A REVISION OF THE STRATIGRAPHY OF THE LEA PARK FORMATION IN WEST CENTRAL SASKATCHEWAN

by

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C O N T E N T S

Illustrations

ABSTRACT

The Lea Park formation is an equivalent of the Upper Cretaceous Milk River and Pakowki formations of southern Alberta. Upper Cretaceous sediments of the Prairie Provinces are derived from land masses which bordered the Western geosyncline. Redistribution of Upper Cretaceous non-marine sediments from the seaward margin of deltas by epeiric sea currents resulted in the deposition of marine sand lenses within the mud-bottomed basin. Palaeontological criteria are the most helpful for distinguishing these marine from other non-marine environments.

The Lea Park formation consists, between Lloydminster and Battleford, of four stratigraphic units. The basal shale unit contains the *Epistomina caracolla* microfauna. Overlying it is a shale characterized by *Verneuilina bearpawensis.* This is followed by a sand and sandstone facies with a marine megafauna. The fourth and highest member in the Lea Park formation is of marine shale. Upward the Lea Park formation passes into the Ribstone Creek, a brackish water arenite formation.

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Introduction

The writer mapped the surface geology of three Geological Permit areas taken up by Bata Petroleums Ltd. during part of August and September of 1946. The leases are located approximately between longitudes 108 degrees and 110 degrees, and near latitude 53 degrees. The boundaries are artificial so they cannot be referred to physiographic features. They are outlined on Map Number 2 accompanying this report.

Objectives

An attempt has been made to clarify the regional correlations by means of our increased data, to adopt mappable classifications of the strata, and to present several new ideas about the origin of the Lea Park sand and other Upper Cretaceous stratigraphic problems. Some emphasis will be placed on regional geology although only a limited area was examined. It was necessary to visit exposures off the leases to collect data on the regional geology. Recent information from the Unity gas field has been embodied in this report.

Methods

The field work was carried out on the basis of a 1 inch to 4 miles reconnaissance map. Twenty three days were spent in the field. A half ton 1946 Fargo truck was used for transportation.

No difficulty was experienced in approaching within short walking distance of exposures with this vehicle. Locations of outcrops were tied in to section boundaries by pace-and-compass surveys. Fossils collected were labeled for laboratory identification work. Literature pertaining to the report was read at the University of British Columbia library. Only positive surface out-crops and reliable well samples were mapped because the writer believes that discontinuous water well sands, if tabulated, may have led to misinterpretations of structure in the past (cf 7 [1]).

Acknowledgements and Previous Work

This thesis was written under Dr. M.Y.Williams guidance. Dr. Williams read over and discussed the ideas presented; the writer is deeply indebted to him. The author wishes to acknowledge the clearcut instructions and many useful suggestions given by Dr. J.O.G. Sanderson who directed the field work. Mr. Clarence G. Matthews' helpful advice on innumerable occasions was of great value in planning the traverses. Mr.J.A. Donnan prepared thin sections of the Lea Park sand. Without the aegis of Bata Petroleums Ltd. the field work would not have been attempted. The writer wishes to thank the company officers for permission to use field notes for thesis material.

Battleford and Fort Pitt sheets of the Geological Survey

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1. Numbers enclosed in brackets refer to list number in the literature cited.

of Canada were useful principally for easy location of the sedimentary rock exposures. Hume and Hage made a preliminary study of the geology of the eastern part of the area and published their findings in Eagle Hills Anticline, Battleford Area, Saskatchewan. The Geology of East-central Alberta by the same authors was the most useful report on the Battle River area stratigraphy. Other writings referred to in this investigation are compiled in the list of literature cited.

Summary of the Battle River Surface Formations

The characteristic discontinuous interdigitation of shales and sandstones of Upper Cretaceous formations provide a problem, in field mapping, with which it is not easy to cope. It seems advisable to map sand and sandstone strata of this area as isolated tongues until they have been correctly correlated. Hume and Hage (7) have attempted to correlate formations on the one criterion of apparent stratigraphic position but met with little success.

The Upper Cretaceous formations were laid down under alternating marine and non-marine environments near alluvial plains. The constituents of the formations were derived from the erosion of land masses to the west and possibly the east. In general, the Lea Park shales are marine, the Lea Park sands are marine and probably, in part, non-marine. Lea Park shales are medium to dark grey in colour in the upper part. Lea Park sand and sandstone carry a fossil marine fauna and would fit best into a marine pattern. These clastics range from very fine grained to somewhat medium grained near the base, from light grey to medium (slightly bluish) grey, from loose to very well indurated, and are locally silty, limy, and arkosic. Although some of the characteristics of river laid deposits are locally present, they appear to have been redistributed under marine conditions. The Ribstone Creek formation represents an interdigit of coarser clastics resulting from erosion within the western land mass by, most probably, the identical drainage pattern that provided the Lea Park sands. Slipper (19) considered the Ribstone Creek formation to be of brackish water origin. Recent work is in agreement with his findings.

