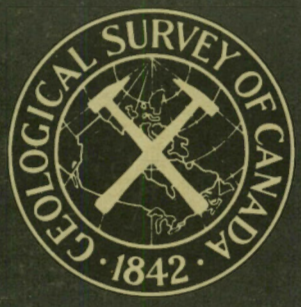

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QUATERNARY STRATIGRAPHY IN SOUTHERN ALBERTA

(Report and figure)

A. Mac S. Stalker

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By

A. MacS. Stalker

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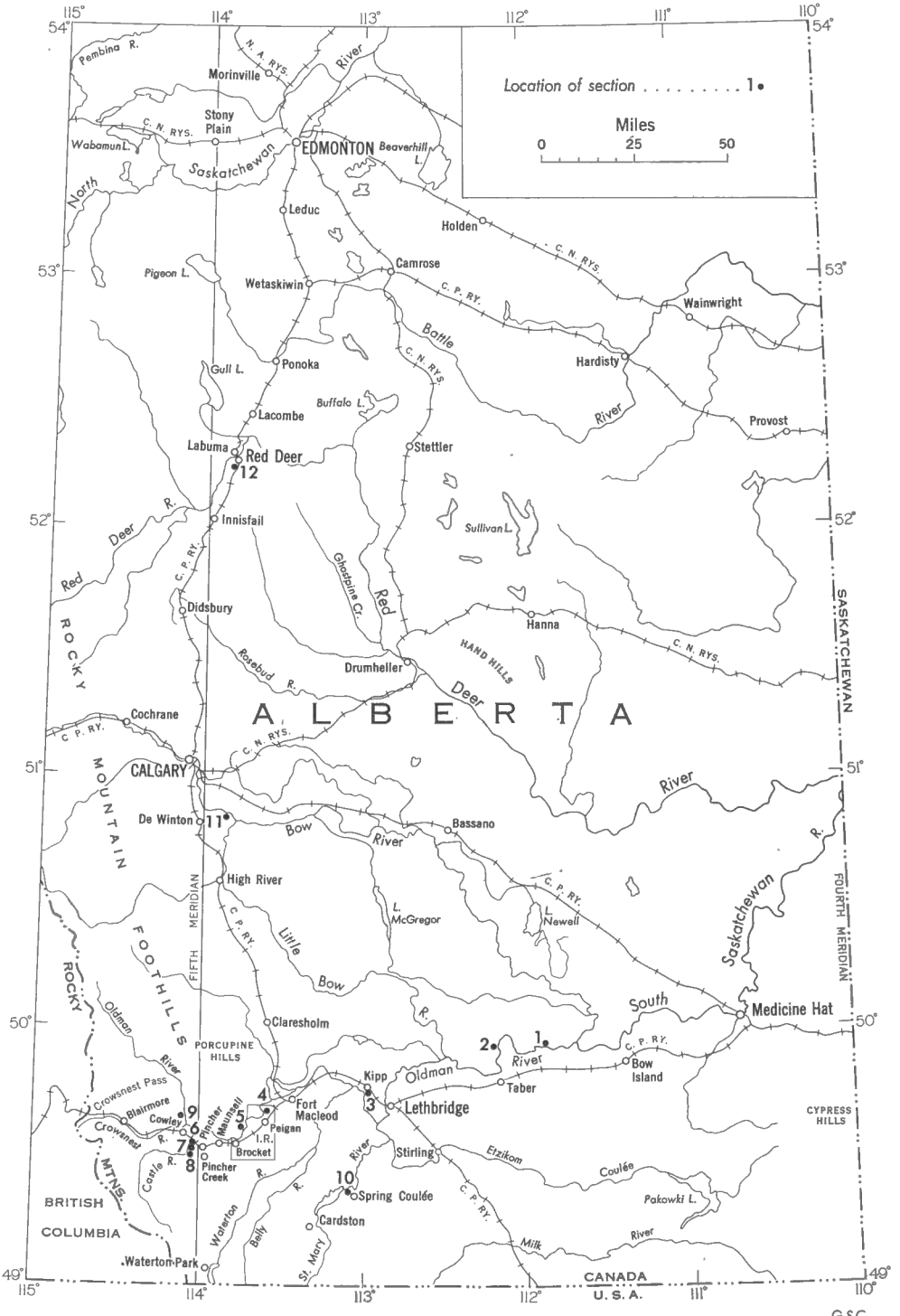

Index map showing location of sections described in appendix

QUATERNARY STRATIGRAPHY IN SOUTHERN ALBERTA

INTRODUCTION

The remarkable exposures of Quaternary deposits along the river valleys of southern Alberta have long been of great interest to geologists. These deposits are well displayed where the modern rivers cut deeply into the fill contained in the deep and broad, buried preglacial valleys. Twelve of the more important stratigraphic sections through these surficial deposits are described here. Several of them have been entirely overlooked in the past. These sections were chosen because of their importance in regional correlation, because of the number and thickness of glacial and interglacial units represented, and because of their accessibility. They are mainly along Oldman and Castle Rivers, but include representative corresponding sections from each of the St. Mary, Bow, and Red Deer Rivers. The locations of these sections are shown on the map (opposite page).

The descriptions of the twelve sections (see Appendix) are intended primarily for field use, for future students of these deposits, and to indicate where good, representative sections can be examined. They are also intended for use in correlation with other surficial sections both in this and nearby regions. Table I contains a provisional correlation between the units of the various sections, including the Laurentide tills of the Plains part of the region and the Cordilleran tills of the Foothills and Rocky Mountains.

The broad, deep preglacial valleys formed excellent locales for preserving from destruction by later glaciers the successive deposits laid down in them. Thus deposits of the first glacier are normally present at the base of the valley fill, just above bedrock or preglacial gravel and sand, and deposits from several of the later glaciers are also generally present. However the stratigraphic section exposed by action of the modern rivers varies greatly from place to place, in both number and thickness of units present. These features can even vary greatly within a single, long exposure. As a result the general stratigraphic section given in this report, and also the descriptions of individual sections (particularly Sections 3, 5, and 10, in the Appendix) are composite. In most instances the maximum thickness of a unit or bed in the section is stated, although the unit may vary greatly in thickness laterally, or even be missing from parts of the exposure. In addition the exposures, and thus the apparent sections, change continuously over the years and may even be destroyed by stream dissection or slumpage, or covered by vegetation. On the other hand, new exposures are often developed by rivers impinging on their banks. Such processes are slow, however. For example most of the exposures reported by Dawson in 1885 remain much as he described them.

Of the sections described in the Appendix, Nos. 5 and 10 are the most complete, are little deformed or slumped, are readily examined, and are used as the reference sections for the Laurentide deposits. The sequence in these two sections is remarkably similar.

Throughout the report the names "Albertan till", "Labuma till", "Maunsell till", "Buffalo Lake till", and "Brocket till" are used where applicable. Albertan till is the till member of the Albertan Formation, as defined by Dawson (1895, p. 510; also 1896, p. 66)[1]. Labuma, Maunsell, and Buffalo Lake tills are from Stalker (1960). "Brocket till" is first used in this paper.

Previous Work

Dawson (1885, 1896) first described the Quaternary deposits exposed along the rivers in southern Alberta. His "Wolf Island" section (1885, p. 141c) corresponds to Section 1 in this report. Calhoun (1906) and Alden and Stebinger (1913) also described sections in southern Alberta, while engaged in study of surficial geology in adjacent regions of the United States. Johnston and Wickenden (1931) discussed the Quaternary stratigraphy in general, and gave particular attention to the Driftwood Bend section northeast of Taber. This exposure is not discussed in the present report. Horberg (1952) made the first detailed study when he described eighteen sections, most of which are along Oldman River near Lethbridge. His "section 18" corresponds to Dawson's "Wolf Island" section and to Section 1 of this report. In general his basal till corresponds to the Labuma till, and his lower till to the Maunsell till. His upper till is found only in Sections 1 and 2 of this report. Horberg (1954) continued with another detailed study farther to the southwest, chiefly along the Belly and Waterton Rivers. In this he described a further sixteen exposures, none of which are discussed in the present paper. Murakami (1960) described the important Spring Coulee - Pinepound exposure (Section 10 of this report). His investigation included detailed stone counts and careful stone-orientation studies.

GENERAL QUATERNARY STRATIGRAPHY

A provisional correlation between some of the units described in the sections is given in Table I.

Preglacial Gravel and Sand

The preglacial (including the Saskatchewan) gravel and sand is the oldest surficial deposit of the region. This deposit is present in Sections 1, 2, 3, 4, 5, 11, 12, possibly in Section 8, and probably in Section 10, though buried below the level of the present St. Mary River. This deposit is typically a loose, clean, well-sorted and well-bedded, round to subround river gravel, with a sand matrix.

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[1]Dates in parentheses are those of publications listed in the References.

Table I.

