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QUATERNARY STRATIGRAPHY IN SOUTHERN ALBERTA
REPORT II: SECTIONS NEAR MEDICINE HAT

(Report, 1 figure and 2 tables)

A. MacS. Stalker



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ABSTRACT

This paper continues the detailed description, begun by the author in 1963, of representative Quaternary sections in southern Alberta. It reviews the results of studies at three bluffs - here called Surprise, Mitchell, and Island* - located along South Saskatchewan River near Medicine Hat. These three sections were chosen from the large number available in the region because of their many similarities, which suggested the possibility of inter-correlation, and because certain of their beds contain many fossil bones. In addition, one of the beds that is among the most prolific producers of bones also yields stones that appear to have been worked by man. These consist mostly of chert pebbles that have been broken and then chipped along one or more edges.

Although the studies encompassed archeology, vertebrate paleontology, and glacial geology, this report deals chiefly with the glacial geology. However, all the age determinations beyond range of radiocarbon dating are based on vertebrate paleontology. The beds apparently range from Kansan to Recent in age, and record at least four separate glacier advances and several interglacial or interstadial intervals. Much study was directed to the unit containing the chipped stones. Its abundant fauna indicates deposition during warm, interglacial conditions, probably in Sangamon time. The basal gravels of Kansan Age also contain many bones, as do presumed Mid-Wisconsin deposits found between the topmost two tills. Other beds have yielded bones in lesser numbers.

* names not officially approved but used here for identification of sections.

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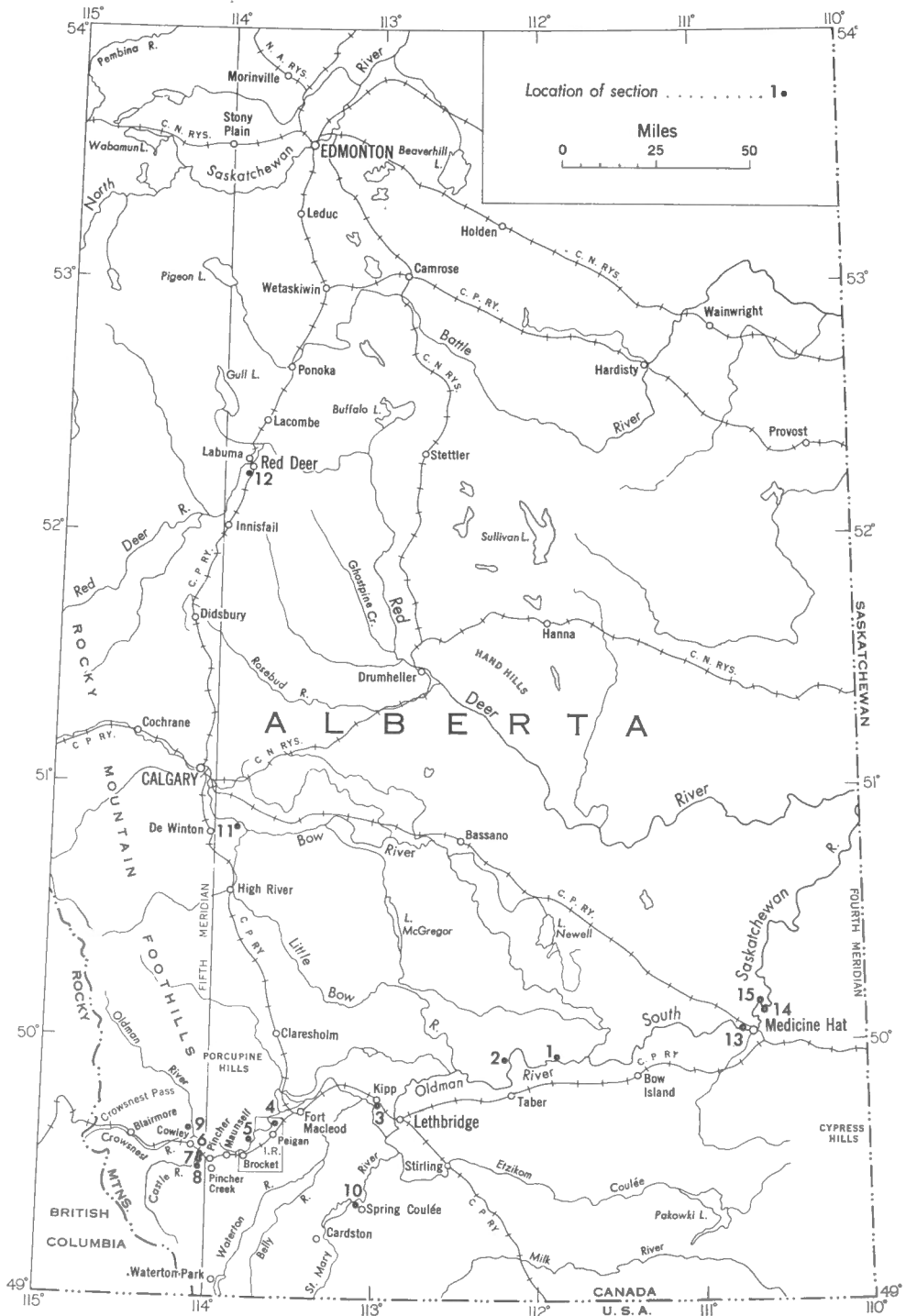


Figure 1. Locations of the Quaternary sections. Nos. 1 to 12 indicate sections previously described (Stalker, 1963). No. 13 = Surprise Bluff, No. 14 = Mitchell Bluff and No. 15 = Island Bluff.

QUATERNARY STRATIGRAPHY IN SOUTHERN ALBERTA

REPORT II: SECTIONS NEAR MEDICINE HAT

INTRODUCTION

In Report I of this series Stalker (1963, Appendix, pp. 11-52) described twelve Quaternary sections in southern Alberta. The present paper describes another three sections from the banks of South Saskatchewan River near Medicine Hat, in the southeastern part of the province. The locations of these three sections, and of the previous twelve, are shown on Figure 1. The sections are described to provide a geological background for studies in archeology and vertebrate paleontology being carried out in the region, and to give a preliminary account of findings up to the end of 1967. The three exposures discussed are only a few of the many found in the area, and some of the others not described here are even thicker and contain more units. These three were chosen because they were most prolific in both fossil bones and chipped stones that appear to have been worked by man. The choices were also intended to indicate where good, representative exposures can be examined.

ACKNOWLEDGMENTS

The writer is indebted to Dr. C.S. Churcher for all vertebrate identifications reported in this paper, and for his welcome advice and many profitable suggestions during the course of the field seasons. The writer expresses his gratitude to Mr. R. Hargrave Mitchell for permission to excavate and to collect fossils on his land, and for many other kindnesses. The writer also thanks Mr. L.O. Lindoe of Medicine Hat for valuable information on exposures and stratigraphy in the area, and for permission to study fossils collected by him over many years.