The origin of the constituents of the Upper Cretaceous beds within the second prairie step has yet to be studied. It is generally recognized that the Canadian Shield was a positive land mass undergoing erosion during Upper Cretaceous time. The positions of the eastern borders of the Upper Cretaceous sea are not known. The writer believes that significant amounts of mud were derived from pre-Cretaceous formations of the east. Conceivably muds from the eastern uplands intercalated with some coarser clastics from the western mountains. This may have resulted in the margination of the chiefly non-marine Milk River formation by the lower Lea Park shales, and such patterns as the bifurcation of the Ribstone Creek formation by the Vanesti shale tongue during early Belly River time.

TABLE OF FORMATIONS

WEST CENTRAL SASKATCHEWAN.					FORAMINIFERA ZONES
UPPER CRETACEOUS	BELLY RIVER BEDS	Ribstone Creek formation	160' in west. 50'(?) in Vera area, but here upper contact eroded.	Non-marine. Sand and sandstone.	
	LEA PARK FORMATION	Uppermost Lea Park shale	Maximum of 200' in Vera area. 120' in Alberta	Marine. Medium grey, silty, contains mother-of-pearl fragments	<u>Haplophragmoides rugosa</u>
		Lea Park sand	Lenses. Trace to 70' thick in Vera area.	Marine and possibly non-marine. Grey to yellow sand and sandstone.	
		Upper Lea Park shale	510' thick in Muddy Lake well	Marine. Medium grey shale, calcareous locally.	<u>Verneuilina bearpawensis</u>
		Lower Lea Park shale	300' thick in Muddy Lake well	Marine. Light to dark grey shale. Traces of bentonite. Locally calcareous.	<u>Epistomina caracolla</u>

Geology

Physiography and Character of the Region

Most of the area is part of the third prairie step with a median altitude of 2000 to 2200 feet. The Eagle Hills are continuous with the Missouri Coteau and demarcate the third from second step. The topography is level to rolling and the influence of Pleistocene glaciation is seen throughout the region. The northeastern part is drained directly by the North Saskatchewan River. The central portion is tributary to the Battle River which finally flows into the North Saskatchewan at Battleford. The southwestern sector has acquired an interior drainage system of creeks and lake basins superimposed on the morainal topography.

The North Saskatchewan River at North Battleford has cut about 150 feet below the top of the northeast bank. The valley is about one mile wide. As it enters the accompanying map sheet it flows southeastwardly in a slight curve but two miles west and four north of North Battleford it is diverted to the southward for three miles. Above Battleford the river's banks range from steep to nearly vertical, but six miles below the cities[1] the northeast bank has a slope of only 250 feet in three miles. Along most of the river there are mid-channel sand islands up to two miles long; however there is a nine mile stretch without any in township 45, ranges 17 and 18. The river is in a stage of early maturity. The fact that the channel is pre-glacial explains the scarcity of outcrops along the river.

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1 Battleford and North Battleford.

Battle River flows in a pre-glacial channel. This river is 50 to 75 feet wide within a floodplain ranging from one half to one mile in width. The meander belt varies from one half to three quarters of a mile broad. Old meander scrolls were not observed along the banks but slumping would certainly have obscured their presence. River terracing would be easy to confuse with the post-glacial lake plains near the outlet of the river. At Unwin, old river terraces are well preserved but these may have been derived by the action of the Manito Lake - Marsden diversion channel waters. Near the intersection of Battle River by Highway 40 the northwest bank is terraced but the southeast is slumped. Resistant sandstones are exposed along Battle River wherever the drift overburden has been stripped.

Drummond Creek emerges from the Eagle Hills in Sweetgrass Indian Reserve between till and gravel cutbanks some 60 feet high. Upstream, where cut by Highway 40, the creek is small and meanders in a valley about 50 feet deep. There the cutbanks have stood up well and are composed of drift containing the largest erratics seen in the district. It is a consequent stream with reference to Pleistocene deposits.

Buzzard Coulee is comparable in size to the Battle River gorge but is nearly dry. It served as a diversion channel in post-glacial time but ~~in age~~ may antedate the Pleistocene epoch.

Lakes are characteristic of those districts served by an interior drainage system. Thackeray Lake has the long narrow outline of an abandoned channel. Winniford Lake, although only two miles southwest of Battle River at Battleford, has not been able to maintain its former junction with the North Saskatchewan River at section 16, township 43, range 16. The lake in section 23, township 43, range 18 occupies a constructional depression greater than 115 feet below any peripheral outlet. It has resulted from morainal blocking on the south and east and may be in part a large kettle. Bedrock is exposed on its north bank. The tiny alkali lake (see Plate 1,B) in the southwest quarter of section 35, township 43, range 18, occupies a depression within a moraine. Lake terraces and sloughs are lineated between Brada (near North Battleford) and the North Saskatchewan River.