Suggested Correlation of Sections Described in Appendix, using Reference Letters of the Various Units

(Units that are merely local or otherwise non-correlatable are omitted)

Origin of Unit	Name of Unit or Type of Material	Suggested Age of Unit	UNIT REFERENCE LETTERS											
			Section 1 (Wolf Island)	Section 2 (Taber)	Section 3 (Kipp)	Section 4 (Peigan)	Section 5 (Brocket)	Section 6	Section 7 (Cowley)	Section 8	Section 9	Section 10 (Spring Coulee-Pinepound)	Section 11 (De Winton)	Section 12 (Red Deer)
Laurentide	Outwash or till	Wisconsin	J (?)	G (?)	S									
Laurentide	Buffalo Lake till	Wisconsin	I	G (?)	P (?)	H (and G ?)	J		E	H, F	G (?)	I	F	D
Cordilleran	Till	Wisconsin						G						
Laurentide	Till	Illinoian (?) or Early Wisconsin (?)					G					G		
Cordilleran	Till									D (?)				
Laurentide	Brocket till	Illinoian (?) or Early Wisconsin (?)		F (?)	H (and I ?)	G (?)	F					E		
Cordilleran	Till	Illinoian (?) or Early Wisconsin (?)						D (?)	C (?)	C (?)	D (?)			
	Interglacial beds			F	G									
	Bedrock		H		F									
Laurentide	Till	Kansan or Illinoian (?)		E (?)										
Laurentide	Maunsell till	Kansan (?)	G	D	E		E		B			D	C and D (?)	C
Cordilleran	Till							B (?)			B (?)			
Laurentide	Labuma till	Nebraskan (?)	E	C	C (?)	F	D					B	B	B
Cordilleran	Albertan till	Nebraskan (?)				C	C					A		
Cordilleran	Albertan outwash	Nebraskan (?)	C (and B ?)			B (?)	B						A	
Cordilleran	Preglacial (Saskatchewan) gravel and sand	Early Pleistocene	B	B	B	B (and A ?)	B					(Buried)	A	A

It contains little weak or weathered material. In the more easterly exposures it consists mainly of quartzite, hard sandstone, and volcanic rocks. Near the Foothills, less resistant rock types, such as limestone, dolomite, and argillite are included. Local bedrock is scantily represented, for the poorly or even non-indurated clays, siltstones, and sandstones of the plains disintegrate readily under water transportation. The feature that distinguishes this material from later gravel and sand deposits, apart from its position at the base of the surficial deposits, is the absence of such rock types as granite, gneiss, schist, gabbro, and pegmatite, which were subsequently brought from the Precambrian Shield by successive Pleistocene ice-sheets.

The preglacial gravel and sand were deposited by Tertiary and Quaternary rivers flowing eastward from the mountains. The deposits at the base of the fill in the preglacial valleys represent the last phase of a long-continued, though intermittent, deposition. Earlier phases included deposition of the Cypress Hills and Hand Hills gravels, and of many deposits at intermediate levels (Stalker, 1960). The onset of Pleistocene glaciation marked the end of deposition of this gravel. In several places near the Foothills, as at Sections 4 and 5 on the Oldman River and upstream from Section 11 on the Bow River, this preglacial deposit becomes siltier and sandier upwards, with fewer but more angular stones, and there is no distinct boundary between it and the overlying Cordilleran till. In these exposures the upper part of this bed consists of outwash from advancing Cordilleran valley glaciers, as stated by Dawson (1896, pp. 38, 39, 58, 59). These glaciers subsequently overran much of their own outwash. Farther east on the plains (Sections 1, 2, 3, 12) several feet of sand or silt commonly overlie the gravel. In most places the deposition of this sand or silt cover took place while the first Laurentide ice-sheet dammed the various rivers farther to the east, thus forming proglacial lakes. This Laurentide ice-sheet subsequently overran the fine material laid down in these lakes. The outwash from the first valley glaciers is distinguished from the other preglacial gravel and sand, as much as possible, in Table I.

Albertan Till

The Cordilleran till overlying the preglacial gravel is described in Section 4, unit C, Section 5, unit C, and Section 10, unit A, but it is also present in exposures along the Bow River west of Section 11. Dawson (1895, p. 510; 1896, p. 66) named it "Albertan till", and the writer agrees in substance with Dawson's description and interpretation of it. This till was deposited by the first glaciers to reach the region, which advanced eastward and northward from the mountains. The Bow Valley glacier advanced almost to Section 11, the Oldman Valley glacier came to within 5 miles of Fort MacLeod, and the St. Mary Valley glacier advanced beyond Section 10. Cordilleran till similarly underlies the oldest Laurentide till found in the preglacial Waterton and Belly River valleys in the southwest of the province. Dawson assigned the Albertan till to the first glacial stage, and called it "pre-Kansan", for the Nebraskan stage had not then been recognized. The writer agrees that it represents the first glaciation in southwestern Alberta, for it is generally associated with or directly overlies the preglacial gravel in the bottoms of the immediate preglacial valleys. If Nebraskan ice reached this region, as is probable, this till is Nebraskan in age.

Labuma Till

The Labuma is the next till in the general stratigraphic succession. It was described by the writer (Stalker, 1960) and is in Sections 1, 2, 4, 5, 10, 11, 12, and perhaps 3, of this report. This is the Laurentide equivalent of the Albertan till, and for similar reasons is also probably Nebraskan. It is typically a dark, consolidated, compact and dense till, which generally contains more stones of rock types found in the Canadian Shield than any of the other tills. Evidently this strong Laurentide glacier reached the Foothills region after the Cordilleran glaciers had somewhat weakened, and was able to replace the latter over those broad areas where Labuma till now overlies the Cordilleran (Albertan) till. Farther east, in the preglacial valleys of the plains, Labuma till generally lies directly on preglacial gravel and sand, and elsewhere on bedrock. It is rare outside these valleys.

Intertill deposits, chiefly sand, overlie the Labuma till in Sections 1, 3, 10, 11, and 12, but in Sections 1 and 3 this layer is thin. In Sections 1, 3, and 12 these deposits separate the Labuma till from the Maunsell till, which normally overlies it. In Sections 10 and 11 presence of the Maunsell till has not been definitely determined, and in these sections the stratigraphic position of the sand is uncertain. Deposits between these two tills also appear farther north in the province, in sections not described here. The Labuma and Maunsell tills have a distinct, sharp contact where intervening deposits are absent.

Maunsell Till

The writer (Stalker, 1960) named and described the Maunsell till. If ice of Kansan age reached this region this till is probably its representative. In general it is lighter in colour than the Labuma till, somewhat less massive, and contains markedly fewer stones derived from Canadian Shield rocks. Its outstanding characteristic is its ability to form the high, vertical bluffs with their well-developed, hexagonal columns that are so well displayed along Oldman River. The Labuma and Brocket tills, and locally the lower part of the Buffalo Lake till, also form similar columns, but not in as grand a manner. A Cordilleran equivalent of the Maunsell till may be present in Sections 6 and 9.

In some places (e.g. Section 1) the Maunsell till is contorted, and includes blocks from the underlying sand and bedrock beds. This contortion is probably not due to its slumping, as similar contortion is found in many places where slumping could not possibly have taken place. Permafrost, or pressures from either overriding ice or overriding bedrock slump, are considered the likely cause.

Intertill Deposits

The major band of intertill deposits in the surficial sequence occurs above the Maunsell till. These deposits are remarkable for the substantial quantity of Cretaceous bedrock contained as immense blocks in them, and for the presence of other sediments containing small amounts of organic matter. The large masses of Cretaceous

bedrock are a puzzling feature of these intertill deposits, and their presence is as yet completely unexplained. The mention of these bedrock blocks solely in the descriptions of Sections 1 and 3 does not do justice to their widespread occurrence. They are present also in exposures near Section 2, and in practically every exposure along Oldman River between Section 3 and the junction with the Bow River, a distance of about 100 miles (about 60 miles in a straight line). In some places a continuous block of this intertill bedrock is more than a mile long, and in some instances may possibly extend continuously for several miles. In addition there is indication from drill-hole logs that one of these large masses 8 to 10 miles north-northeast of Taber may spread over several square miles and be up to 90 feet thick, though generally much thinner. Commonly, and perhaps in most exposures, the bedding in these masses is approximately horizontal or only slightly deformed, but elsewhere there is much contortion. The large bedrock masses are thought to be in equivalent stratigraphic positions in all the exposures, and thus they form an extremely valuable and easily recognized marker horizon.