PREVIOUS WORK

Dawson (1885, 1896) was the first geologist to describe Quaternary deposits exposed along the rivers in southern Alberta. He was followed by Calhoun (1906) and Alden and Stebinger (1913), who described sections in the same region while engaged in studies of surficial geology in adjacent parts of the United States. Johnston and Wickenden (1931) discussed the Quaternary stratigraphy and gave general descriptions of various sections, during their extensive studies on the Prairies. Horberg (1952) made the first detailed study and described eighteen sections, most of them along Oldman River near Lethbridge. He followed this in 1954 with descriptions of sixteen exposures farther southwest, chiefly along Belly and Waterton rivers. Stalker (1963) next described the twelve sections mentioned earlier. Westgate (1965, p. 92) described two sections in the Medicine Hat region, the second of them corresponding to the Island Bluff section (see Appendix, Section 15). There are major differences in the two descriptions of this one section, particularly in

its lower parts. In a later report, Westgate (1968, pp. 95, 96; sections 11, 12, 13) repeated the two descriptions and added a third.

PRESENT STUDIES

The writer started work in the Medicine Hat region in 1959 with a reconnaissance survey of bluffs along the river, at which time bones were found in some exposures. Since 1963, the work has continued each summer, steadily increasing in scope as the value and complexity of the exposures became apparent. During the summers of 1965, 1966 and 1967 the writer was accompanied by Dr. C.S. Churcher, of the Royal Ontario Museum, Toronto, and the Department of Biology, University of Toronto. Dr. Churcher supervised collection and study of the vertebrate fossils.

GENERAL GEOLOGY

A complex system of buried valleys, ranging in age from perhaps pre-Quaternary to Mid-Wisconsin, criss-crosses the area near and north of Medicine Hat. Most of those valleys were at least as large as the present South Saskatchewan Valley. They are now filled with material deposited by successive glaciers, lakes, aggrading rivers, and wind. The deposits are exposed on numerous bluffs along the modern river, from a few miles west of Medicine Hat to about ten miles north of the city. The stratigraphy varies greatly, not only from bluff to bluff, but even within any single, long exposure. The exposures are also undergoing rapid change as the river eats into their bases and as major slumps take place. The slumps destroy parts of the exposures, but at the same time they reveal new facets by uncovering parts formerly hidden. Despite such factors, it is unlikely that future major revisions of the three descriptions given here will be required.

In the descriptions of the sections, the maximum thickness of a unit or bed is normally given, even though the unit may vary greatly in thickness or be missing in places. Radiocarbon dates are expressed in "radiocarbon years", without attempt to convert them to calendar years by correcting for the true half-life of C^{14} or for past changes in atmospheric C^{14} content. Generally, glacial or stade names accorded units beyond the range of radiocarbon dating have been obtained from identification of vertebrate fossils. These do not necessarily correlate directly with the similar names used by glacial geologists, and are generally older, e.g., the Kansan of the vertebrate paleontologist may be older than the Nebraskan of the glacial geologist.

Although the deposits described below span a large part of Quaternary time, deposition was intermittent and most of the period is not represented. Even during those stages represented, deposition took place during only a small part of the time.

STRATIGRAPHY

A provisional correlation between units at Surprise, Mitchell, and Island bluffs (see Appendix, Sections 13, 14, 15 respectively) is given in Table I. The writer considers it unwise at this time to attempt any correlation

with sequences described elsewhere, because the Medicine Hat exposures and others described previously evidently lie in different buried valley systems and the beds cannot be traced with certainty between the valleys. Study of vertebrate fossils and volcanic ash beds should, in time, permit such correlations.

Table I
Correlation of units at Surprise, Mitchell and Island bluffs

Deposit	Unit reference letters		
	Surprise Bluff (west)	Mitchell Bluff	Island Bluff
Postglacial deposits	SBK	MBM	IBP
Brown till	SBJ	MBL	IBO
Intertill deposits	SBI	*	IBN
Contorted till	SBH	MBK	IBL or IBM
Lowest intertill deposits	SBG	MBJ	IBJ
Lowest till	SBF	MBI	IBI
Upper sands and gravels	SBD	MBF, MBG, MBH	IBF, IBG, IBH
Lag (?) gravel	SBC	MBE	IBE
Lower sands	SBB	MBD	IBD
Carbonaceous deposits	*	MBC	IBC
Basal gravel and sand	*	MBB	IBB

* Deposit not noted in section.

Basal gravel and sand

The 'basal gravel and sand' is the oldest surficial deposit of the region. In Table I it is shown as Units MAB and IBB in Mitchell Bluff and Island Bluff sections, and probably is present beneath the basal slump at Surprise Bluff. This deposit typically is a loose, clean, well-sorted and well-bedded, round to subround river gravel, with sand lenses and matrix. It contains practically no weak or weathered material. No stone counts have been made at the three bluffs, but studies elsewhere in the vicinity indicate the gravel consists of about 15 per cent quartzite, 60 per cent hard sandstone, 10 per cent chert and flint, 13 per cent red or grey argillite, with some local bedrock and the occasional specimen of igneous sill-rock from the Rocky Mountains. No limestone and only one dolomite stone were found. The scarcity of carbonates may reflect the destruction of weak material during lengthy river transportation.

Apart from its position at the bottom of the surficial deposits, the feature that distinguishes the 'basal gravel and sand' from later gravel and sand deposits is its lack of the granites, gneisses, schists, gabbros, and pegmatites that subsequently were brought from the Precambrian Shield by Pleistocene ice sheets. The presence of red argillite, igneous sill-rocks,

abundant quartzite and hard sandstone, along with the almost complete absence of limestone, dolomite, and green argillite, indicates that the bulk of the deposit originated near the Glacier Park region of Montana, about 175 miles to the southwest.

By 1967, the 'basal gravel and sand' had yielded only a few scraps of bone at Island Bluff and none at Mitchell Bluff, though subsequently bones have been found in large numbers at both places. Bones found in these materials elsewhere in the vicinity have been identified. In 1967, Churcher (personal communication) commented on them as follows:

"The earliest beds comprising the Lowest Quartzite Gravels contain a restricted fauna with camel, horse, mammoth, sloth, and a possible dog. The horse can be identified with some confidence to Equus scotti, a form generally reported from the Kansan period, and the camel appears to show tendencies of being slightly smaller than Camelops hesternus and may well represent either Camelops kansanus, an unnamed species, or another camelid genus as yet not recognized

In conclusion, the identification of Equus scotti has confirmed a Kansan date for the lowest Quartzite Gravels."

The old age of the deposit and its position directly above bedrock near the base of a buried valley, together with the absence of stones from the Canadian Shield, would suggest that the deposit is part of the Saskatchewan Gravels and Sands. However, the writer considers it premature to assign it to that formation at this stage of the studies.