Manito Lake is the largest body of water in the area. It is bounded on the southwest by a sand dune terrane and on the north and east by cliffed glacial deposits. No bedrock exposures are known around its shores. It appears to be the northeast fraction of a large post-glacial lake which extended into Alberta on the west and towards Vera, Saskatchewan on the southeast. Dune formation of the lake sands by winds blowing off the ice sheet have piled the sands up higher than the local fluvial base level of the late ice shrinkage period.

The Eagle Hills, although terminated at Battle River, are a conspicuous topographic feature. They rise in some places to over 2400 feet above sea level and are approximately

800 feet higher than the level of the North Saskatchewan River. The Hills are a pre-glacial erosion escarpment. Formed of Upper Cretaceous strata, exposed in Pipestone Creek, they were mantled with drift during Pleistocene time. At the time of the retreat of the last glaciers the ridge dammed a pro-glacial lake.

The utilized terranes are given over to wheat farming and cattle ranching - the main industries of the region. Farmhouses in the rural areas are one half to one mile apart and evenly distributed in the arable sectors. The principal towns are North Battleford, Battleford and Lloydminster(9). Lloydminster derives a small revenue from crude oil production. The main villages of the region are Delmas, Prongua, Rockhaven, Cloan, Edam, Paynton, Maidstone, Waseca, Lashburn, Marshall, Lone Rock, Marsden, and Neilburg.

Both the Canadian National and the Canadian Pacific Railways have east to west through lines across the area. The Canadian National also maintains a spur line from Battleford to Carruthers. The main lines of the two railways pass through Unity, in township 44, range 22, south of the area under consideration.

Highway 5 is the one trunk road from Battleford to Lloydminster. Highway 40 is being improved and now is located across Sweetgrass Indian Reserve close to the railway, and joins with Highway 29 north of Prongua. Highway 29, from Battleford to Wilkie, is graveled except for a short distance.

Secondary and local roads provide access to nearly all of the area but their condition depends on the weather. After a rainfall most of the mud roads become extremely slippery but sandy roads may remain passable.

Native vegetation includes a number of floral species peculiarly adapted to local environments. These have been listed by Mr. J. Mitchell in Soil Survey of Southern Saskatchewan. Prickly pears (Opuntia) flourish near bentonitic mud slides. Black poplar (Populus balsamifera) is common on the Eagle Hills. Canoe birch (Betula papyrifera) and common alder (Alnus incana) make up local deciduous groves. Jack pine (Pinus banksiana) was noted in some of the sand dune regions.

The area is semi-arid with an average annual precipitation of about 15 inches. The soil is supplied with water by the spring thaw and by infrequent rains through late spring to summer. There is an extreme annual range in temperature between - 50°F to over 100°F. The weather is not very dependable and grain-killing frosts have occured in the month of July. Wind and dust storms are not common but may be quite strong.

Sedimentation in the Western Geosyncline

The sediments of Lea Park and Belly River age were deposited within a physiographic and structural basin termed the Western[1] geosyncline. Marine beds were laid down within an epeiric sea which lay between marginal

1. The Eastern geosyncline is called the Appalachian trough.

alluvial plains of the west and a land mass to the east of the present Palaeozoic - Pre-Cambrian contact. This was a Gulf sea with an outlet toward the southeastward. There appears to have been free drainage from the encircling lands to the sea.

The contact between the Lea Park formation and the underlying Alberta formation gives little hint for the interpretation of a change in provenance.[1] If the axis of the geosyncline moved only in a vertical path we might expect a record of continuous sedimentation along that line which would yield some suggestions of what the adjacent lands were like. However the axis (or axes) became a function of other variables such as sources and availability of sediments depending on the migration of divides on the contiguous uplands. A strip of continental sediments was characteristic of the western margin of the sea. This strip's seaward limits were very sharply demarcated by marine shales and sands. Even so it is obvious that we can form little opinion of the adjacent lands from direct cont~~r~~acts between the rocks themselves.

