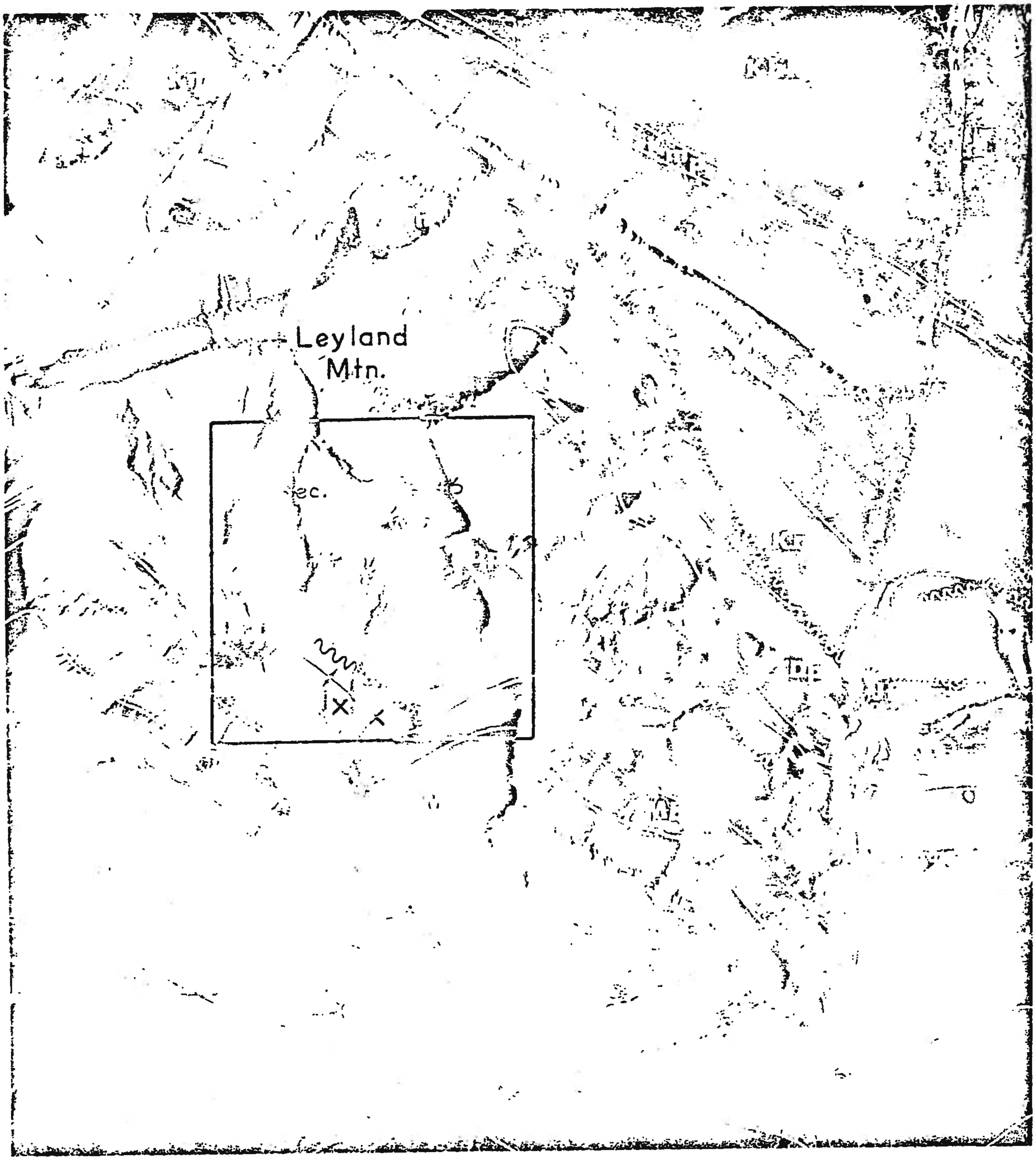
In 1965 Inland Cement Company Limited became a division of Sogemines Limited which now leases these quarries near Cadomin.