Carbonaceous deposits

The dark blue clay overlying the 'basal gravel and sand' at Island Bluff, and the fine sand in similar position at Mitchell Bluff, belong to the same unit (Table I, Units MBC and IBC). Despite its thinness, the unit is widespread in the Medicine Hat area, and has been found in exposures extending over a distance of six miles. As a result, it forms an easily recognizable marker horizon. The dark clay, rather than the fine sand, is its normal constituent.

The unit is highly carbonaceous wherever found, containing abundant plant remains and pieces of wood. In places, near the middle of the unit, these form a bed six inches to one foot thick. Though logs three feet or longer are present, most are six inches to one foot in length and have been flattened by the weight of overlying material. Leaves and stems of bushes and smaller plants are common, as well as seeds; all these are probably largely from swamp and pond plants. The plant material is largely of local origin, rather than having been washed into the deposit as is the case with the plant material in other units.

Deposition of the carboniferous materials began shortly after the underlying gravel had been laid down. The materials accumulated slowly and perhaps intermittently in shallow ponds, probably on an abandoned flood-plain. Every now and then the water level lowered sufficiently to allow tree growth on swampy areas, at other times it rose sufficiently to permit

deposition of clay or fine sand. The deposit marks a long interval between deposition of the underlying gravel and deposition of the overlying sands. Its time of deposition is apparently more closely associated with the gravel than with the sands.

This unit was first investigated at Island and Mitchell bluffs in 1968. Bones found at that time have yet to be identified.

Lower sands

'lower sands' is the name used for all materials between the 'carbonaceous deposits' and the deposit containing the first appearance of stones from the Precambrian Shield. They comprise Unit SBB at Surprise Bluff, Unit MBD at Mitchell Bluff, and Unit IBD at Island Bluff. These units consist mostly of medium to fine sand, generally becoming finer upward, but of silt with thin clay bands near the top. A few pebble bands and scattered pebbles are also present. Of the pebbles collected from the 'lower sands' at Mitchell Bluff, 20 per cent were quartzite, 30 per cent hard sandstone, 25 per cent chert and flint, 10 per cent argillite, and 15 per cent from local bedrock. In other exposures, 90 per cent of the pebbles were quartzite and hard sandstone, 3 per cent chert or flint, and the rest local bedrock. Obviously, the chief area of provenance remained the Rocky Mountains. As yet no glacier had reached the area to add stones from the Precambrian Shield.

Most of the 'lower sands' were laid down by a slow-flowing, meandering, aggrading river. The materials do not reveal any extended disruption of deposition and the unit probably was laid down as one continuous sequence. Alternate stages of high and low water, along with continuous change of river course, caused formation of the prominent channel bedding now displayed. During flood stages, fine sand and silt were deposited on the adjoining floodplains. The fine material toward the top of the unit evidently resulted from a slackening of current due to blockage of the river farther downstream. The varved silt and clay near the top at Mitchell Bluff demonstrates presence of cold water at the time it was formed. This, in turn, implies that an ice sheet was in the vicinity and that the river was being obstructed by an advancing glacier. Whether the approaching ice and resulting obstruction of the river were responsible for all the aggradation that formed the unit, is not known.

No radiocarbon dates have been obtained from the three sections described here, but elsewhere along the river wood from this sand unit has yielded dates of >46,700 years B.P. (GSC-543, Lowdon et al., 1967, p. 13) and >36,000 years B.P. (GSC-847, unpublished). The small amount of vertebrate material recognized to date in the 'lower sands' includes prairie dog (Cynomys cf. ludovicianus), elephant (Mammuthus sp. jeffersoni), horse (Equus cf. conversidens), and camel (Camelops sp.). Bones from these sands are less mineralized than those from the 'basal gravel and sand', and the fauna is markedly different. This indicates a long span of time between deposition of the 'basal gravel and sand' and commencement of deposition of these 'lower sands.'

Lag gravel (?)

A foot or two of poorly-sorted, largely angular to subangular, gravel overlies the 'lower sands' at Surprise, Mitchell, and Island bluffs (Units SBC, MBE and IBE respectively). This gravel contains abundant stones from the Precambrian Shield - the first indication of Laurentide ice sheets having reached the area. The gravel is thought to be a lag screened from till and other materials found elsewhere along the river at the same horizon but missing at the three bluffs. As seen elsewhere, those deposits consist of five feet of dark, nearly black, till covered by sixty feet of sand and gravel, in turn overlain by another forty-five feet of the dark till.

The gravel obviously was not transported far by water, but it was probably laid down by a river re-establishing its course following a glaciation and cutting through those dark tills and other deposits from the preceding glacial stage. It marks the beginning of an interglacial stage, probably the Sangamon.

No radiocarbon dates have been obtained from this unit, but at each of the bluffs it has yielded a few bones, including Equus cf. lambei or cf. niobraransis.

Upper sands and gravels

The 'upper sands and gravels' directly overlies the 'lag gravel' in most of the exposures along the South Saskatchewan River near Medicine Hat, and they generally form prominent features in the bluffs. The deposit is about one hundred feet thick at both Mitchell and Island bluffs, where it comprises Units MBF, MBG, MBH and Units IBF, IBG and IBH. It overlies the 'lag gravel' with gradational contact. At Surprise Bluff it consists of Unit SBD and is only twenty-two feet thick. Here the contact is erosional, and most of the lower part of the deposit is missing. However, the five-foot-thick, overlying clay, Unit SBE at the west end of Surprise Bluff, probably belongs to the same sequence of deposition, and forms the upper part of the deposit there. This clay unit has not been observed elsewhere but, in most places, the deposit is finer near the top than it is lower down.

The 'upper sands and gravels' were laid down over a protracted time in either shallow lakes or in a broad, interglacial valley by a sluggish, aggrading river. Because lake levels fluctuated and river channels meandered, deposition was intermittent and the deposits were frequently exposed to the air. The time covered by those lapses in deposition cannot be estimated. The beds of the top twenty or so feet of the deposit are normally much deformed and contorted. This is well displayed at both Mitchell and Island bluffs, but at Surprise Bluff is seen only at the east end (not described in the Appendix). The likely cause of the deformation is frost action, and this may have heralded the approach of a fresh glacier. The dark clay unit at Surprise Bluff may represent ponding in front of that advancing ice.

A gravel bed (Units MBG and IBG), found about two-thirds way up the deposit at both Mitchell and Island bluffs, is not present at the west end of Surprise Bluff but is prominent at the east end. It is here called the 'artifact band', because of the abundance of chipped chert stones scattered through it. This band has been the most prolific of all the deposits in the number of fossils produced, having yielded, up to the end of 1968, about one

thousand bone specimens, many of good quality and diagnostic. Most of them were from the Mitchell Bluff exposure. It also contains some small mollusc shells and weathered, rust-stained fragments of wood. Due to the presence of the chipped stones and the bones, the 'artifact band' has received more attention than any of the other units. Most of the work has been done at Mitchell Bluff, where excavation is easiest.