Physical characters of clastics are useful in determining the nature of provenances. Character is determined by the parent material, the degree of weathering, and by subsequent erosion and transportation. The Lea Park and later shales contain very fine grain-ed alluvial clastics, eroded shore

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1. Provenance refers to a terrane from which an association of sediments was derived.

material, aeolian dusts, and float of organic origin. Amongst these components, sea wave erosion has produced unmeasured but enormous quantities of muds. The windward shore or shores of the sea were subjected to all the rigours of wave sweeping, and a consequent repression of conditions favorable to life along that coastline would increase the tendency towards abnormal surface denudation. The questions of climatic temperatures and seasonal weather within the environment are worthy of thought even if they are only postulative. There is no evidence to show that the sea froze over. ~~In the periods when the mean temperature of the region was high the lessening in viscosity of the water would result in significantly increased wave erosion by winds~~. Waves moving in across a steeply dipping beach retain their power for concerted cutting of the shoreline. Waves which must travel across low flats have their power dissipated in building up an offshore bar and bringing the shore to a mature stage.

Transportation of clastics does not necessarily cease after deposition in the river delta has been accomplished. Various agencies are constantly active in the sea which redistribute transportable materials. Mention has been made of the role of waves in attacking shores; they may also be very effective in truncating delta strata. Any turbulence would bring into suspension the finest clastics and render them available for lateral distribution. Undertows acting over a long time will control the migration of appreciable volumes of coarse and fine grained mineral particles. Along shore currents result in directed lateral distribution. Dr. V. C. Illing (11) has observed that "instability of the sea floor during the processes of sedimentation creates guiding conditions for the marine currents which govern the distribution of the sand lenses." Marine currents will be further discussed when the possible mode of origin of the Lea Park sand is suggested.

The epeiric sea was characterized by certain physical properties. Condensation was perpetual but probably of no real importance except to remove dust from the atmosphere. Evaporation was present at all times. Cloud derivatives of the sea may have been blown about, changed to rain, and precipitated. Little is known of the Shield land mass but it would seem that, because there, elevations were brought about by epeirogenic movements, the borderland would be low and present no physiographic barrier to cloud passage. The heat capacity of the sea would tend to prevent extreme temperatures. This 'mediterranean' environment, although its effects were lessened when the sea became nearly landlocked, is a fundamental conception one must keep in mind whether considering sedimentation, life zones of the cold-blooded reptiles, or plant growth of Upper Cretaceous time.

The sea water was chemically active. We are principally concerned with its dissolving power. There was no tendency for salts to accumulate because the sea was joined to the open Atlantic Ocean by way of the 'Gulf'. Empirical studies have shown that the salt content in a sea of this type does not increase over a restricted period of time. No salt deposits are known within the remnant bounds of the Lea Park shale.

Now that the main points of the environment and its controls have been reviewed, the next step will be an attempt to fit the geological formations into the picture. In general Cretaceous seas of the Western geosyncline had mud bottoms. Sandy facies tongue eastward into a gross shale body. If the region is viewed in east-west vertical cross-section a zig-zag contact between the shale and sand is seen. This contact varies both vertically and laterally with time.

If a generalization that the coarser clastics were derived under normal river erosion is true it is readily understood why the movement of the delta front would depend mainly on the supplies and dispositions of sediments. Broad climatic cycles could definitely control delta growth by functioning as an erosion inhibitor under arid conditions and as an erosion stimulator when a state of humidity predominates.

The history of the diastrophic movements which involved the basin is debatable. It is difficult to separate cause from effect. The simplified tableau usually envisioned is of a geosyncline being concurrently depressed and mudded so that its southwest-northeast profile remains essentially static. Epeirogenic movements tended to maintain this equilibrium. Orogeny is of secondary importance and that only insofar as it effected the western supply of sedimentary materials. When sub-aerial planation has been established along geosynclinal margins quite a small positive change in the position of sea level will permit the waters to encroach over very large areas. As the shoreline passes inland the former sub-aerial sediments will be flooded and eroded, especially if they have not been submerged below the marine base level of erosion. Later strata will contact the underlying rocks along an erosional unconformity.

Isostasy impresses itself on the geologic column. It is always associated with erosion, both in a causitive and in a resultive relationship. The rate of isostatic movement often determines the range in thickness of groups of strata. Dr. A. W. Nauss (14) has written; "a general sinking of the whole province of Alberta - - - may have resulted from the withdrawal of subcrustal material to form the Crowsnest volcanics in the mountains, (and) allowed the Upper Cretaceous ocean to advance to the foot of the Selkirk Mountains." Withdrawals of magmatic materials to form volcanic emissions are not always followed by associated down-warpings. For example the Coast Range region was elevated during the Cenozoic era despite widespread emissions of volcanic rocks. The Crowsnest volcanics were probably deposited within an area little larger than the area from which they were derived. Granted that there may have been a sinking of the Selkirk Mountains from which the Crowsnest volcanics were extruded, the addition of flows and beds to their surface would maintain nearly the initial altitude. Lineations of volcanic belts are determined by zones of weakness. Available magma would be present beneath the Selkirk Mountain weak zone so it is not necessary to postulate any lateral supply of molten materials. It is concluded that isostasy alone furnished mechanisms for the maintenance of the basin and, most probably, for the major advances and retreats of the Upper Cretaceous sea (28).