The occurrence of these large bedrock masses amid the Pleistocene deposits is disconcerting. Slumping takes place with great ease in the soft, easily lubricated bedrock of the area, but this is not thought to be the cause of their displacement. Slumping should cause more contortion and deformation of the beds than is found, and such extensive but relatively thin blocks would hardly be expected to hold together under such a method of transportation. The chief argument against slumping as the agent of transportation is the apparent lack of proper conditions or gradient necessary to cause such slumping. Shove or pushing by an ice-sheet also seemingly would not allow such widespread but thin blocks to retain their shape or even hold together during movement. The most attractive hypothesis, even though not satisfactory, is that these masses were dragged beneath an actively moving glacier into their present positions. The top of the bedrock may have become attached to the base of the ice-sheet by freezing, pulled away from the underlying bedrock, and then slid over the underlying slippery shales and tills to be deposited when the glacier could drag it no farther. A high water-table, such as would likely be present under glacial conditions, could have aided the process by increasing the lubrication of the underlying deposits. There remains the fact, however, that in many places the bedrock masses are overlain by alluvium (e.g. Section 3), whereas if they had been dragged into place beneath ice, they would presumably be overlain by till. The question as to their means of transportation cannot yet be answered.

Pleistocene alluvium is fairly widespread immediately above the bedrock masses, and this alluvium locally contains wood whose age, however, is beyond the range of C^{14} dating[1]. The wood in each instance was washed into place by the river, and is scattered through the deposit as small sticks and branches, commonly iron-stained.

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[1] See dates given in discussion after Section 3, Appendix.

Brocket Till

The dark brown till (unit F) directly overlying the Maunsell till at Section 5, is here named "Brocket till". It is a Laurentide till, 5 feet thick at Brocket, and contains stones from the Precambrian Shield. In southern and central Alberta it is moderately well indurated, massive, forms a steep, commonly almost vertical face with, locally, columnar structures and even hoodoos, and contains rather few stones but otherwise has about the same grain-size composition as the other tills. Where the Brocket till occurs along with the Labuma and Maunsell tills in an exposure, as in Section 5, it contains a somewhat higher proportion of stones from the Shield than does the Maunsell till, but noticeably fewer than the Labuma till. In colour and composition it is intermediate between these two older tills—possibly a result of the Brocket glacier having advanced in a direction intermediate to that of the other two glaciers. It is not as well indurated or tough as either of these other tills, nor is the columnar structure as marked as with the Maunsell till. These traits are characteristic of the Brocket till wherever it has been found, and they result from its composition, its age, and the amount of compression and drying it has undergone. Fundamentally it has been subjected to more compression and compaction by weight of subsequent ice-sheets than have the overlying tills, but to less than the underlying tills.

Farther east the Brocket till commonly overlies the intertill Cretaceous bedrock masses, as at Section 3 where it is up to 25 feet thick. Both here and in Section 10 where it is also readily observed, this till displays properties similar to those it shows in the Brocket section. In Sections 3, 5, and 10 its cliff face is nearly vertical.

Though it is present locally, the Brocket till in the preglacial valleys has been largely destroyed by later glaciers, as it is rather high in the section and somewhat vulnerable. It is well displayed in certain interglacial valleys; for example it is probably the lowest till in part of the interglacial Ghostpine Creek valley, farther north in the province, which was greatly deepened after the Maunsell glaciation.

The Brocket till evidently represents an ice-advance that was distinct from the one that laid down the Maunsell till. If the Maunsell till is of Kansan age, the Brocket till may be Illinoian, and the intervening wood-bearing sediments with the large bedrock masses, Yarmouthian. The Brocket till could just as well be of pre-classical Wisconsin age, however. Till similar in appearance to the Brocket and thought to be in the same stratigraphic position, is present in Sections 6, 7, 8, and 9. This till, which lacks stones from the Precambrian Shield, may be a Cordilleran equivalent of the Brocket till.

Light Brown Till

At the Brocket section the Brocket till is overlain by 8 feet of light brown till. The contact between these two tills is indistinct at close-hand but from a distance it appears sharp due to the

contrast in colour of the tills and a change in the slope of the cliff face, with the younger till generally being less indurated and forming the easier slope. In Section 10 there is 5 feet of varved silt and clay, and sand, between the same two tills, though this deposit is obscured by slumping of the upper till. In addition, contortion of the light till and the underlying and overlying sediments causes difficulty in interpreting the contact. In Section 3 much of the surface is hidden by slump, but the light brown till is thought to be absent. A Cordilleran equivalent of this light brown till has not been recognized.

The relation between the Brocket till and this overlying light brown till is not known. They have many common features, such as a similar content of stones from the Precambrian Shield. Besides colour and degree of consolidation, the chief differences lie in the lack of vertical structure in the upper till and its consequent inability to form columns and steep cliff faces, and the ease with which it slumps. These differences apparently do not stem from weathering, nor did the upper till originate in the Cordillera. The writer previously (Stalker, 1957) assumed that these two tills represented a single ice-advance, but now considers them to represent distinct ice-advances and the upper till to be of pre-classical Wisconsin age.

Buffalo Lake Till

The youngest widespread tills in the area are the Buffalo Lake till, described previously (Stalker, 1960), and its Cordilleran equivalent. Both have similar traits, except for the presence of stones derived from the Precambrian Shield in the Buffalo Lake till; and the most outstanding feature of both is a lack of coherence, which allows ready slumping. As a result these tills commonly occur under gentle, overgrown slopes near the top of river banks, and thus are not as easily studied as the lower tills. In the western exposures along Oldman and Castle Rivers, outwash, proglacial-lake deposits, and river deposits, both overlie and underlie the Buffalo Lake till. These were laid down in front of the glacier as it first advanced westward and later melted back eastward, in both cases damming the Oldman and other valleys. The deposits underlying the till were preserved as the ice-sheet was near the limits of its advance, and was too weak to pick up or destroy these deposits to any extent as it flowed over them. In particular, there were several halts of ice-margin retreat during the melting stage, during which large outwash plains were built. These river and lake deposits are particularly well displayed in Section 5.

The Buffalo Lake till, and its Cordilleran equivalent, are of Wisconsin age, but it is not known whether they include part of the pre-classical Wisconsin or how late into the classical Wisconsin they extend. They probably include the Tazewell substage but, in south-western Alberta, not the Cary.

Younger Tills

A younger till than that just described appears at the top of the sequence east of Section 4. This corresponds to the upper till of Horberg (1952, p. 316), and may represent a Cary readvance

(Horberg, 1952, pp. 308, 316). Laurentide ice apparently did not reach this region in Valders time.

A late Cordilleran ice-advance is recorded at high altitudes, generally above 5,500 feet, in some of the mountain valleys farther to the west. This advance did not reach any of the sections described here. The time of this advance is not known, but it was probably later than any of the Laurentide advances described above.

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APPENDIX

Description of Sections 1 to 12

Section 1 (Wolf Island Section). North bank of Oldman River, north of Wolf Island, about 20 miles northeast of Taber in NW 1/4 sec. 20, tp. 11, rge. 14, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
L	Numerous stones on surface	-	
	Material unknown, overgrown; gentle rise from top of cut to prairie level	10.0	10.0
K	NON-GLACIAL Fine sand and silt, rusty yellow or reddish brown, stoneless	30.0±	30.0±
	Contact largely hidden		
J	GLACIAL Till, dark greyish brown, compact, contains Precambrian Shield stones	5.0±	5.0±
	Contact largely hidden		
I	GLACIAL Till (Buffalo Lake till), light brown, loose, unconsolidated and does not form steep cliffs, largely overgrown; Precambrian Shield to Cordilleran stone ratio is 1 to 2; not known whether whole thickness is till, or if more tills than one are present	80.0±	80.0±
	Sharp contact		
H	BEDROCK MASSES Sand, shale, coal, ironstone (Cretaceous)	45.0±	45.0±
	Contact hidden		
G	GLACIAL Till (Maunsell till), blue-grey if dry, dark blue or black if wet; hard; compact, has a weak columnar structure; Precambrian		

	Shield to Cordilleran stone ratio is about 1 to 1; a boulder pavement of stones 1 foot or more in length is present about 2 feet below top of this till	11.0	11.0
	Contact obscure		
F	GLACIAL (?) Sand, buff colour, stoneless, contains till stringers	1.0	1.0
	Obscure contact with stringers of till running into overlying sand		
E	GLACIAL Till (Labuma till), grey if dry, black if wet; hard, compact, sticky	12.0	12.0
	Contact hidden		
D	NON-GLACIAL (?) Present only locally Medium sand, with silt stringers; buff to reddish, with dark carbonaceous streaks; stoneless except for pebble band at base; alluvial; this sand may be filling in channels carved in the Labuma till (E) and overlying sand (F), and if so this deposit should be placed between the sand (F) and Maunsell till (G)	15.0	15.0
C	GLACIAL Silt, minor clay; the silt is noticeably pink, the clay is dark brown; varved with relatively thin clay bands	3.0	3.0
	Interbedded, gradational contact		
B	PREGLACIAL Gravel, sand; stones to 7 inches long but mostly 3/4 inch to 2 inches long, subround to disc-shaped; gravel coarsest in lower half of unit, and most of the sand is in the top 4 feet; Precambrian Shield stones not present	20.0	20.0
	Sharp contact		

A	BEDROCK Foremost Formation (Cretaceous)	13.0	13.0
	Level of Oldman River	-	-
	Total thickness		245.0±

Discussion—The preglacial gravel (unit B) was deposited quickly and displays little bedding or crossbedding. It may consist of outwash from the Cordilleran Oldman Valley glacier that was laid down near the shore of the preglacial lake ponded in front of the advancing Laurentide glacier. As the Laurentide glacier advanced farther, extending the preglacial lake westward, the gravel was dropped farther to the west, and only fine material was carried to this point where it was laid down as the silt and varves of unit C in the cold water of the deeper part of the lake. The pink colour of the silt indicates an origin in the Rocky Mountains south of Crowsnest Pass. This in turn suggests that either the northern tributaries to the Oldman River were blocked by ice at this time and only southern tributaries were carrying material eastward, or that valley glaciers in the Castle River - Waterton Park region were actively producing fine rock flow, which was carried eastward by meltwater. The gravel and sand, and overlying silt, form one continuous sequence of deposition. Most of the slumping in this exposure takes place through slippage on top of the silt.