The 'artifact band' consists mainly of strongly crossbedded, poorly-sorted gravel composed largely of angular to subangular stones and including numerous armoured silt or clay balls. Sand and silt lenses are common. At Mitchell Bluff a well-consolidated bed of massive silt, upto one-foot-thick, forms the top of much of the deposit. The silt was laid down in quiet ponds on a river floodplain following deposition of the gravel, and it contains a few bones and plant fragments. At Mitchell Bluff the gravel is about 25 per cent quartzites and hard sandstones, 15 per cent dolomites, 10 per cent limestones, 8 per cent cherts and flints, and 30 per cent stones from the Precambrian Shield, with the remainder being from local bedrock and sill or volcanic rocks from the west. The quartzites and sandstones came mostly from the Rocky Mountains, whereas the dolomites and most of the limestones and cherts were brought by Laurentide glaciers from the cherty, Paleozoic carbonate formations found along the southwestern edge of the Precambrian Shield, and probably from Manitoba. Many of the dolomites are striated. Interestingly enough, many of the stones in the gravel are strongly wind-faceted, polished, or frosted. The angularity and poor sorting of much of the deposit, and the small amount of water abrasion of the bones, show that the gravel was not carried far by water before deposition. Flash floods under arid conditions may have deposited much of the bed.

The chipped stones in the 'artifact band' consist mostly of chert. There are also a few igneous rocks that may have been used for polishing or rubbing, and a few bones that appear to have been worked by man. Some of the cherts display secondary flaking along the knife edges. The author is not competent to judge whether these objects are truly artifacts, a decision best left to archeologists, but as a geologist he has, up to now, been unable to visualize any natural method that could have shaped some of these objects.

The 'artifact band' has yielded two radiocarbon dates: GSC-780, wood from Mitchell Bluff, dated > 30,000 years B.P. (Lowdon and Blake, 1968, p. 219); and GSC-876, mollusc shells from the east end of Surprise Bluff, dated > 36,000 years B.P. (unpublished). Mollusc shells collected at Surprise Bluff and identified by Dr. A.H. Clarke, Head, Invertebrate Zoology Section, National Museum of Canada, included:

Aquatic Species

Sphaerium sulcatum (Lamarck)
Stagnicola sp.

Pisidium compressum (Prime)
Gyraulus deflectus (Say)

Terrestrial Species

Oxyloma cf. retusa (Lea).

Dr. Clarke comments:

"The aquatic mollusks are characteristic of perennial, mesotrophic to eutrophic water bodies. The assemblage is probably derived from a depth close to or deeper than the limit of emergent vegetation because pulmonate gastropods are not well represented.

... Probable depth range: 5 to 10 feet (estimate)."

Table II
Fauna from 'upper sands and gravels'

Fauna	Occurrence		
	Surprise Bluff	Mitchell Bluff	Island Bluff
<u>Canachites ? canadensis</u> (spruce grouse)			X
<u>Homo sapiens</u> (man) (indirect evidence only)	X	X	X
<u>Lepus</u> sp. (hare)			X
<u>Cynomys</u> cf. <u>ludovicianus</u> (black-tailed prairie dog)		X	X
<u>Citellus ? richardsonii</u> (Richardson's ground squirrel)		X	X
Rodentia indet. (mouse)			X
<u>Canis</u> sp. (dog)		X	
<u>Vulpes</u> sp. (fox)			X
<u>Mammuthus jeffersoni</u> (Jefferson's mammoth)	? X	X	X
<u>Equus conversidens</u> (Mexican ass)	X	X	X
<u>Equus</u> spp. indet.		X	
<u>Camelops hesternus</u> (western camel)	X	X	X
<u>Cervus canadensis</u> (wapiti)			X
<u>Rangifer tarandus</u> (caribou)			X
<u>Antilocarpa americana</u> (prongbuck)			X
<u>Ovis</u> cf. <u>canadensis</u> (mountain sheep)			X
<u>Bison</u> sp. ? cf. <u>latifrons</u> (extinct large bison)	? X	X	

Though bones are commonest in the 'artifact band', they are also found throughout the entire 'upper sands and gravels', and particularly good specimens have come from the sands and silts lying between the 'artifact band' and 'lowest till'. Fragments of rust-stained, weathered wood and small mollusc shells are also most prevalent in those upper deposits. Animals identified from the 'upper sands and gravels' up to the end of 1967 (Table II) indicate a fairly warm climate.

In addition to the fauna reported in Table II, Westgate (1965, p. 92) listed Bison bison occidentalis? as being present near the top of the 'upper sands and gravels'. Dr. Churcher, while examining the site from which Westgate's bison bones came, noticed that other bones at that location appeared fresh, and that the overlying beds were disturbed. Some of those

bones were, therefore, radiocarbon dated, and the result, 0 ± 140 years B. P. (GSC-704; Lowdon and Blake, 1968, p. 219), confirmed that the bones were of recent origin. Apparently they had been buried by slump. The date casts doubt on the identification of Bison bison occidentalis?, for that bison is generally considered to have become extinct several thousand years ago.

Lowest till

The 'upper sands and gravels' are overlain by twenty-five feet of grey till at Island Bluff (Unit SBF), by six feet of somewhat darker grey till at Mitchell Bluff (Unit MBI), and by nine feet of dark greyish-brown till at Island Bluff (Unit IBI). Those units apparently represent the same till sheet, though the correlation with Island Bluff is less definite than that between Surprise and Mitchell bluffs. For convenience in this report, this till sheet is referred to as the 'lowest till'.

The 'lowest till' is typically silty and clayey, and is less stony than other tills of the region. It is also typically dark, compact, dense, and well-consolidated, though perhaps less indurated than the overlying till and so forming a gentler cliff face. Its outstanding characteristic is a tendency to break into narrow fragments, one to three inches long, that are hard, irregular, and angular. The till normally is massive, and only at Island Bluff is other material present. This "other material" consists of a white-coloured silt and sand bed that may be merely a large inclusion of local bed-rock, flattened and spread out.

Counts at Mitchell and Island bluffs indicate that about 50 per cent of the stones are carbonates or cherts from the Paleozoic formations found along the southwestern edge of the Canadian Shield. Another 30 per cent came from the Shield proper, and the rest are of local origin or were first brought into the region from the Rocky Mountains by river and subsequently picked up by ice. The stone counts suggest that the glacier movement had a strong southwesterly component. However, an orientation study at Mitchell Bluff indicates flow toward S 65° E; at Island Bluff it is also to the southeast, whereas at Surprise Bluff results were indeterminate. No matter from what direction flow may have been, the ice had certainly advanced several hundred miles over the dark shales, siltstones, and sandstones of the Prairies before reaching the area. As a result, the Cretaceous formations of the Great Plains supplied the silt and clay to the matrix of the till, and those materials are chiefly responsible for the dark colour and other properties of the unit.