Acknowledgments

The writer is indebted to Messrs. G. W. McNeill and J. T. Farmer, both of Edmonton for bringing this deposit to the attention of the Research Council of Alberta and for courtesies during its examination.

Description of the Limestone

The southerly band of rocks of the Palliser Formation which crosses the road and railway about 2-1/2 miles south of Cadomin extends northwesterly to Leyland Mountain and beyond. On the southern slope of Leyland Mountain samples of limestone were collected in Lsd. 3, Sec. 35, Tp. 46, R. 24, W. 5th Mer. from two cliffs, one on each side of the creek (Fig. 2). There the creek has cut a valley vertically about 400 feet, but stratigraphically about 300 feet into what appears to be the uppermost part of the Upper Devonian Palliser Formation. Farther south in the Rocky Mountains the Palliser Formation has been divided into an upper Costigan Member, and a lower Morro Member. However, the lithology of the nearly 300 feet sampled corresponds more closely with that of the Morro Member. One concludes that the Costigan Member is very thin or absent on Leyland Mountain. There, this part of the Palliser Formation forms an anticline whose axis strikes 125° and plunges to the southeast. The dip of the southern limb ranges up to 34° south. As shown in Fig. 3, the southern slope on the west side of the creek is a little greater than the



Kbl	Blackstone Formation	Jf	Fernie Group
Kmp	Mountain Park Formation	₨sr	Spray River Formation
Kl	Luscar Formation	Mr	Rundle Group
Kc	Cadomin Formation	Mb	Banff Formation
Kn	Nikinassin Formation	Dp	Palliser Formation

Fault ~~~~~ Anticline —┼—

Fig. 2. Aerial photograph of the area near Cadomin, Alberta. Geology modified after B. R. MacKay (1929a and b). Scale: 1 mile = 2 inches.

Fig. 3. Overlapping photographs looking west and showing limestone beds of the Palliser Formation on the west side of the creek in Lsd. 3, Sec. 35, Tp. 46, R. 24, W. 5 Mer.

A. Mississippian and Triassic strata forming the mountain in the middle of Sec. 34, Tp. 46, R. 24, W. 5 Mer. These rocks overlie Palliser limestone in the foreground.

B. Anticline in Palliser limestone with a faulted northerly limb.

C. Slope on the south limb of the anticline is a little greater than the dip. Section 1 is in the lower left part of the outcropping.

dip. About 250 feet north of the anticlinal axis, the northern limb is cut by a nearly vertical fault which strikes about 125°. South of the fault the limestone is exposed for about 700 feet along the creek. East of the creek the limestone is exposed for about 700 feet along the axis of the anticline, and west of the creek for more than 1000 feet. These distances indicate that about 5-1/2 million tons of limestone are available for quarrying south of the fault on the east side of the creek and a greater quantity west of the creek. Leyland Mountain, which rises to a peak at an elevation of 8341 feet about one mile north of the fault, consists of rocks of the Palliser Formation, but whether they consist largely of limestone or dolomite is not known.

On the west side of the creek (marked 1 in Fig. 2) a stratigraphic thickness of about 150 feet above the creek was sampled by collecting chips of limestone of about equal size at intervals of about two feet across the strata. The intervals were estimated not measured and so thicknesses are only approximate. On the east side of the creek (Sec. 2) a stratigraphic thickness of about 195 feet from the axis of the anticline to about 90 feet above the creek was sampled in the same way except that in the lower 50 feet chips were collected at intervals of 4 feet. The chips were grouped into nine samples. The interval represented by each sample and the correlation between the two sections are shown in Fig. 4. The limestone sampled is dark to light grey, very fine grained, and dense. Chert nodules are present in one interval, and another contains some mottled limestone. Worm tubes or borings similar to those found elsewhere in the Palliser Formation by Beales (1953, p. 2285) were