The local deposit of sand (unit D) probably represents fill in an interglacial or interstadial stream valley.

The sand (unit F) between the Labuma and Maunsell tills (units E and G) was originally thicker, but much of it was incorporated into the Maunsell till as pockets and lenses. This reduced the ability of this till to form the good vertical columns it displays elsewhere.

The top till (unit J) was covered by slump from overlying deposits, was overgrown, and thus is poorly exposed, but it is darker, better consolidated, and more compact than the Buffalo Lake till (unit I). It may be nothing more than a large block of Brocket till that either was picked up by the Buffalo Lake glacier and incorporated into its till, or that slumped into place from a bed, now buried, of Brocket till higher up on the walls of the preglacial valley. Brocket till is not exposed near this locality, however, and this dark till probably represents a distinct glacier advance. If so, it would correspond to the top till in Section 2 and the outwash in Section 3, unit S.

The absence of stones indicates that during deposition of the overlying sand and silt (unit K) the western shore of the preglacial lake in front of the receding Laurentide ice-sheet was a

considerable distance to the west. The interstadial Oldman River dropped its load of coarse material near this shore, and the lake currents were not strong enough or in such a direction as to carry in stone-bearing ice-rafts from the glacier.

The surface stones (unit L) may represent outwash from a slight readvance of the glacier, or else a change in current direction or drop in lake level, which caused either ice-rafted stones or river alluvium to be brought to the area.

Section 2 (Taber Section). West bank of Oldman River, about 9 miles north of Taber, in NW 1/4 sec. 19, tp. 11, rge. 16, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
H	POST-GLACIAL		
	Sand, grey; grades from medium sand at bottom to fine sand at top; a few scattered stones; alluvial	7.0	
	Fine to medium gravel, alluvial	0.3	
	Sand, grey, alluvial	2.0	9.3
	Contact generally obscure		
G	GLACIAL		
	Till (Buffalo Lake or younger till), dark brown; Precambrian Shield stones common; massive, poorly consolidated, and generally forms a gentle slope, which is normally overgrown	11.0	11.0
	Sharp contact		
F	MOSTLY NON-GLACIAL		
	Fine gravel, sand matrix	5.0	
	Sand, till (?); alternating beds of horizontal undeformed sand and grey till or colluvium, mostly 2 to 5 inches thick; the sand contains small pieces of wood, which were washed into place; largely alluvial	10.0	
	Medium sand, grit, silt, with the silt mostly near the top; some carbonaceous bands, scattered stones; rusty streaks; scattered small pieces of wood present, chiefly in the rusty streaks; alluvial	20.0	
	Silt, dark colour, compact	0.5	
	Sand, rusty	0.5	36.0
	Contact largely hidden		

E	GLACIAL Till, brown, massive, unconsolidated, and slumps readily; Precambrian Shield stones common	15.0	15.0
	Contact largely hidden		
D	GLACIAL Till (Maunsell till), dark grey; Precambrian Shield stones fairly common; compact, hard, well-consolidated; columnar structure with columns up to 20 feet high, 2 or 3 feet thick, on the nearly vertical face	30.0	30.0
	Sharp to gradational contact		
C	GLACIAL Till (Labuma till), very dark grey to black; contains a few thin sand beds, but mostly massive and breaks into small irregular pieces a few inches long; rather few stones for a till; Precambrian Shield stones present	5.0	5.0
	Sharp contact		
B	PREGLACIAL Gravel, pockets of sand; the stones are chiefly quartzite, hard sandstone, and Crowsnest volcanic rocks; no Precambrian Shield type stones present. Stones mostly 2 to 6 inches long; many are crushed and broken, a few weathered; the top 2 feet of the gravel and bottom 10 inches of the overlying till are locally weathered to a rusty yellow; alluvial	22.0	22.0
	Sharp contact		
A	BEDROCK Siltstone, sandstone, coal, ironstone (Cretaceous)	35.0	35.0
	Level of Oldman River	-	-
	Total thickness	-	163.3

Discussion—The broken stones in the preglacial gravel (unit B) were crushed by the weight, pressure, and grinding action of overriding glaciers, particularly of the first (Labuma) glacier. Similar crushing of preglacial gravel is found elsewhere, particularly farther north in the province.

The till (unit E) between the Maunsell till (unit D) and overlying wood-bearing sediments (unit F) appears similar to the Brocket till. It is placed in this stratigraphic position as the overlying beds (unit F) resemble those observed above the large bedrock masses in Section 3. Though this bedrock is not present in this exposure it occurs at this horizon a short distance to the north, where the beds it underlies have been dated at more than 32, 000 years. Equivalent beds at Section 3 have been dated at more than 35, 000 years. Unit E and underlying deposits are therefore older than classical Wisconsin.

The thin 'till' beds in the sand of unit F may be simply flood-plain alluvium. They may, however, result from the alternate floating and grounding of the margin of an ice-sheet in a lake or slow-flowing river, with resultant deposition of layers of sand and till. Similar bands of till, and sand, silt, or gravel, occur in unit I of Section 3.

Section 3 (Kipp Section). East bank of Oldman River, about 1 1/2 miles south of Kipp, in E 1/2 sec. 18, tp. 9, rge. 22, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
S	Numerous stones on surface; outwash	-	
	Material overgrown; gentle rise from top of cut to prairie level	10.0	10.0
	Sharp contact		
R	NON-GLACIAL Silt (loess?), light brown, stoneless, contains scattered snail shells; massive with vertical structure; aeolian	25.0	25.0
	Sharp contact		
Q	NON-GLACIAL Clay, silty, dark grey to black, contains rare stones and scattered snail shells; massive; lacustrine	15.0	15.0
	Sharp contact		
P	GLACIAL Silt, clay, minor till and sand; varved, with about 90 varves, which increase in thickness upward; lacustrine	19.5	
	Silt, clay; varved, with 2 varves; may represent a silty till with clay partings	3.5	
	Silt, clay, minor sand; stony; varved with 7 varves; lacustrine	2.2	25.2
	Sharp contact		
O	GLACIAL Sand, silt, clay, scattered stones; largely composed of small fragments of earlier varves; alluvial	6.5	

	Sand, silt, clay; varved, with about 12 varves, contains scattered stones; lacustrine	13.7	20.2
	Sharp contact		
N	NON-GLACIAL (?)		
	Fine to medium sand, silt, stoneless; alluvial	27.6	
	Medium to fine sand, silt, stoneless; alluvial	15.9	
	Silt, minor sand near base; scattered stones; alluvial	5.0	
	Medium sand; alluvial	3.0	51.5
	Sharp contact		
M	NON-GLACIAL (?)		
	Gravel; stones to 3/4 inch long; alluvial	0.5	
	Gravel, sand; stones to 1/2 inch long near base, medium sand near top; alluvial	2.6	3.1
	Sharp contact		
L	NON-GLACIAL		
	Fine to medium sand; stoneless except for scattered pieces of coal; alluvial	7.0	7.0
K	NON-GLACIAL (?)		
	Gravel, yellow to rust colour; stones to 3/4 inch long; alluvial	1.7	
	Silt	0.4	
	Gravel, yellow to rust colour; stones to 3/4 inch long; contains scattered fragments of wood; alluvial	1.2	3.3
	Sharp contact		
J	NON-GLACIAL (?)		
	Silt; contains scattered gypsum crystals; alluvial	1.7	