The age of the 'lowest till' can only be conjectured. If the glacier that laid it down also caused the proglacial ponding represented by Unit SBE at Surprise Bluff and the deformation evident at the other bluffs, the till evidently was laid down shortly after deposition of the 'upper sands and gravels'. If the 'upper sands and gravels' are of Sangamon Age, the till should be pre-Classical Wisconsin. However, the number of overlying till sheets and fossiliferous units indicate that it may be older.

Lowest intertill deposits

The alluvial and lacustrine deposits forming Unit SBG at Surprise Bluff, Unit MBJ at Mitchell Bluff and Unit IBJ at Island Bluff, have yielded bones only at Island Bluff. Those bones, which included ?Equus sp., ?Mammuthus sp., and possibly artiodactyl, came from the angular, poorly-sorted gravel forming the bottom of the unit there. Elsewhere, what is thought to be the same unit has yielded Mammuthus primigenius. Screening of the sand and silt at Mitchell Bluff would probably reveal bones of small animals there also. Small pieces of wood found at Mitchell Bluff gave a radiocarbon age of >38,000 years B. P. (GSC-1044, unpublished).

When first discovered, this unit was thought to be of minor importance and was largely ignored. The discovery of the bones and wood was completely unanticipated. The interval represented by the unit must now be recognized as having been sufficiently long for development of soil, growth of trees, and introduction of the fauna mentioned above. It is probably of interstadial rank. Its age is not known, but may be pre-Classical Wisconsin. In the unlikely circumstance of the interval being interglacial, it would be of Sangamon Age.

Contorted till

The dark grey till Unit MBK at Mitchell Bluff corresponds to the dark, greyish-brown till Unit SBH at Surprise Bluff. It is not known which of units IBL or IBM is the corresponding till at Island Bluff; both may be.

This unit is referred to as the 'contorted till' because its strong deformation, best developed towards the base of the unit, is a distinguishing trait practically everywhere. None of the other tills show this deformation to nearly the same extent. It reveals itself in convolutions; in inclusions of sand, silt, or bedrock completely enclosed by till, or of till completely incased in sand, silt, or bedrock; in stringers of till jutting into underlying deposits and lenses of those deposits injected upward into the till; and in strong internal folding and faulting. These features commonly are accentuated by abundant inclusions from the underlying material, whether bedrock or surficial deposits, that contrast vividly with the till itself. In places the deformation is so strong and inclusions so abundant that it is impossible to draw a demarcation between the till and underlying deposits. Of the three bluffs under consideration, this deformation is best seen at Surprise Bluff, but is even better displayed at other bluffs in the vicinity.

The 'contorted till' resembles the 'lowest till' in most respects, and its characteristics arise from the same source - incorporation into its matrix of vast quantities of dark clay and silt from the Cretaceous formations of the Prairies. However, the unassimilated inclusions and the contortions cause it to be weaker than the 'lowest till'. It contains the highest percentage of carbonates of any of the tills, 80 per cent at Surprise Bluff and 77 per cent at Mitchell Bluff. At both these sites, Shield types comprise 15 per cent of the stones, and local types are practically absent. As the carbonates came predominantly from the Paleozoic formations bordering the southwestern margin of the Canadian Shield, altogether more than 85 per cent of the stones came from the Shield or its margin. At other nearby exposures the percentages run equally high or even higher.

The dark colour and high percentage of stones from the vicinity of the Shield suggest that the glacier moved southwestward. This is strongly borne out by stone orientation studies. At Mitchell Bluff a preferred orientation at about S 45° W was observed, and studies at two other nearby bluffs gave similar peaks at about S 75° W. A study at Surprise Bluff proved indeterminate.

The deformation in the till probably resulted from ice overriding permafrost, and its incorporation of large masses of frozen ground. The unit undoubtedly is of Wisconsin Age and, because well-developed, abundant faunas have been found between it and the overlying till, is probably of pre-Classical Wisconsin Age.

Intertill deposits

The alluvial and lacustrine deposits underlying the top till are only eight feet thick at Island Bluff (Unit IBN) and twenty-six feet thick at Surprise Bluff (Unit SBI), but elsewhere in the area they reach thicknesses of nearly one hundred feet. At Mitchell Bluff their thickness is not known. In 1968 these beds yielded a considerable number of bones at Surprise Bluff and at another bluff farther west, and it is anticipated that they will prove to be one of the most prolific sources of bones in the area. However, most of the bones have yet to be studied, and only horse, camel, and artiodactyl have been identified. So far, no radiocarbon dates have been obtained.

The deposit was laid down in a broad, deeply-incised, river valley that undoubtedly took at least as long to form as the present South Saskatchewan valley. The subsequent deposition in that valley of the nearly 100 feet of lacustrine fine sand and silt, found elsewhere at this horizon, must also have taken a long time. As the Classical Wisconsin interstades appear too short for these developments to have taken place, it is suggested that this deposit is of Mid-Wisconsin Age.

Brown till

The youngest or surface till forms Unit SBJ at Surprise Bluff, Unit MBL at Mitchell Bluff, and Unit IBO at Island Bluff. Though thin at those places, it elsewhere reaches thicknesses of fifty feet or more. Besides its colour - it is the only light brown till in the area - it is readily recognized by a moderately- to well-developed columnar structure. This encourages the formation of a steep cliff face. A moderately stony till, with stones mostly small, it is less indurated and probably sandier than the other tills.

This till is more variable than the others. Content of carbonates ranges from 30 per cent at Mitchell Bluff to 50 per cent at Island Bluff. More of the carbonates and cherts are of Rocky Mountain provenance than is the case with the other tills. Shield stone content ranges from 25 to 30 per cent, hard sandstone and quartzite content from 10 to 30 per cent, and the percentage of local bedrock is everywhere low.

Many of the properties of this till, such as its brown colour, its weakness, its stone ratios, and its sand and silt content, suggest that the glacier responsible for its deposition moved over the largely freshwater Tertiary and Cretaceous formations found farther to the northwest. A strong,

N 50° W orientation of the stones at Surprise Bluff supports this view. However, orientations at other bluffs indicate movement from the northeast. The glacier that deposited this till probably was neither as thick nor as strong as the earlier glaciers, and was more controlled by local topography. These factors would partly explain its variable composition and stone alignment and its weak compaction. Otherwise, though not likely, the variability might arise from miscorrelation of two separate till sheets, or the glacier might have had two distinct lobes, one of which deposited the till at Surprise Bluff and the second which deposited the till elsewhere.