Dr. C. H. Crickmay (2) proposed that a range of mountains existing during the Cretaceous period in the region of the present Selkirk range be termed the Zephyria Mountains. This high land mass is evidenced by the criterion of grain size change in sediments and by studies in palaeogeography. It has been called to our attention that: "From west to east across the southern plains the beds correlated with the Lea Park of Saskatchewan show the following changes: in southwestern Alberta there are partly marine sands at the base followed by non-marine sands and shales above; in southeastern Alberta there are possibly partly marine sands at the base followed by non-marine sands and shales with, at the top, marine shales; in southern Saskatchewan the strata are entirely marine and mostly shales; and in Manitoba there are marine shales and calcareous shales. So from west to east non-marine conditions give place to marine, sands disappear, and the shales become partly calcareous" (2). The Zephyria Mountains were, without doubt, a lofty chain. Swift streams and creeks furnished coarse clastics to more mature rivers in the larger valleys. Deltas, built eastward into the epicontinental sea, provided sediments to marine agencies for redistribution. There does not appear to have been much, if any, plain flooding with development of typical red beds, mud cracks, and crossbedding in this area because such rock features neither were observed in the well cuttings examined nor in the outcrops visited.

Dr. F. H. McLearn (2) describes the scene as an "invasion of marginal alluvial plains built out from the west." Other geologists have pointed out that non-marine tongues can represent conditions where deposition was more effective than subsidence (2). Still another that: "the stratigraphy of post-basal Upper Cretaceous strata is complicated by the fact that the sediments were derived largely from the highlands west of the seaway. As these highlands were repeatedly uplifted and actively eroded, vast quantities of sand and mud were carried down to the Cretaceous sea, and coarser material accumulating to form a coastal plain, locally extended into great deltas while the finer material was distributed more evenly over the sea floor."

Dr. Nauss (14) has written, "marine shale members in the

Vermillion area have sharp lower contacts but gradational upper ones. The same phenomenon was observed by Sears, Hunt and Hendricks (1941) in New Mexico. They explain it as being due to sedimentation in a continually sinking basin. When the rate of accumulation exceeds the rate of sinking the basin gradually becomes filled, and continued deposition results in coarser non-marine clastics, which rest with a gradational contact on the subjacent marine shale. Later, when the rate of submergence surpasses sedimentation, the sea spreads over the low coastal plain with a rapidity which is a consequence of the lowness and flatness of the terrane, and which results in marine shale lying with a sharp contact on the submerged detritus." This has not occured in the case of the Lea Park sand with its gradational top and bottom contacts and its marine facies.

The Lea Park sand has probably been derived as a large complex spit or beach from delta sands. It has the appearance of a lense rather than a tongue. More stratigraphic work in east central Alberta is necessary before its bounds can be defined. It may be that it consists of several sheet-like bodies for the facies is pinched out in Altoba No.2 between occurrences in Colony No. 2 and Bata No. 16. A comparable situation is recognized in the southeastern United States: "Florida was completely submerged throughout most of the (Cenozoic) era for it is made of thick marine limestones resting on a late Cretaceous floor. Until Miocene time it was so far from shore that little detrital sediment reached it, but since that date fine sand from the Carolina streams has drifted southward with the shore currents to form beaches along the east coast like that of Daytona" (17).

The eastern margin of the geosyncline forms an intriguing topic for investigation. Dr. McLearn (2) has called attention to the main points of the problem: "Emergence of the eastern part of the Cordilleran geosyncline, on the site of Alberta, Saskatchewan, and Manitoba, followed and the Palaeozoic sediments were subject to erosion. It has not yet been established:

(1) Just when the uplift occured.

(2) How high the sediments of the trough were uplifted.

(3) What stage of erosion was reached by the end of Triassic time."

Dr. Wickenden has shown (2): "that the Jurassic deposits in the east, on the site of Saskatchewan and Manitoba, are not entirely marine, but that non-marine deposits are present as well, recording a marginal alluvial or delta plain there. This alluvial plain does not appear to have been built out from the western border of the sea, like those of the Cretaceous, because no non-marine Jurassic deposits have been found in the west. Nor does it appear to have been built out from the southwest. There remains the possibility that it was built out from the eastern shores of the sea."
It follows that Cretaceous marine erosion of the eastern

shore line was probably more effective than subaerial planation of the Shield land mass. This would explain the lack of coarse clastics along the eastern margin of the Upper Cretaceous deposits. Marine erosion, it is thought, would then result in a broad coastal beach. There would tend to be a minimum of sediment formation because this landform would effectively maintain itself in this environment by destroying the power of wave cutting.