	Silt, sand, grit; yellow to rust colour; contains scattered stones; alluvial	1.1	2.8
	Sharp contact		
I	GLACIAL		
	Till, black if damp, dark bluish grey if dry, rust colour or yellow along joints; compact, indurated	3.7	
	Sand, till stringers, rust or yellow colour; stony	0.6	
	Till, black if damp, dark bluish grey if dry, rust colour along joints; indurated, compact, columnar structure; contains gravel lenses to 6 inches thick	2.7	7.0
	Contact hidden		
H	GLACIAL		
	Till, dark brown; outcrop largely obscured by slump; thickness estimated	25.0	25.0
	Sharp contact		
G	NON-GLACIAL (?)		
	Sand, loose, mostly massive; few or no stones but contains scattered pieces of coal	15.0	
	Sand, yellow or rust colour, compact	3.5	
	Sand, grit, pebble bands; normally rust colour, in places light to dark grey; contains scattered pieces of wood (source of wood for radio-active carbon dating)	0.8	19.3
	Sharp contact		
F	BEDROCK MASSES		
	Siltstone, consolidated, dark grey	1.0	
	Sandstone, consolidated, white; contains an ironstone band, clay partings, and coaly lenses	4.0	5.0
	Sharp contact		

E	GLACIAL Till (Maunsell till?), dark brown to black; indurated, compact columnar structure well developed; thickness approximate	30.0	30.0
	Sharp contact		
D	NON-GLACIAL (?) Sand	1.0	1.0
	Sharp contact		
C	GLACIAL Till (Labuma till), dark blue to black; indurated, compact, columnar structure	30.0	30.0
	Sharp contact		
B	PREGLACIAL Gravel, minor sand (Saskatchewan gravel and sand); upper 3 feet of unit is weathered and rusty; stones to 6 inches but mostly less than 4 inches long	20.0	20.0
	Sharp contact		
A	BEDROCK Bearpaw Formation	15.0	15.0
	Level of Oldman River	-	-
	Total thickness		315.4

Discussion—The Kipp section was previously discussed by the writer (Stalker, 1958a, b), but unit reference letters are changed here. Radiocarbon dates of wood collected from unit G are as follows:

L 433 B.....greater than 30,000 years
L 433 B (Humic portion)..... " " 34,000 "
L 455 A..... " " 25,000 "
L 455 A (Humic portion)..... " " 37,000 "

These dates suggest that all deposits underlying unit G are older than the classical Wisconsin.

Section 4 (Peigan Section). South bank of Oldman River, in Peigan Indian Reserve about 2 miles northwest of Peigan, in approximately SE 1/4 sec. 21, tp. 8, rge. 27, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
J	GLACIAL		
	Sand, scattered stones with lenses of gravel towards bottom, outwash	25.0	
	Contact mostly sharp		
	Coarse gravel; stones to 24 inches long, mostly 1 inch to 4 inches long; poorly sorted; gravel grades laterally both to east and west into ripple-marked sand, apparently brought in from southeast; outwash	40.0	65.0
	Sharp contact		
I	GLACIAL		
	Sand, grit, scattered stones; massive, outwash	3.0	
	Gradational contact		
	Gravel; stones mostly 1 inch to 2 inches long; outwash	5.0	
	Sharp contact		
	Medium sand, lenses of fine gravel; outwash	8.0	16.0
	Generally a sharp, undulating contact		
H	GLACIAL		
	Till (Buffalo Lake till?), dark brown with streaks oxidized to reddish brown, silty; generally massive but locally contorted into overlying sand; contains Precambrian Shield stones	4.0	4.0
	Sharp contact		

G	GLACIAL Sand, minor silt, stones rare; sand beds up to 3 feet thick; the silt is contained in thin lenses; outwash (?)	10.0	
	Sharp contact		
	Till, reddish brown, locally oxidized to yellow; sandy, moderately stony with some Precambrian Shield stones; shows a poorly developed horizontal banding	1.0	
	Sharp contact		
	Sand, grey, locally oxidized to yellow; crossbedded; scattered stones; deposited from north	2.0	13.0
	Sharp contact		
F	GLACIAL Till (Labuma till), dark greyish brown if dry, dark grey to black if damp; well-indurated, compact, mostly massive but contains some oxidized sand and silt lenses; moderately stony, and contains Precambrian Shield stones; breaks into irregular pieces 1 inch to 4 inches long; displays contortion and deformation	9.0	9.0
	Sharp contact		
E	GLACIAL Silt, minor clay; varved with about 17 varves, which increase in thickness upwards; stoneless; lacustrine	4.0	4.0
	Sharp contact		
D	NON-GLACIAL (?) Sand, reddish brown; stoneless near bottom, but contains a pebble band and scattered stones near top; alluvial	1.5	1.5
	Contact generally sharp		

C	GLACIAL Till (Albertan till), light grey, but top 3 feet and bottom 3 feet oxidized brown; massive, except for pebble bands near top; stones numerous near bottom, but become fewer upwards, some to 12 inches long; does not contain Precambrian Shield stones	8.0	8.0
	Contact locally gradational, elsewhere sharp		
B	PREGLACIAL AND GLACIAL Gravel, reddish sand matrix; stones to 8 inches long, but mostly 1 inch to 3 inches long; stone types include quartzite, sandstone, limestone, dolomite, conglomerate, Crowsnest volcanic rocks, but no Precambrian Shield stones; the gravel has been contorted, the bedding mostly destroyed, and long axes of many of the stones are now vertical; mostly alluvial, but may include outwash from Oldman Valley glacier	5.0	5.0
	Contact hidden		
A	PREGLACIAL Slump; probably overlies gravel and bedrock	5.0	5.0
	Level of Oldman River	-	-
	Total thickness		130.5±

Discussion—This section contains the most easterly exposure of Albertan till (unit C) that has been noted along Oldman Valley. The lowest Laurentide till (unit F) is shown as Labuma till in Table I. If this rather uncertain designation is correct, units D and E are the best sample of water-lain deposits yet found between the Albertan and Labuma tills. This suggests that the Oldman Valley glacier had started its retreat before the Laurentide Labuma glacier reached this point, and that the sand and varved silt and clay were deposited in a lake ponded between the two glaciers. This exposure has one of the few examples seen of contorted Labuma till.

Most of the rest of the section consists of river deposits and outwash, and river erosion was probably responsible for removing the other tills. The chief till (unit H) above the Labuma is thought to be Buffalo Lake, but it is thin, contorted, and highly oxidized. This site lay directly in front of the ice-margin during one halt in retreat of the Buffalo Lake glacier, and near meltwater streams flowing from the ice. As a result the outwash overlying the Buffalo Lake till is thick and coarse.

Section 5 (Brocket Section). Northwest bank of Oldman River, about 4 miles northeast of Brocket, in S 1/2 sec. 34, tp. 7, rge. 28, W 4th mer.

(Note: This section is about 1 1/2 miles long, and stretches between NW 1/4 sec. 27, tp. 7, rge. 28, W 4th mer., and SW 1/4 sec. 35, tp. 7, rge. 28, W 4th mer.)

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
P	GLACIAL Scattered large boulders on surface	-	-
	Silt, sand, scattered stones; weathered; chiefly outwash	4.0	
	Sand, with boulders to 2 feet long; weathered, bedding destroyed; probably outwash	2.0	6.0
	Contact obscure		
O	GLACIAL OR NON-GLACIAL Sand, largely slumped and overgrown, loose; outwash or alluvium	8.0	8.0
	Contact obscure		
N	NON-GLACIAL Silt, sand, stoneless; alluvial or lacustrine	2.0	
	Fine sand, stoneless; alluvial or lacustrine	5.0	7.0
	Gradational contact		
M	GLACIAL Silt, clay; varved, with most of the varves about 3 inches thick and consisting chiefly of silt; the top part of this deposit is contorted; lacustrine	5.0	5.0
	Contact largely hidden, probably gradational		

L	GLACIAL Fine sand, stoneless; alluvial (?)	10.0	10.0
	Contact largely hidden, probably gradational		
K	GLACIAL Silt, clay; varved, with most of the varves 3 to 4 inches thick and consisting chiefly of silt; only a few scattered stones, which become rare towards the top; lacustrine	13.0	
	Gradational contact		
	Silt, stony; alluvial (outwash?)	2.0	15.0
	Gradational contact		
J	GLACIAL Till (Buffalo Lake till), light brown, silty; this is the most poorly consolidated till in this section and it is much slumped; breaks into small, irregular pieces; moderately stony, with about 4% Precambrian Shield stones, 1% Crowsnest volcanic rocks, 15% local bedrock; stone orientations indicate glacier movement of S44°W or N44°E	10.0	10.0
	Gradational contact		
I	GLACIAL (?) Silt, fine sand, light grey; extremely stony, with stones increasing in number upwards; beds about 1 foot thick; lacustrine or alluvial	4.0	4.0
	Sharp contact		
H	NON-GLACIAL Clay, lacustrine	0.5	
	Gradational contact		
	Silt, lacustrine (?)	0.5	
	Gradational contact		