There is as yet no proof that Classical Wisconsin ice reached this area, but it is assumed to have done so. If it did, this youngest till would be of Classical Wisconsin Age, and would probably represent the full Classical Wisconsin glaciation of the region. It likely was deposited between 22,000 and 16,000 years ago.

Postglacial deposits

The 'postglacial deposits' include Unit SBK at Surprise Bluff, Unit MBM at Mitchell Bluff, and Unit IBP at Island Bluff. They consist mostly of gravel, sand, and silt laid down by South Saskatchewan River as it resumed flow following the last glaciation and before it started to incise its present valley. Ice farther north may even have prevented it from lowering its grade and developing a valley during the time these surface deposits were being laid down. There is no indication of widespread proglacial ponding in the area at that time, nor of extensive lake deposits. Evidently the river entered the region from the higher land to the west, spread over the Medicine Hat area with a constantly shifting course and a slackened current, and there deposited its load somewhat in the manner of a fan delta. As a result, the surface deposits are extremely variable both laterally and vertically. Wind subsequently modified the surface of the deposits, a modification that still continues.

The deposits have yielded an elephant bone and a horse tooth at Mitchell Bluff; both yet unidentified. They have yielded a few bones elsewhere, including a tooth of *Mammuthus primigenius*, but no extensive fauna has yet been found.

Deposition of these surface deposits followed closely the recession of the last glacier, but it is not certain how long ago that took place. They were probably laid down 15,000 to 13,000 years ago.

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APPENDIX

DESCRIPTIONS OF SECTIONS 13, 14 and 15

APPENDIX

DESCRIPTIONS OF SECTIONS 12, 13 and 14

(see Figure 1 for locations)

Section 13, Surprise Bluff (west). South bank of South Saskatchewan River, near the west edge of Medicine Hat (S 1/2 sec. 34, tp. 12, rge. 6, W 4th mer.), (50°2'10"N, 110°45'W). The west part of the bluff is described.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
SBK	POSTGLACIAL			
	Sand, silt, a few stones; lacustrine and alluvial	5.0	5.0	5.0
	Sharp, horizontal contact			
SBJ	GLACIAL			
	Till, light greyish brown; a moderate number of stones, mostly small, including many from Precambrian Shield; well-developed columnar structure, with cliff face nearly vertical; stone orientations indicate glacier movement of about N 55° W (or S 55° E)	8.0	8.0	13.0
	Sharp, horizontal contact, locally deformed			
SBI	NONGLACIAL			
	Gravel, medium to fine, subangular to subround	1.0		
	Sand, mostly coarse, minor gravel; gravel bed is about 5 feet above base; material loose; cliff face retreats rapidly	20.0		
	Gravel, some sand and grit; stones to 5 inches - mostly 1/2 inch to 2 inches long - including many from Precambrian Shield; deposit poorly sorted, loose; cliff face retreats rapidly; deposit contains scattered bones	5.0	26.0	39.0
	Contact sharp, mostly horizontal			
SBH	GLACIAL			
	Till, dark greyish brown; moderate number of stones, including many from Precambrian Shield; till locally contorted and deformed and contains silt bands; a weak till; cliff face retreats rapidly; orientation of stones poor	12.0	12.0	51.0
	Contact mostly sharp, horizontal			

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
SBG	NONGLACIAL			
	Sand, medium, stoneless; alluvial?	5.0		
	Sand, fine, and silt, stoneless; grades from sand at base to silt at top; lacustrine?	13.0	18.0	69.0
	Sharp, horizontal contact			
SBF	GLACIAL			
	Till, grey; few to moderate number of stones, mostly small, including many from Precambrian Shield; massive; cliff face retreats moderately	25.0	25.0	94.0
	Sharp, horizontal contact			
SBE	GLACIAL			
	Clay, dark grey, stoneless; massive, cliff face retreats rapidly; lacustrine (proglacial ponding?)	5.0	5.0	99.0
	Sharp, horizontal contact			
SBD	NONGLACIAL			
	Sand, medium to coarse, minor grit, stoneless; the grit and coarse sand occur in 6 inch beds near top; upper part displays channel bedding; steep cliff face; alluvial	22.0	22.0	121.0
	Contact mainly horizontal, truncates underlying beds			
SBC	NONGLACIAL			
	Gravel; stones to 4 inches; mostly 1 inch or 2 inches long, typically angular to subangular, with many stones from Precambrian Shield; poorly sorted; rare bones; alluvial (lag gravel?)	2.0	2.0	123.0
	STONES FROM PRECAMBRIAN SHIELD FIRST APPEAR HERE			
	Contact mostly horizontal, gradational			
SBB	PREGLACIAL			
	Sand, pebble bands; pebbles chiefly fragments of shale and siltstone from local bedrock; channel bedding prominent; alluvial	11.0		
	Horizontal contact that truncates underlying beds			
	Sand, grading upward from coarse to medium, fine pebble gravel at base; pebbles mostly fragments of shale and siltstone from local bedrock; scattered stones to one inch long near top; cliff face generally steep; alluvial	20.0		

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
	Contact truncates underlying beds, with local channelling into those beds.			
	Sand, medium, stoneless; prominent channel and foreset bedding; indicated direction of deposition from west; alluvial	15.0		
	Gradational contact			
	Sand, minor silt and clay; sand occurs in beds 3 inches thick separated by thin, dark grey, silt and clay bands; alluvial (floodplain)	5.0		
	Sharp contact that truncates underlying beds			
	Sand, minor pebble bands; loose; cliff face retreats rapidly; alluvial	15.0 (observed)	66.0	189.0
	Base of deposit covered by slump			
SBA	Concealed by slump	25.0	25.0	214.0
	Level of South Saskatchewan River			
	Total thickness	214.0	214.0	214.0

Section 14, Mitchell Bluff. Southwest bank of South Saskatchewan River, about 6 miles north of Medicine Hat (NE 1/4 sec. 32, tp. 13, rge. 5 W 4th mer.), (50° 7' 45" N, 110° 38' 40" W).

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
*MBM	MOSTLY POSTGLACIAL			
	Gravel, sand; stones to 10 inches long but mostly 1 inch to 4 inches long, subround to round; Precambrian Shield stones common; some beds mainly composed of fragments of coal; strong cross and channel bedding, with deposition from southwest indicated; material mostly loose; cliff face retreats rapidly; a few bones present; alluvial, may include some outwash	20.0	20.0	20.0
	Sharp contact, mostly horizontal but with channels incised into the underlying till			
*MBL	GLACIAL			
	Till, light brown; moderately stony but large stones rare; nearly vertical cliff face with incipient columnar structure; stone orientations indicate glacier movement of about N 50° E (or S 50° W)	18.0 (observed)	18.0	38.0
	Contact not observed			
MBK	GLACIAL			
	Till, dark grey; resembles underlying till (Unit MBI) but contains fewer stones; cliff face nearly vertical	10.0	10.0	48.0
	Sharp contact, horizontal for the most part			
MBJ	NONGLACIAL (?)			
	Sand, medium, stoneless, loose; alluvial	3.0		
	Clay, silt, rare stones; contains scattered, small pieces of wood; apparently floodplain deposit	1.5		
	Sand, fine, stoneless, loose; alluvial	1.5	6.0	54.0
	Sharp, horizontal contact			
MBI	GLACIAL			
	Till, dark grey; stony, with many large stones; breaks into hard, irregular fragments about one inch long; cliff face nearly vertical	6.0	6.0	60.0
	Sharp, horizontal contact			

* Units marked with an asterisk are not exposed at main section, but are found about one-half mile farther east along the bluff (NW 1/4 sec. 33, tp. 13, rge. 5, W 4th mer.).