The past discussion has dealt with what the writer considers to be the guiding principles of the geosynclinal sedimentary evolution. Next the Upper Cretaceous formations will be examined individually, historically, and in detail.

Lea Park Shale

The Lea Park shale was named by Dr. J. A. Allan (1). It occurs typically between Lea Park and Battleford on the banks of the North Saskatchewan River. The shale beds are overlain by the Ribstone Creek formation. Downwards it passes into calcareous shale of the Alberta formation.

Dr. R.T.D. Wickenden (2) has divided the Lea Park formation into two zones. The Lower Lea Park is characterized by the foraminifera Epistomina caracolla which, he stated, indicated "general equivalence of this part of the formation with the Milk River of Alberta." The Upper Lea Park zone contains the Verneuilina bearpawensis Wickenden fauna and is a Pakowki equivalent.

Third and fourth Zones are added by the writer. The third is the Lea Park sand with a mega-fossil fauna. The fourth zone is marine shale and has been described in the Muddy Lake (8) and Bata No. 16 (p. 27) well logs. It is typified by carrying *Haplophragmoides rugosa* which was formerly ascribed to the Grizzly Bear shale. This revision of the stratigraphy of the Lea Park formation means that in the Rush Lake well the thickness of the formation is 1450 feet instead of 1140 feet as previously measured. (2).

Dr. Nauss (14), working in the Vermillion area, found two useful foraminiferal horizons in the upper Lea Park. Thirty feet below the top of the Lea Park a new species of *Bulimina* was discovered. Two hundred feet below the top of the Lea Park a new species of *Anomalina* associated with *Neobulimina canadensis, Cushman and Wickenden* occured along with pyrite having an oolitic-like structure. He observes the "upper 200 feet consists of silty shale containing plant fragments and nuculid pelecypods together with some gray clay-shale and thin lenses of fine-grained sand." This description closely fits the uppermost Lea Park, studied by the present writer near the North Battleford bridge, except that no fossil pelecypods were found in that locality.

Cone-in-cone structures have not been described in the literature on this area. They have been found marking the Pakowki-Foremost contact in southern Alberta (29). The writer was impressed by their widespread occurrance both in incipient stages and in complete development in surface outcrops of the Lea Park formation. The structures were noted near Big Gully Creek, alongside the road in S.E.1/4, se.28, tp.43, rge.17, W.3rd mer., on a roadcut in North Battleford, in a cutbank of Battle River (center, sec.22, tp.44, rge.18, W.3rd mer.), and on the north bank of Battle River in N.E.1/4, sec.11, tp.47, rge.25, W.3rd mer. An example of the sequences of the structure and related strata measured on the north bank of Big Gully is as follows:

	Sandstone, mottled rusty and grey. Top obscured.
1' 0"	Sand, grey-green, fine to medium grain, massive.

Farther east and underlying the above:

3' 0"	Sand, as above.
2" to 4½"	Band of cone-in-cone structure, very lensing, buff to cream.
4"	"Ironstone", chocolate brown, aphanitic grained, weathers out in nodules and grades downwards into:
trace to 14"	Sandstone, hard, grey, fine grain, arkosic.
2" to 3"	Cone-in-cone structure.
2" to 4"	Shale, friable, dull light grey, shattered texture.

The most striking feature of the limestone cone-in-cone structure is its association with the sand size clastics as well as with shales. That is, there seems to be no evidence to make us assume that the ease of sedimentation occured in a sand, mud, limestone order.

Nauss (14) accounts for the variation in the thickness of the Lea Park formation in two ways. He states:

1. "Sedimentation was slower in the northeast where farther from sources of the shales.
2. The upper limit of the Lea Park occured at higher stratigraphic levels on the northeast because marine conditions lasted longer there."

These statements require modification as a result of our new data. Present knowledge is meagre regarding the sources of the Lea Park formation. Moreover, mere distances from a source terrane would not seem to be the only factor involved. The sediments were effected by marine transporting agencies, the rates of local and wide subsidences, and the irregularities of the lower contact surface. Further, because thinning of the Lea Park shale is offset - to a certain extent - by local thickenings of the Ribstone Creek sands, it is fundamental that the reverse of Nauss' first statement would be more likely. At Hudson Bay Oil and Gas No.1 (l.s.5, sec.8, tp.49, rge. 12, W. ~~3rd~~ 4th. mer.) the Ribstone Creek formation measures 285 feet thick, the Lea Park shale 615 feet, or a total of 900 feet of strata. The thickness of the Ribstone Creek formation in the Muddy Lake well is not known - it may be that it is not present, the Lea Park is 995 feet in depth. Some distance to the southward the Lea Park shale in the Rush Lake well is 1450 feet thick and a sand overlying it, which may be a Ribstone Creek equivalent, is 60 feet thick.