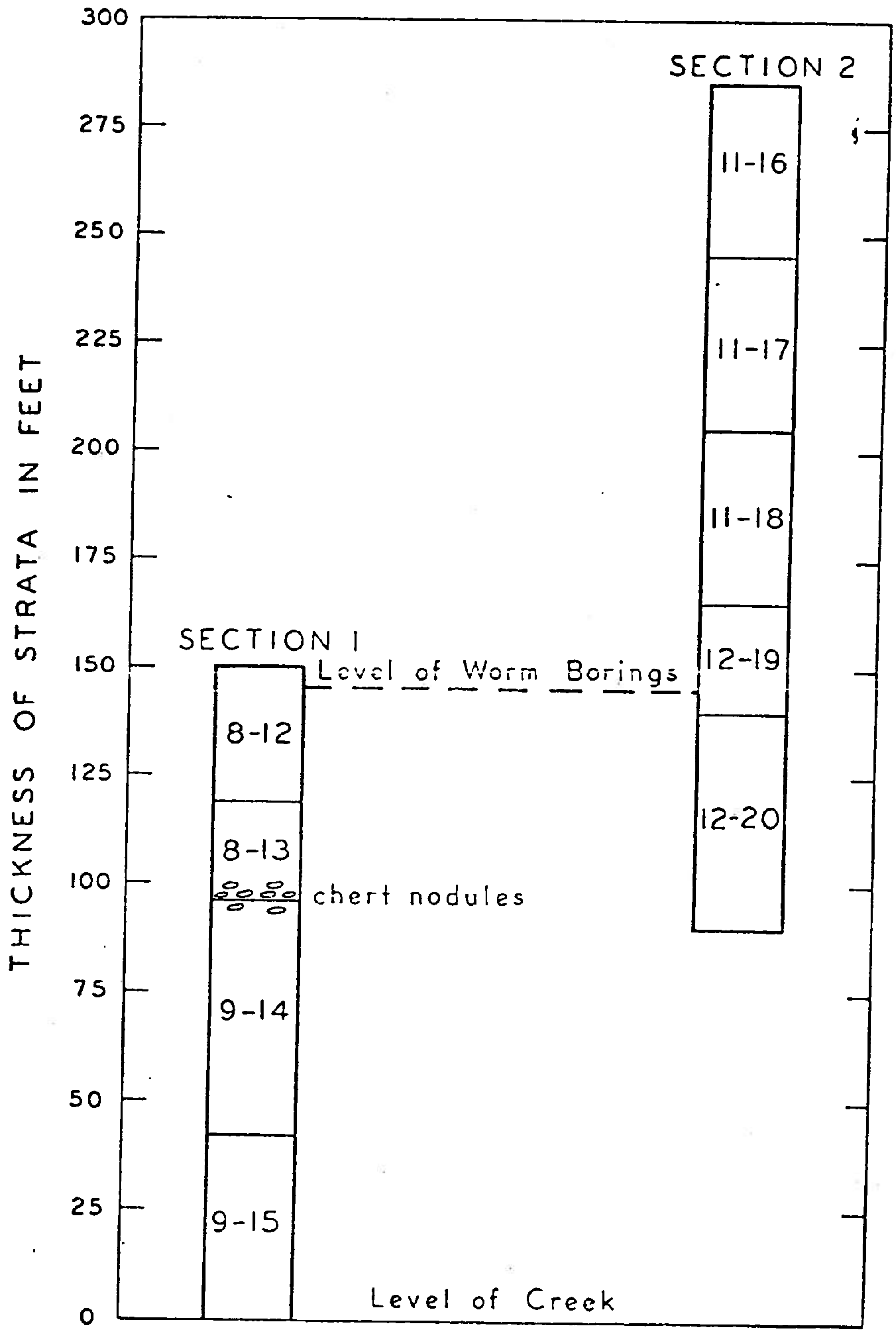


Fig. 4. Locations of analyzed limestone samples in two sections on Leyland Mountain. The blocks in each section are numbered with the corresponding sample number.

noted at one stratigraphic interval, on both sides of the creek. Other details of the samples follow.