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
MBH	<p>NONGLACIAL</p> <p>Sand, minor silt and clay, rare stones becoming more common upward; silt and clay beds most prominent in upper part; many beds consist mainly of fragments of former silt and clay varves; strongly channel bedded, also strongly contorted and deformed; indicated direction of deposition from southwest; bones, small molluscs, and plant fragments present; cliff face steepest near top, but generally retreats rapidly; alluvial</p> <p>Contact mostly sharp, horizontal</p>	30.0	30.0	90.0
MBG	<p>NONGLACIAL</p> <p>Gravel, sand lenses, local silt blocks; stones to 6 inches, but mostly 1 inch to 2 inches long, many angular or sub-round, some fractured; gravel includes many stones from Precambrian Shield; an extremely variable unit, with much well-developed foreset bedding, that generally indicates deposition from south-southwest; cliff face steep; deposit contains numerous bones, also pieces of chert that appear worked by man; alluvial</p> <p>Sharp, horizontal contact that truncates underlying beds</p>	5.0	5.0	95.0
MBF	<p>NONGLACIAL</p> <p>Sand, scattered stones; many beds consist largely of fragments of former varves or pieces of coal; strongly channel bedded with indicated direction of deposition from east or southeast; cliff face moderately steep; mostly alluvial</p> <p>Contact placed at start of strong channel bedding and steepening of cliff face; horizontal except where underlying beds truncated by channelling</p> <p>Sand, pebble bands, some with much coal; sand coarse and gritty at base, becomes finer upward; bedding mostly horizontal, but foresets locally present; indicated direction of deposition from east; material loose, and cliff face retreats rapidly; rare, scattered bones present; alluvial and lacustrine</p> <p>Gradational, horizontal contact</p>	28.0	56.0	151.0

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
MBE	NONGLACIAL			
	Gravel; stones to 10 inches long but mostly 1 inch to 2 inches, many angular or fractured; stones from Precambrian Shield common; deposit loose and cliff face retreats rapidly; rare bones present; alluvial (lag gravel ?)	1.5	1.5	152.5
	STONES FROM PRECAMBRIAN SHIELD FIRST APPEAR HERE			
	Sharp, horizontal contact			
MBD	PREGLACIAL AND GLACIAL			
	Sand, fine, and silt; greyish white; contains pebbles and pieces of coal; deposit becomes finer upward and is topped by five silt and clay varves, each 2 inches thick; locally cross bedded; deposit weakly indurated and forms a nearly vertical cliff face; mostly lacustrine (proglacial ponding ?)	5.0		
	Sharp, uneven contact			
	Sand, fine to coarse, grit, with pebble band present about 3 feet above base; grit beds contain much coal; part of deposit is strongly crossbedded; deposit mostly non-indurated, and cliff face slopes at about 45 degrees; bones occur near pebble band; fragments of snail shells and plants scattered in the fine material; mostly alluvial	9.0		
	Gradational contact			
	Sand, fine, and silt, clay stringers in upper part; light grey; stones lacking; deposit weakly indurated and cliff face nearly vertical; alluvial (floodplain)	6.0		
	Gradational contact			
	Sand, medium to coarse, gravel and clay near base; deposit displays channel and cross bedding; bones, sticks and stumps present, particularly towards base; material mostly loose; cliff face retreats moderately; alluvial	20.0	40.0	192.5
	Contact generally sharp			
*MBC	PREGLACIAL			
	Sand; fine, grey, silty; alluvial	1.0		
	Gravel, present only locally; stones to 5 inches long, subround to round; wood or peat band locally present above the gravel; bones common; alluvial	0.5		

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
	Sand, medium, dark grey, silty; displays channel bedding; alluvial	1.0	2.5	195.0
	Gradational contact			
*MBB	PREGLACIAL			
	Gravel, sand matrix; well-sorted; stones to 10 inches long, mostly 1 inch to 4 inches, subround to round; deposit contains abundant scattered bones; alluvial	3.0	3.0	198.0
	Sharp contact			
MBA	Bedrock (?) (Foremost Formation?)			
	Sand, medium to fine, clay and silt matrix; light grey	5.0		
	Concealed by slump	3.0	8.0	206.0
	Level of South Saskatchewan River			
	Total thickness	206.0	206.0	206.0

Section 15, Island Bluff. Northeast bank of South Saskatchewan River, about 7 miles north of Medicine Hat (SW 1/4 sec. 4, tp. 14, rge. 5, W 4th mer.), (50° 8' 15" N, 110° 38' 20" W).

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
IBP	POSTGLACIAL			
	Surface modified by wind, with blow-outs and with dunes to 10 feet high Sand, silt, stoneless; includes buried soils; 4-inch-thick volcanic ash band present about one foot above base of deposit; mostly aeolian	10.0	10.0	10.0
	Sharp, generally horizontal, contact			
IBO	GLACIAL			
	Till, light brown; moderately stony, including stones from Precambrian Shield; moderately indurated; cliff face nearly vertical and displays columnar structure; stone orientations indicate glacier movement of about N 25° E or S 25° W	18.0	18.0	28.0
	Sharp, horizontal contact			
IBN	NONGLACIAL (?)			
	Silt, sand; stones generally lacking but gravel present locally; sand found mainly near top; face retreats markedly over sand; deposit locally absent; thickness varies greatly; mostly alluvial	8.0	8.0	36.0
	Sharp, horizontal contact			
IBM	MOSTLY GLACIAL			
	Till, greyish brown; small number of stones, including some from Precambrian Shield; some horizontal banding; cliff face moderately steep	3.0		
	Sharp, horizontal contact			
	Silt, scattered stones, light brown; weakly indurated and forms steep cliff face; lacustrine (?)	4.0		
	Sharp, undulating contact			
	Till; resembles overlying till, but contains more stones and lacks banding	5.0		
	Sharp, uneven contact			
	Silt, light brown; lacks stones; cliff face nearly vertical; lacustrine (?)	2.0	14.0	50.0
	Sharp, undulating contact			
IBL	GLACIAL			
	Till, dark grey; silt band locally present 2 feet from top; top 2 feet brown and probably weathered; breaks into angular			