There is a considerable variation in the thickness of the shale but it is not shown that the Lea Park lasted to a higher horizon on the northeast. Thickness has little to do with the age of a stratum, index fossils will aid in dating times of deposition. Both at Muddy Lake and at Rush Lake the uppermost Lea Park, Haplophragmoides rugosa bearing, shales have been overlain by presumably Ribstone Creek equivalents during a nearly contemporaneous sedimentation of non-marine(?) beds.

Field descriptions of some typical exposures of Lea Park shales follow:

1. Location: Center sec. 22, tp.44, rge.18.
   Altitude: Battle River water level about 1560 feet.

   Cutbank on south side of Battle River.

   35' Shale, (somewhat obscured), dirty medium grey(wet), hackly, blocky, disrupted crushed appearance. Locally stained with limonite and ochre. About 20 feet above water level there is a band of large ($1\frac{1}{2}$' by 4') concretions, buff to yellow, circular spalling. Appears to have cone-in-cone structure at top of concretions. One concretion is a hard black calcareous rock vertically veined with calcite. Outcrop continuous around meander.

2. Location: N.W.$\frac{1}{4}$, sec.36, tp.41, rge.15
   Altitude: around 1550 feet.

   Roadcut. Estimated 50 feet above North Saskatchewan River.

   3' plus Shale: banded at top. Yellow (limonitic) and light grey 1" to 3" bands. One band of yellow brown clay ironstone, nodular-like. Hackly to friable. In bottom part shale is friable, medium to dark grey, slightly earthy. All somewhat distorted. Few minute black carbonaceous specks or fragmentary plant remains. Trace of tiny pockets of fine to medium quartz grains. Deltaic?

3. Location: Center sec.17, tp.46, rge.18

Altitude: 1700 feet approximately.

Meander on Turtlelake Creek. Fifty foot high cutbank on east side.

Lea Park Shale. Blocky to hackly, no bedding, medium to light grey, friable. Few large concretions of siltstone, medium grey. Well developed selenite crystals. Baculites sp. 1' long. Local dull ochrous staining.

4. Location: N.W.¼, sec. 31, tp.47, reg.19

Altitude 1775 feet.

South side of Highway 26, east bank of coulee.

Lea Park Shale: moist, hackly, medium grey, ochrous. Ellipsoidal concretions to 3 feet - buff and red-brown stained; calcite crystals on fracture faces; siltstone, limy, some blue staining.

5. Location: N.E.½, sec.22, tp.48, rge.21

Altitude: about 1700 feet.

West bank of North Saskatchewan River.

7'0"	Drift, small boulders.
5'0"	Lea Park shale, finely hackly, rusty to ochrous.
3'6"	Shale, more blocky, medium grey, hackly, some light yellow staining, in small bands.
1'0"	Concretions, discontinuous.
10'0"	Shale, much the same as above, but coarsely hackly, traces of ochrous staining on some bedding planes, light yellow stains. Selenite crystals to 1".
20'0"	Obscured
1'0"	Shale, medium to dark grey (moist), hackly.
65'	Obscured to water's edge. Probably shale.

6. Location: S.E.¼, sec.4, tp.46, reg.27.

Altitude: about 1850 feet.

Roadcut between Unwin store and railway tracks.

?	Loam
1' plus	Shale, medium to dark grey, limonitic, hackly to blocky. Contained a 6" angular block of hard, blue-grey sandstone, speckled with oriented carbonaceous particles. Few small pockets of medium grain well rounded quartz sand.

7. Location: N.E.¼, sec.28, tp.46, rge.27

Altitude: around 2000 feet.

Near railway fill over coulee, 50 feet below tracks, south end of culvert.