Sample No.	Thickness of Interval (Feet)	Feet above Creek	Description
		Section 1, West Side of Creek	
8-12	32	118-150	Dark grey, dense, very fine grained limestone, some with a brownish color; worm borings; bedding planes or fractures parallel to beds are 2 to 6 inches apart.
8-13	22	96-118	Dark grey, dense, very fine grained limestone with irregular black chert nodules up to 10 or 20 cubic inches in size in lower 5 feet and becoming more abundant in lowest 2 feet.
9-14	54	42-96	Dark grey, dense, very fine grained limestone with black chert nodules in upper 4 feet.
9-15	42	0-42	Dark grey, dense, very fine grained limestone in beds up to one foot thick; prominent joints at bottom strike 240° and dip 80° north.
		Section 2, East Side of Creek	
11-16	40	245-275	Dark grey, dense, very fine grained limestone.
11-17	40	205-245	Dark grey, dense, very fine grained limestone; weathered surface is light grey.
11-18	40	165-205	Light and dark grey, dense, very fine grained limestone with a few shaly partings.

12-19	25	140-165	Light and dark grey, dense, very fine grained limestone, some with fine laminae, and worm borings.
12-20	50	90-140	Dark grey, dense, very fine grained limestone, some with light buff dolomitic mottling.

Composition of the Limestone

The chips of limestone comprising each of the nine samples were crushed, quartered, and finely ground prior to being analyzed by X-ray diffraction techniques and by chemical methods. X-ray diffraction powder patterns, which were run on a Norelco Diffractometer, showed the presence of calcite, dolomite, and quartz, in all samples except 11-16 and 11-17, which contain only calcite and quartz in amounts above the limits of detection. Complete results of the analyses are given in table 1. Analytical methods for the chemical determinations are according to ASTM Designation C25-58 except for Na_2O and K_2O which were determined by flame photometer. Fe_2O_3 is total iron as Fe_2O_3. S is total sulfur but is below the limit of detection in all samples. The limit of detection of P_2O_5 is 0.001 per cent. Available lime was determined after ignition of samples at 1200°C for two hours. Intensities of the (101) and (104) peaks for quartz and dolomite, respectively, on the X-ray diffraction patterns were obtained by measuring areas on charts run under the same operating conditions but without standards or other refinements.

Figure 5 shows that almost all the MgO is present in dolomite, and that almost all the SiO_2 is present in quartz. The scatter of the points about the regression lines is mostly due to the degree of precision in measuring the areas under the peaks,