	Silt, fine sand, light grey; bedded and displays current ripples; the numerous stones include Precambrian Shield types; volcanic ash parting near bottom; alluvial	2.0	3.0
	Sharp contact		
G	GLACIAL Till, light brown though darker than top till (unit J), many rusty streaks; silty and unconsolidated and does not form a prominent vertical cliff face; contains Precambrian Shield stones	8.0	8.0
	Gradational contact		
F	GLACIAL Till (Brocket till), dark brown; silty and poorly consolidated, though more compact and better indurated than overlying till (unit G) and forms a steeper cliff face; displays vertical structure, tending towards columns; moderately stony, with about 8% Precambrian Shield stones, 3% Crowsnest volcanic rocks, and 10% local bedrock; stone orientations indicate glacier movement of S58°W or N58°E	5.0	5.0
	Contact generally sharp, locally appears gradational		
E	GLACIAL Till (Maunsell till), light bluish grey, becoming somewhat darker near top; an indurated, compact, clayey and silty till displaying the best columnar structure of any till in the section; moderately stony with about 1% Precambrian Shield stones, 4% Crowsnest volcanic rocks, and 8% local bedrock; stone orientations indicate glacier movement of S58°W or N58°E	15.0	15.0
	Sharp contact		

D	GLACIAL Till (Labuma till), dark brown or grey to black, darkest of the tills in this section; a clayey indurated, compact, massive till, but less competent than underlying (unit C) and overlying (unit E) tills and does not form as steep a cliff face; breaks into small, angular pieces, 1 inch to 3 inches long; extremely sticky and rubbery if wet; moderately stony, with about 9% Precambrian Shield stones, 3% Crowsnest volcanic stones, and 10% local bedrock stones; stone orientations indicate glacier movement of S51°W or N51°E	17.0	17.0
	Sharp contact		
C	GLACIAL Till (Albertan till), light grey if dry, dark brown if wet; an indurated, resistant, silty till with tendency to columnar structure, and forms a nearly vertical cliff face; very stony, the stoniest till in section, due largely to a high content of stones from the preglacial river gravel and early glacial outwash gravel; does not contain Precambrian Shield stones, but contains 3% Crowsnest volcanic rocks and 25% local bedrock stones, the last being the highest percentage of such stones in any till of this section; stone orientations indicate glacier movement of S41°W or N41°E; locally there is a well-striated boulder pavement at top of this till, with soled boulders to 2 feet long; striae on surface of these boulders have average strike of about S40°W or N40°E	15.0	15.0
	Gradational contact		
B	PREGLACIAL TO GLACIAL Gravel, well-rounded to sub-rounded with stones to 10 inches long, but mostly 2 to 3 inches long, generally becomes finer		

	towards top; brown silt or fine sand matrix; this unit grades with decreasing number of stones and increasing content of matrix into the overlying till; no Precambrian Shield stones present, about 3% Crowsnest volcanic rocks and 14% local bedrock stones; the top foot of the gravel is weakly cemented with lime; largely outwash with some preglacial alluvial gravel	6.0	6.0
	Sharp contact		
A	BEDROCK Willow Creek Formation	5.0	5.0
	Level of Oldman River	-	-
	Total thickness		139.0

Discussion—The Brocket section was also described previously (Stalker, 1957). This is a straightforward and easily studied exposure, in which the sequence agrees in essentials with the other nearly complete section, No. 10. The Brocket section and Section 7 are the chief links in correlating between the Laurentide glacier deposits of the plains and the Cordilleran glacier deposits of the Foothills and Rocky Mountains.

Section 6. East bank of Castle River, about 3 miles west-northwest of Pincher, in NE 1/4 sec. 2, tp. 7, rge. 1, W 5th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
K	POST-GLACIAL Silt, brown, weathered towards top and contains lime stringers; a bank of volcanic ash less than 1/2 inch thick is present 4 feet from base; alluvial (?)	10.0	
	Gravel; stones to 8 inches long but mostly 1 inch long; many stones coated with lime; alluvial	3.0	13.0
	Sharp contact		
J	POST-GLACIAL Soil, dark grey; developed on alluvium	0.6	
	Soil, with whitish grey lime horizon; developed on alluvium	0.6	1.2
	Sharp contact		
I	POST-GLACIAL Gravel; stones to 8 inches long, mostly 1 inch to 3 inches long, include some Precambrian Shield stones; many stones coated with lime; sand lenses absent; alluvial	8.0	8.0
	Sharp contact		
H	GLACIAL Silt, clay; varved, with about 30 varves mostly 3 to 6 inches thick; moderately stony; lacustrine	15.0	15.0
	Sharp contact		
G	GLACIAL Till, dark brown, massive, breaks into small, irregular flakes, moderately indurated and compacted,		

	not very sticky; does not contain Precambrian Shield stones	10.0	10.0
	Sharp contact		
F	NON-GLACIAL Sand, yellow to brown, stoneless	0.3	0.3
	Sharp contact		
E	GLACIAL Sand, minor silt, greyish brown; very stony, with most of the stones between 1 inch and 3 inches long; the stony silt beds may possibly be till	5.0	5.0
	Sharp contact		
D	GLACIAL Till, dark brown; moderately indurated, compacted; breaks into small, irregular flakes; does not contain Precambrian Shield stones	25.0	25.0
	Sharp contact		
C	GLACIAL Silt, clay; varved, with 5 to 8 varves; rare stones	1.5	1.5
	Sharp contact		
B	GLACIAL Till, dark grey if damp, light grey if dry; contains many large boulders, does not contain Precambrian Shield stones	3.0	3.0
	Sharp contact		
A	BEDROCK Willow Creek Formation	35.0	35.0
	Level of Castle River	-	-
	Total thickness		117.0

Discussion—Tills 'B', 'D', and 'G' are thought to be the Cordilleran equivalents of the Maunsell, Brocket, and Buffalo Lake tills respectively (see Table I). These correlations are as yet tentative.

The volcanic ash in unit K is probably from the eruption of Glacier Peak, Washington, 6,700 years ago (Rigg and Gould, 1957).

Section 7 (Cowley Section). Northeast bank of Castle River, about 3 miles southeast of Cowley, in S 1/2 sec. 2, tp. 7, rge. 1, W 5th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
F	GLACIAL Coarse sand, alluvial	4.0	
	Silt, clay, varved, with varves 1 inch to 2 inches thick, lacustrine	15.0	19.0
	Sharp contact		
E	GLACIAL Till (Buffalo Lake till), greyish brown if damp, weathered rusty-yellow on exposed surfaces; silty, massive, poorly indurated and does not form steep cliffs, breaks into angular pieces about 1 inch long; numerous stones, many well striated; about 1% of stones are from Precambrian Shield	20.0	20.0
	Sharp contact		
D	GLACIAL Silt, clay; varved with about 18 varves composed of dark grey silt and black clay, mostly 2 inches but up to 8 inches thick; varves are thickest near centre of unit where they also contain many stones; lacustrine	5.0	5.0
	Sharp contact		
C	GLACIAL Till, dark grey if dry, dark grey to black if damp, much darker than underlying or overlying tills; silty, clayey, indurated, compact, massive, breaks into irregular small pieces; slight tendency towards columnar structure on cliff face; stony, stones mostly		

	limestone and sandstone, does not contain Precambrian Shield stones	11.0	11.0
	Sharp contact		
B	GLACIAL Till, light grey or buff if dry, dark grey if damp; silty, indurated, compact; weakly bedded near top and bottom with about 30 thin horizontal stringers of silt present, but elsewhere massive; breaks into angular pieces 1 inch to 3 inches long; stony, with about 3% Precambrian Shield stones, 4% Crowsnest volcanic rocks, remainder mostly sandstone and limestone	18.0	18.0
	Sharp contact		
A	BEDROCK Willow Creek Formation	25.0	25.0
	Level of Castle River	-	-
	Total thickness		98.0

Discussion—The bedrock (unit A) dips eastward at about 20 degrees, but has been truncated and planed off to give a sharp, horizontal contact with the overlying till.

Till unit B resembles the Maunsell till in Section 5. Stone orientations in it indicate glacier movement of either N55°W or S55°E. Movement was probably northwesterly, however, and may have resulted from the ice expanding northwards after having advanced westward through the Porcupine Hills up Oldman Valley.

Stone orientations in till unit C show two preferred directions—N67°E (or S67°W) and N75°W (or S75°E). The average alignment is about east-west. The absence of Precambrian Shield stones indicates that the glacier was advancing eastward, or toward Oldman Valley.

The top till (unit E) is thought to correspond to the Buffalo Lake till found on the plains. Its stones have a pronounced N77°W (or S77°E) orientation. As this appears to be a Laurentide till the glacier is thought to have advanced westward up Oldman Valley through the Porcupine Hills, thence spreading northwestward toward Crowsnest Valley.