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
	fragments about one inch long; cliff face moderately steep	18.0 (observed)	18.0+	68.0
	Contact mostly obscured by slump			
IBK	GLACIAL			
	Till, dark brown, but lighter in colour than overlying till; contains few stones, fewer than overlying till, but includes some from Precambrian Shield; cliff face only moderately steep, but steeper than that of overlying till; bottom part of deposit includes whitish sand beds 4 inches to 2 feet thick, these may be inclusions from local bedrock	60.0	60.0	128.0
	Sharp, undulating contact			
IBJ	NONGLACIAL			
	Sand, silt, minor clay, stones present solely near top; sand mostly medium, consists partly of fragments of earlier silt and clay varves; silt is light brown, and weakly indurated; alluvial (floodplain?)	4.5		
	Gravel; stones to 4 inches long, mostly 1/3 to 2/3-inch long, mostly angular to subangular, many of Shield origin; deposit poorly sorted, evidently deposited quickly; cliff face of variable steepness; alluvial	2.0	6.5	134.5
	Sharp, undulating contact			
IBI	GLACIAL			
	Till, dark greyish brown; few stones, some of Shield origin; breaks into angular fragments 1 inch to 3 inches long, otherwise massive, hard and compact; cliff face less steep than with any of the other tills; this till sheet is divided into two nearly equal halves by whitish sand band one-foot-thick (bedrock inclusion?)	9.0	9.0	143.5
	Sharp, horizontal contact			
IBH	NONGLACIAL			
	Sand, silt, clay, scattered stones; clay is stony and occurs in till-like stringers near top of deposit; much of deposit is crossbedded, contorted, and deformed; cliff face steep	12.0		
	Sharp contact, horizontal except where channels cut into underlying deposit			
	Sand, clay, minor grit, rare pebbles; sand and clay beds alternate; pebbles present in lower part only; foreset bedding near base, channel bedding near top; deltaic and alluvial	11.0		

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
	Sharp, horizontal contact			
	Sand, fine to medium; stones common near base, none near top; bedding horizontal; material loose; cliff face retreats rapidly, lacustrine?	6.0		
	Gradational, horizontal contact			
	Gravel, sand; stones to 1 inch long, but most about 1/2 inch, generally angular to subangular, Shield stones common; sand occurs in lenses and as matrix in gravel; deposit loose and poorly sorted; alluvial	1.0		
	Sharp, horizontal contact			
	Sand, medium to coarse, a few pebbles near base; deposit mostly massive and unconsolidated; cliff face retreats rapidly; rare, scattered bones; alluvial	12.5	42.5	186.0
	Sharp, horizontal contact			
IBG	NONGLACIAL			
	Gravel; stones to 2 inches long, mostly 1/2 to 1 inch long, angular to subround, many of Precambrian Shield origin; matrix clayey and silty; scattered bones present; alluvial	0.5	0.5	186.5
	Sharp, horizontal contact			
IBF	NONGLACIAL			
	Sand, silt, clay; lower part consists of horizontal, alternating beds of clay and fine sand, upper part of medium to fine sand; stones not present, fossils not observed; deposit mostly non-indurated; cliff face retreats rapidly; alluvial (floodplain) and lacustrine	20.0		
	Gradational, horizontal contact			
	Sand, fine, stoneless; fossils not observed; deposit mostly massive, but shows some horizontal bedding; non-indurated; cliff face retreats rapidly, largely slump covered; mostly lacustrine	37.0	57.0	243.5
	Gradational, horizontal contact			
IBE	NONGLACIAL			
	Gravel; stones to 10 inches long, mostly 2 or 3 inches long, many angular or subangular, Shield stones common; sand matrix; deposit loose, poorly sorted, contains a few bones	2.0	2.0	245.5
	STONES FROM PRECAMBRIAN SHIELD FIRST APPEAR HERE			
	Sharp, horizontal contact			

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
IBD	PREGLACIAL			
	Sand and silt, stoneless; grades from medium sand near base to silt at top; bedding mainly horizontal; cliff face steepens upward to vertical at top; alluvial near base, lacustrine at top	15.0		
	Sharp, horizontal contact, at top of well-developed channel bedding			
	Sand, minor stony and coaly bands; stones to 2 1/2 inches, but mostly 1 inch long, deposit displays well-developed channel bedding with deposition from south indicated; scattered pieces of bone present, also plant fragments near base; deposit extremely variable both horizontally and vertically; alluvial	11.0		
	Sharp, horizontal contact, with local channels cut into underlying material			
	Sand, minor clay and silt, a few stones near middle; deposit mostly fine to medium sand with interspersed thin beds of dark grey clay and silt, bedding horizontal; scattered pieces of rusty wood in lower part; deposition from southwest indicated; cliff face retreats rapidly; deposit largely slump covered; alluvial (floodplain)	20.0 (observed)	46.0	291.5
	Bottom of unit and contact not observed			
**IBC	PREGLACIAL			
	Clay, dark bluish grey, carbonaceous muck, scattered stones; clay is dense, compact, sticky, contains scattered sticks, and is overlain by band of carbonaceous silt and clay up to 1/2-foot-thick containing leaves, stems, and logs to 5 inches in diameter; lacustrine	1.5	1.5	293.0
	Contact generally sharp, horizontal			
**IBB	PREGLACIAL			
	Gravel, grit; stones to 8 inches, but mostly 3 to 5 inches long, near top and bottom; centre part of deposit mainly coarse grit; stones well rounded, consist mostly of quartzite, hard sandstone, and chert; deposit partly cemented into conglomerate; bones abundant, especially at base of deposit; alluvial	5.0	5.0	298.0
	Sharp, horizontal contact			

** Units marked with an asterisk are not exposed at main section, but are found about one-quarter mile farther northwest along the bluff, in north centre of sec. 5, tp. 14, rge. 5, W 4th mer.

Unit Reference Letter	Description	Bed Thickness (feet)	Unit Thickness (feet)	Cumulative Thickness (feet)
**IBA	Bedrock (Foremost Formation)			
	Sand, medium to fine, dark blue clay, silt	5.0	5.0	303.0
	Level of South Saskatchewan River			
	Total thickness		303.0	303.0

Units *IBA, *IBB, and *IBC are exposed only at the west end of the bluff, and then only when the river is low. Unit IBG is thought to correspond to the 'artifact band' found at Mitchell Bluff, and thus the division between Units IBF and IBH is placed there. It is possible, however, that the thicker gravel bed found thirteen feet higher, in Unit IBH, corresponds to the 'artifact band'. If so, Unit IBF should be extended up to the base of that bed. The east end of Island Bluff is rapidly becoming overgrown and its deposits are less distinct than formerly.