Table 1. Analyses of Limestone Samples from Leyland Mountain

Sample Number		8-12	8-13	9-14	9-15	11-16	11-17	11-18	12-19	12-20
		Weight Per Cent								
As Analyzed Chemically	CaO	54.43	50.47	53.28	53.77	54.54	54.26	54.12	53.00	48.99
	MgO	2.26	2.07	1.30	1.51	0.65	0.63	0.93	2.35	5.32
	SiO_2	1.73	5.60	2.31	1.05	1.31	1.65	1.34	0.59	1.56
	Al_2O_3	0.24	0.23	0.10	0.12	0.22	0.32	0.25	0.26	0.22
	Fe_2O_3	0.10	0.12	0.08	0.11	0.13	0.15	0.10	0.06	0.12
	Na_2O	0.13	0.06	0.06	0.06	0.07	0.06	0.06	0.06	0.06
	K_2O	0.13	0.14	0.09	0.09	0.10	0.14	0.12	0.07	0.12
	P_2O_5	0.002	0.000	0.000	0.000	0.002	0.003	0.003	0.000	0.005
	S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	L.O.I.	43.16	41.16	42.70	43.38	43.08	42.92	43.01	43.74	43.67
	H_2O -	0.05	0.03	0.03	0.05	0.06	0.03	0.02	0.04	0.07
		100.23	99.88	99.95	100.14	100.16	100.16	99.95	100.17	100.13
	Available Lime	88.5	77.2	89.3	92.4	92.6	90.7	92.9	92.3	83.3
Calculated from Chemical Analyses	$CaCO_3$	93.56	90.08	95.09	95.97	97.34	96.84	96.59	94.59	87.44
	$MgCO_3$	4.73	4.33	2.72	3.16	1.36	1.32	1.95	4.92	11.13
Calculated from Chemical Analyses on Non-volatile Basis	CaO	91.95	85.60	93.11	94.82	95.65	94.84	95.08	93.99	86.88
	MgO	3.96	3.51	2.27	2.66	1.14	1.10	1.63	4.17	9.43
	SiO_2	3.03	9.50	4.04	1.85	2.30	2.88	2.35	1.05	2.76
	Al_2O_3	0.42	0.39	0.17	0.21	0.39	0.56	0.44	0.46	0.39
	Fe_2O_3	0.18	0.20	0.14	0.19	0.23	0.26	0.18	0.11	0.21
		Arbitrary Scale								
Intensities of Peaks on X-ray Patterns	Dolomite (104)	36	33	13	16	0	0	6	43	105
	Quartz (101)	5	17	7	3	4	5	3	2	5

Chemical Analyst: H. Wagenbauer, Research Council of Alberta.