A recent slip-off slope, which truncates the other deposits and is locally covered with a few feet of river gravel, forms the surface of the cut. At the east end of the section the cliff rises gently for another 50 feet above the part of the exposure described, but the underlying material is completely hidden by vegetation. This material is thought to consist mostly of varved lake silt and clay.

Section 8. East bank of Castle River, about 4 miles west of Pincher Creek, in east centre sec. 27, tp. 6, rge. 1, W 5th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
J	POST-GLACIAL Sand, silt, scattered stones; weathered, obscured by slumping and vegetation; alluvial	10.0±	10.0±
	Contact hidden		
I	GLACIAL Silt, clay, thinly varved; overgrown and covered by slump; lacustrine	5.0	
	Silt, scattered stones; weathered, overgrown, and partly covered by slump; probably outwash	10.0	15.0
	Contact mostly hidden		
H	GLACIAL Till (Buffalo Lake till), light brown, silty and sandy; poorly consolidated and slumps easily; Precambrian Shield stones common; largely overgrown	20.0±	20.0±
	Contact mostly hidden		
G	GLACIAL Gravel; stones mostly 1 inch to 3 inches long, round to subround; deposit largely hidden by slump and overgrowth; alluvial or outwash	3.0	
	Silt, clay; thickly varved; stony; mostly covered by slump; lacustrine	10.0±	13.0±
	Contact mostly hidden		

F	GLACIAL		
	Till (Buffalo Lake till?), minor sand, light brown; the sand occurs in thin partings cutting horizontally through the till; poorly consolidated and mostly covered by slump; contains Precambrian Shield stones	10.0	
	Sand, white, stoneless	1.0	
	Till, light brown, sandy; similar to till above	2.0	
	Sand, scattered stones; poorly bedded; a boulder pavement with stones to 1 foot long is present at top; resembles till, but is probably outwash	4.0	
	Till, light brown; resembles the till high in this unit	4.0	21.0
	Sharp contact		
E	NON-GLACIAL (?)		
	Sand, silt, rare stones; alluvial (?)	4.0	4.0
	Sharp contact		
D	GLACIAL		
	Till; resembles the till lower in this unit	1.0	
	Sand, medium; scattered stones; alluvial (?)	1.0	
	Sharp contact		
	Till, very dark brown, sandy; contains more large stones than the other tills, also contains a few Precambrian Shield stones; this is a well-indurated, resistant till, which forms a vertical cliff face	5.0	7.0
	Sharp contact		

C	GLACIAL Till, very dark brown to black, the darkest till in this section; sandy and silty, moderately stony; does not contain Precambrian Shield stones; massive, breaks into angular pieces about 1 inch long; forms a fairly steep cliff face	12.0	12.0
	Sharp contact		
B	ALLUVIAL (?) Gravel, much slumped and surface largely covered, but appears to be poorly sorted and bedded; consists of round stones 1 inch to 10 inches long, with sand matrix; Precambrian Shield stones not seen	12.0	12.0
	Sharp contact		
A	BEDROCK Willow Creek Formation	40.0	40.0
	Level of Castle River	-	-
	Total thickness		154.0

Section 9. West bank of Oldman River, about 5 miles north of Cowley, in NE 1/4 sec. 16, tp. 8, rge. 1, W 5th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
G	GLACIAL (?) Slumped and overgrown; stones including many Precambrian Shield stones common on surface; poorly consolidated Buffalo Lake till probably underlies the surface slump and vegetation	40.0	40.0
	Contact covered		
F	NON-GLACIAL Silt, fine sand, coarsest near top; massive, with suggestion of vertical or columnar structure; stoneless; probably loess, aeolian	20.0	20.0
	Sharp contact		
E	GLACIAL Silt, clay; varved, grading from thin varves mostly composed of clay at base to thicker varves consisting mostly of silt at top; scattered stones, which become more common upwards	13.0	13.0
	Gradational contact, with till becoming more clayey and less stony upward		
D	GLACIAL Till, dark brown, clayey; massive, good columnar structure, breaks into angular pieces 1 inch to 3 inches long; stony, with a few Precambrian Shield stones	13.0	
	Gradational contact		
	Till, silty, brown to grey, lighter in colour than overlying till; less indurated than overlying till;		

	includes horizontal silt partings and suggestion of horizontal banding. Precambrian Shield stones not seen	7.0	20.0
	Gradational contact		
C	GLACIAL Silt, clay; varved, stony, and the silt bands by themselves resemble till; lacustrine	2.0	
	Sharp contact		
	Silt, clay; varved, with 6 varves; stoneless; lacustrine	0.5	2.5
	Sharp contact		
B	GLACIAL Till, light buff if dry, medium grey if damp; shows good columnar structure, but this is not as well developed as in overlying till (unit D); stony at base, stones fewer but larger upward, many large boulders of local sandstone in middle; Precambrian Shield stones not seen	10.0	10.0
	Sharp contact		
A	BEDROCK Willow Creek Formation	25.0	25.0
	Level of Oldman River	-	-
	Total thickness		130.5

Discussion—The two parts of till unit D and the underlying and overlying silts (units C and E) probably represent a single depositional sequence. Deposition of fine material commenced when the Crowsnest Valley glacier dammed Oldman River and ponded a proglacial lake. As Cordilleran ice approached, the deposits became stonier until a weak glacier covered the area and laid down a till. A strong Laurentide glacier then replaced the waning Cordilleran ice and deposited the best till seen in the exposure. A proglacial lake succeeded the Laurentide ice, and lacustrine varved silt and clay were deposited. With further retreat of the waning Laurentide ice and shoaling of the lake, streams from the west brought more material to this point and the varves thicken and become stonier upward. Loess was deposited by the wind after the lake had drained.

Section 10 (Spring Coulee - Pinepound Section). The Spring Coulee section lies on the northeast bank of St. Mary River, about 2 miles north of Spring Coulee, in SE 1/4 sec. 8, tp. 5, rge. 23, W 4th mer.

The Pinepound section is on the east bank of Pinepound Creek, just above its junction with St. Mary River, in NE 1/4 sec. 5, tp. 5, rge. 23, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
L	POST-GLACIAL Sand, silt, yellowish brown, stoneless; aeolian	1.0	1.0
	Sharp contact		
K	POST-GLACIAL Soil, developed on alluvial silt; dark purple to black at top, grading through brown "B" horizon to white lime horizon; stoneless; a poorly developed soil	0.8	
	Silt, dark brown, becoming very dark towards bottom, stones rare; vertical jointing and structure, some suggestion of horizontal banding, including 8 carbonaceous bands; aeolian, or flood-plain deposit	6.0	
	Soil, dark purple to black at top, grading through brown "B" horizon to white lime horizon at base; stoneless	3.0	
	Coarse sand, light purple; pebbles rare near base but become more common upwards; these include pieces of charcoal and coal, and are mostly subangular; bedding horizontal and deposit not deformed; alluvial	2.0	11.8
	Sharp contact		
J	GLACIAL AND POST-GLACIAL Sand, light grey, crossbedded, contorted; deposited from northwest; alluvial	4.0	

	Silt, minor clay, partly varved; light brown; this material is strongly deformed and has been intermixed with upper part of underlying till; lacustrine	4.0	8.0
	Contact obscure		
I	GLACIAL Till (Buffalo Lake till), clayey and silty, reddish brown if dry, dark brown if damp; poorly consolidated, noticeably less consolidated than lower tills, vertical joints cause blocks 1 inch to 2 inches wide, which aid in formation of steep cliff faces; large stones rare but smaller ones moderately common; about 28% of stones (excluding stones from local bedrock) are from Precambrian Shield; stone orientations indicate glacier movement of N87°W or S87°E (probably the latter); upper 5 feet of this till is strongly contorted into overlying silt and clay	20.0	20.0
	Sharp contact		
H	GLACIAL Silt, minor clay, light grey with rusty yellow streaks; weakly varved, with varves 1 inch to 3 inches thick; lacustrine	3.0	
	Silt, minor gravel; pebbles are subangular to subround; lacustrine or alluvial	4.0	
	Silt, minor clay, gravel; weakly varved with about 18 varves in the unit; contorted gravel beds at base, mostly lacustrine	3.0	10.0
	Sharp contact		
G	GLACIAL Till, light brown with rusty streaks along joints; a silty-sandy till with minor lenses of silt and gravel; large stones rare but smaller ones moderately common; Precambrian Shield to Cordilleran stone ratio is 7 to 93; stone orientations indicate		