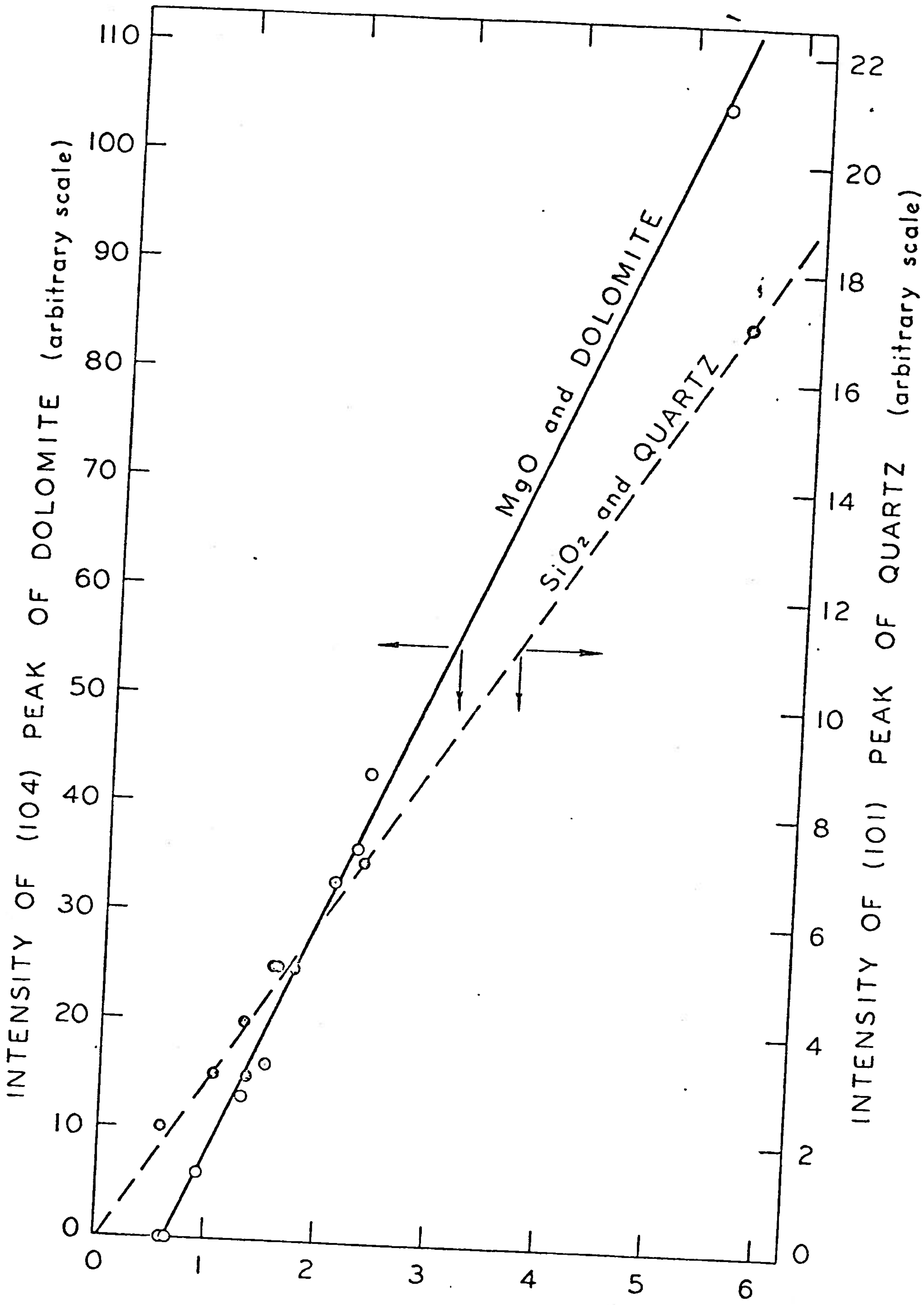


Fig. 5. Relation between MgO and dolomite and between SiO_2 and quartz in samples of limestone from Leyland Mountain.

and to the fact that no special effort was made to grind the samples to a particle size where better reproducibility in intensities could be expected.

Other indications of the reliability of the analyses can be obtained by calculation of molecular ratios of the chemically determined constituents (L.O.I. is assumed to be CO_2). If all the CaO and MgO are present as carbonates, these ratios show that the L.O.I. is low by an average of 0.5 per cent in the nine analyses, or the CaO and MgO are high by an equivalent amount. Check analyses by a commercial analyst on samples 9-14 and 12-19, show 52.61 per cent CaO and 52.86 per cent CaO respectively, thereby suggesting the latter as more likely. The conclusions based on Figure 5 as well as the low concentrations of Al_2O_3 practically eliminate the possibility that some of the MgO is present in a clay mineral such as chlorite. Molecular ratios also show insufficient Al_2O_3 in any of the analyses to permit all the Na_2O and K_2O to be present in micaceous clay minerals. These discrepancies, however, are not large enough to affect the conclusions from the nine analyses.

Four of the samples are high enough in CaO and low enough in MgO to be classed as high calcium limestone. Four samples are calcium limestone, and one is magnesium limestone. The purest limestone comprises a stratigraphic interval of about 120 feet at the top of section 2 which is on the east side of the creek. Although not sampled, similar limestone is to be expected above the sampled part of section 1 on the west side of the creek. The sample with the highest silica content contains some chert nodules. Some of the silica in the other samples may be due to surface contamination from sand, silt, or clay, as the chips comprising the samples were obtained from outcrops.

The results for available lime are not necessarily those that would be obtained from lime from this deposit, burned in a commercial kiln, as the time, type, and temperature of burning affect results for available lime. They merely give an indication of what might be obtained if the limestone were burned in the same way as in the laboratory.

In order to assess this limestone for industrial uses, chemical specifications of lime for various purposes, obtained from the 1964 book of American Society for Testing Materials Standards, Part 9: Cement, Lime, Gypsum, are tabulated in table 2. To facilitate comparison of the analyses in table 1 with the specifications in table 2, the analyses of table 1 have been calculated on a non-volatile basis. The 120 feet of limestone represented by samples 11-16, 11-17, and 11-18 meet the specifications for all chemical, building, and cement uses requiring calcium lime in table 2 except the manufacture of calcium carbide and grease, which require lower SiO_2, or lower MgO. Although some blending may be required, limestone represented by the other samples except possibly 12-20 meets the specifications for all building and cement uses requiring calcium lime in table 2.

Conclusions

The samples obtained from parts of two outcrop sections indicate that a stratigraphic thickness of more than 100 feet of limestone near the top of the Palliser Formation on Leyland Mountain is high calcium limestone. A stratigraphic

Table 2. ASTM Chemical Specifications[1] for Lime Products

(from 1964 Book of ASTM Standards, Part 9: Cement; Lime; Gypsum)

Weight per cent on non-volatile basis except as noted.

ASTM Designation	Material	Use	CaO	MgO	CaO+MgO	SiO_2	Al_2O_3	Fe_2O_3	S	P	SO_3
Chemical Limes											
C45-25	Quicklime	Cooking rags for paper	90[2]	-	-	-	-	-	-	-	-
	Hydrated lime		64.3[2]	-	-	-	-	-	-	-	-
C46-62	Quicklime / Limestone	Sulfite pulp	-	-	95.0 min		3.0 max		-	-	-
C53-63	Quicklime	Water treatment	90[2] min	-	93 min	-	-	-	-	-	-
	Hydrated lime		68.1[2] min	-		-	-	-	-	-	-
C258-52	Quicklime	Calcium Carbide	92 min	1.75 max	-	2.0 max	1.0[3] max		0.2 max	0.02 max	-
C259-52	Hydrated lime	Grease	90[4] min	1.5 max	-	1.0 max	-	0.5 max	-	-	-
C433-63	Quicklime	Hypochlorite bleach	90[2] min	-	-	-	-	0.3 max	-	-	-
	Hydrated lime		68[2] min	-	-	-	-	0.3 max	-	-	-
Building Limes and Cement											
C5-49	Quicklime	Structural	75 min	20 min	95 min		5 max		-	-	-
C6-49, C206-49, C207-49	Hydrated lime	Finishing, Special Finishing, Masonry	-	-	95 min	-	-	-	-	-	-
C49-57	Hydrated lime	Silica brick	90.0 min	2.5 max	-	3.0[5] max	1.5 max		-	-	-
C141-61	Hydraulic hydrated lime	Structural	-	5[6]	60 min 70 max	16 min 26 max	12 max		-	-	-
C150-63	Portland cement[7]										
	Type I		-	5.0 max	-	-	-	-	-	-	2.5-3.0 max
	Type II		-	5.0 max	-	21.0 min	6.0 max	6.0 max	-	-	2.5 max
	Type III		-	5.0 max	-	-	-	-	-	-	3.0-4.0 max
	Type IV		-	5.0 max	-	-	-	6.5 max	-	-	2.3 max
	Type V		-	4.0 max	-	-	-	-	-	-	2.3 max
C415-63	Quicklime & Hydrated lime	Sand-lime products	90.0 min	2.5 max	-	3.0[5] max	1.5 max		-	-	-

1. Limits for loss on ignition and carbon dioxide are not included because the amounts of these constituents in various lime products are dependent on the conditions under which the raw materials are burned and their subsequent handling, not on the composition of the starting material.
2. As available lime.
3. Fe_2O_3 0.5% max.
4. As available calcium hydroxide.
5. Includes all insolubles.
6. Max for high calcium lime; min for magnesium lime.
7. For all types of cement, max loss on ignition of 2.5 to 3.0 per cent.

A dash indicates no specification

thickness of more than 150 feet below the high calcium limestone may be described as calcium limestone with some magnesium limestone. Most of the lower limestone is suitable for the manufacture of cement, nearly all building limes, and some chemical limes; the upper high calcium limestone is suitable for most chemical limes, as well as cement, and calcium building limes. The topography and structure of the deposit are such that a minimum of 5-1/2 million tons of limestone could be readily quarried mostly from what is almost a dip slope on the southern limb of an anticline. Core drilling for more reliable data on grade and reserves is needed.

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