	glacier movement of N50°W (or S50°E); upper part of this till is locally intermixed with overlying silt, clay, and gravel	25.0	25.0
	Contact obscure		
F	GLACIAL Sand, silt, clay; varved; unit is largely obscured by slump and shows strong deformation	4.0	4.0
	Contact obscure		
E	GLACIAL Till (Brocket till), dark brown, very dark if damp; has weak columnar structure and forms steeper cliff faces than overlying till; large stones rare but smaller ones moderately common; Precambrian Shield to Cordilleran stone ratio is 5 to 95; stone orientations indicate glacier movement of N50°W (or S50°E)	20.0	20.0
	Sharp contact at Pinepound exposure		
D	GLACIAL Till (Maunsell till), silty, light bluish grey if dry, bluish brown if damp; columnar structure; large stones are rare, and stones in general are noticeably smaller than in underlying (Labuma) till; Precambrian Shield to Cordilleran stone ratio is 6 to 94; stone orientations indicate glacier movement of N53°E (or S53°W)	20.0	20.0
	Nature of contact unknown		
C	GLACIAL Silt, minor clay, light grey; deposit is varved with about 60 thin varves, which become thicker upwards; a layer of till-like material about 1 foot thick occurs near middle of the deposit; some scattered stones which		

	become more common upwards; lacustrine	5.0	5.0
	Sharp contact		
B	GLACIAL Till (Labuma till), dark grey to black if damp, lighter if dry, upper part oxidized to light brown, darkest of the tills; clayey and silty, massive, compact and hard; breaks into angular fragments 1 inch to 3 inches long; has a weak columnar structure on cliff faces; large stones (1 foot to 2 feet long) common, Precambrian Shield to Cordilleran stone ratio is about 1 to 3; stone orientations indicate glacier movement of N5°W or S5°E (probably the latter)	20.0	20.0
	Sharp contact		
A	GLACIAL Till (Albertan till), minor silt, clay; till is dark, greenish brown if damp, yellowish grey if dry; includes horizontal partings of pink silt and black clay towards bottom of unit; contains many small, angular stones, none of which are of Precambrian Shield origin	2.0	2.0
	Level of Pinepound Creek	-	-
	Total thickness		146.8

Discussion—Murakami (1960) discussed this section in detail. The exposure occurs at the spot where the modern St. Mary River crosses a preglacial valley.

Preglacial gravels are not exposed at either the Spring Coulee or Pinepound subsections. Holes drilled nearby enter such gravel at greater depth and the gravel probably directly underlies the Albertan till at both these exposures.

The Albertan till (unit A) is exposed only at the Pinepound exposure. The lack of Precambrian Shield stones indicates this is a Cordilleran till, and the pink silt bands suggest

a southern or western origin. As only the very top of this unit was exposed, stone orientations could not be made, but the stones appear to have northward alignment. The glacier responsible for this till is thought to have advanced northward down the preglacial St. Mary Valley.

The intertill silt and clay (unit C) is seen only at the Spring Coulee subsection, whereas the Maunsell till (unit D) is best exposed at the Pinepound cut. Although the intertill unit is probably correctly placed in the section, it may possibly be later than the Maunsell till.

The deposits overlying the Maunsell till (unit D) are displayed to best advantage at the Spring Coulee exposure, and some of the units are missing at the Pinepound exposure.

The deformation of units F, G, H, I, and J is not necessarily caused by slumping, but may result from effects of later ice-advances and, particularly in the highest beds, from frost action.

Unit L was deposited by dust storms over a widespread region during the dry years between 1930 and 1940, and covered well-developed soils. Only a weakly developed soil has yet formed on it.

Section 11 (De Winton Section). South bank of Bow River, about 7 miles east of De Winton, in E 1/2 sec. 5, tp. 22, rge. 28, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
H	POST-GLACIAL		
	Soil, developed on aeolian sand; light to dark brown; probably formed since 1930	1.0	-
	Soil, developed on aeolian silt; light brown at base, dark brown to black at top	1.0	2.0
	Sharp contact		
G	POST-GLACIAL		
	Soil, developed on alluvial silt; light brown at base, black at top; scattered small stones	1.5	
	Fine sand and silt, limy, alluvial	2.0	
	Fine sand, scattered small stones; displays good bedding and cross-bedding; in places the upper part of this sand has been eroded, leaving a surface concentration of stones; this deposit is locally absent; alluvial	6.0	9.5
	Sharp contact		
F	GLACIAL		
	Till (Buffalo Lake till), light brown near top, darkens downward to dark brown or dark grey towards base; poorly consolidated near top, better consolidated towards bottom; contains Precambrian Shield stones	18.0	18.0
	Sharp contact		
E	NON-GLACIAL (?)		
	Sand, light brown, indurated, stony; locally absent; alluvial	2.5	
	Gradational contact		

	Sand (fine to medium), light brown, stoneless; alluvial	2.5	5.0
	Sharp contact		
D	GLACIAL Till, sand; unit consists of 24 bands of alternately dark grey or blue, clayey, compact till and fine, stoneless sand; till beds are up to 4 feet thick, sand beds to 3 feet thick	20.0	20.0
	Sharp contact		
C	GLACIAL Gravel, sand matrix; stones up to 6 inches long, but mostly 2 inches long; alluvial	2.5	
	Sharp contact		
	Sand; grades from medium near bottom to coarse near top; scattered stones, particularly numerous near middle where deposit has till-like appearance; alluvial	4.0	
	Sharp contact		
	Till, sandy, stony	0.5	
	Sharp contact		
	Medium sand, bluish grey, stoneless; alluvial	3.0	10.0
	Sharp contact		
B	GLACIAL Till (Labuma till), dark grey, well-indurated, compact, massive; contains Precambrian Shield stones; most of unit is covered by slump	90.0±	90.0±
	Sharp contact		
A	PREGLACIAL TO GLACIAL Gravel; grades from medium gravel in top 5 feet, with stones to 8 inches but mostly 3 inches long, to		

coarse near bottom, with stones to 24 inches, but mainly 8 inches long; bottom part of unit also contains angular blocks of local bedrock up to 12 feet long and rounded boulders to 5 feet long; these large blocks are well-striated; stones are chiefly quartzite, sandstone, dolomite and particularly among the smaller stones, limestone; mostly outwash (Albertan outwash) from Bow Valley glacier	30.0	30.0
Level of Bow River		
Total thickness		184.5

Discussion—An early Bow Valley glacier approached this exposure from the west, but perhaps did not quite reach it. Outwash from this glacier forms a large part of unit A, and is equivalent to the Albertan till found a few miles upstream. The increasing fineness upwards of unit A indicates that the Bow Valley glacier was retreating as the Laurentide glacier advanced westward. It may, though this is less likely, be due to deepening of the lake ponded in front of the Laurentide ice, which forced meltwater streams from the Bow Valley glacier to drop the coarse part of their load farther to the west.

Units C and D probably belong to the same sequence of deposition. Similar interbedded till and sand is described under Section 2, where alternate floating and grounding of the margin of an ice-sheet is thought to be the most likely cause of the alternation of beds. In the present case, however, post-depositional deformation may have had an important role in intermingling the beds.

Section 12 (Red Deer Section). Gravel pit in City of Red Deer, at south edge of town, just west of old highway crossing with Canadian Pacific Railway, in SE 1/4 sec. 17, tp. 38, rge. 27, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)
F	POST-GLACIAL		
	Soil, supporting aspen poplar and other vegetation	2	
	Sandy gravel, purplish; stones mostly less than 1 inch long; contains many pieces of coal; Red Deer River alluvium	3	5
	Sharp contact		
E	GLACIAL		
	Silt, clay, varved; varves mostly 8 to 10 inches thick with relatively thick silt bands and thin clay bands	10	
	Sharp contact		
	Silt, clay, minor till, varved; consists of deformed varves about 3 inches thick, with till replacing silt in varves near middle of deposit	5	15
	Sharp, undulating contact		
D	GLACIAL		
	Till (Buffalo Lake till), brown, only weakly indurated; contains stones from Precambrian Shield	7	7
	Sharp contact		
C	GLACIAL		
	Till (Maunsell till?), sand; till is dark blue; at south end of exposure sand lies below till, but towards north end it is found in blocks up to 4 feet long that are surrounded by till; there, underlying sand has been squeezed up into till		

	and whole mass is strongly contorted; till contains stones from Precambrian Shield	10	10
	Sharp contact		
B	GLACIAL Till (Labuma till), dark blue or grey if dry, black if damp; contains Precambrian Shield stones; till is missing at south end of exposure	4	4
	Sharp, even contact marked by well-developed boulder pavement		
A	PREGLACIAL Sand, contorted and intermixed with upper part of underlying gravel	3	
	Gravel; stones to 10 inches long, mostly 1 inch to 4 inches long; no Precambrian Shield stones present	8	11
	Level of floor of gravel pit	-	-
	Total thickness		52

Discussion—The face of this gravel pit has been continuously pushed back for about 10 years in order to use the underlying gravel, and development is still taking place. The exposure was at its most informative stage during the summer of 1959. During these 10 years the thickness and degree of contortion of the units have varied greatly, but the sequence revealed has not changed. The sequence of beds is similar to that in the buried preglacial valley of Red Deer River northeastward to about Camrose, but the units along most of this buried valley, as revealed along banks of the present river and from drill-holes, are thicker.

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