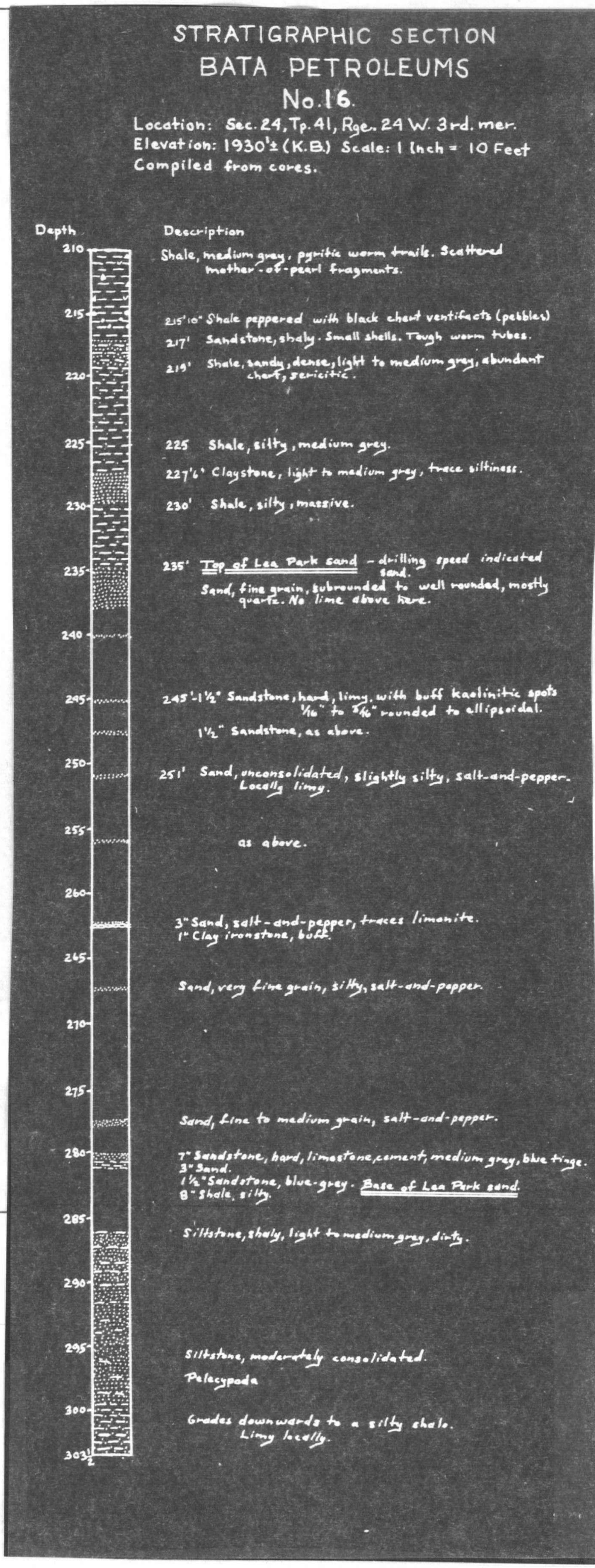
South end:	5'0"	Boulder clay in two bands. Lower light grey, upper medium grey.
	1'0"	Gravel conglomerate, pebbled, medium grey. Post-Tertiary.
	0'6"	Sandstone, lensing, blue-grey concretions. Lea Park.
	6'0"	Shale, medium grey, blocky, fairly well banded, some fine sand lenses with traces of red minerals.

Opposite side (north of culvert):

12' plus shale, medium grey, brown on some bedding planes. Sand lenses to 2", fine grained. Shale has a conchoidal fracture, blocky, pyritic. Pelecypoda fossils. Fine black and brown carbonaceous material.

Lea Park Sand

A sand, sampled in the Verbata No.2 well and cored in the Bata No. 16 well, was correlated with a sand that had


STRATIGRAPHIC SECTION
BATA PETROLEUMS
No.16.
Location: Sec. 24, Tp. 41, Rge. 24 W. 3rd. mer.
Elevation: 1930'± (K.B.) Scale: 1 Inch = 10 Feet
Compiled from cores.
Depth
Description
210
Shale, medium grey, pyritic worm trails. Scattered mother-of-pearl fragments.
215
215'10" Shale peppered with black chert ventifacts (pebbles)
217' Sandstone, shaly. Small shells. Tough worm tubes.
219' Shale, sandy, dense, light to medium grey, abundant chert, sericitic.
220
225
225 Shale, silty, medium grey.
227'6" Claystone, light to medium grey, trace siltiness.
230
230' Shale, silty, massive.
235
235' Top of Lea Park sand - drilling speed indicated sand.
Sand, fine grain, subrounded to well rounded, mostly quartz. No lime above here.
240
245
245'-1½" Sandstone, hard, limy, with buff kaolinitic spots 1/16" to 5/16" rounded to ellipsoidal.
1½" Sandstone, as above.
250
251' Sand, unconsolidated, slightly silty, salt-and-pepper. Locally limy.
255
as above.
260
3" Sand, salt-and-pepper, traces limonite.
1" Clay ironstone, buff.
265
Sand, very fine grain, silty, salt-and-pepper.
270
275
Sand, fine to medium grain, salt-and-pepper.
280
7" Sandstone, hard, limestone cement, medium grey, blue tinge.
3" Sand.
1½" Sandstone, blue-grey. Base of Lea Park sand.
8" Shale, silty.
285
Siltstone, shaly, light to medium grey, dirty.
290
295
Siltstone, moderately consolidated.
Pelecypoda
300
Grades downwards to a silty shale. Limy locally.
303½

been encountered within the Lea Park formation by wells near the 4th meridian. First mention of this sand is in <u>Oil and Gas in Western Canada</u> where Hume wrote: "In Ribstone-Blackfoot area drilling has demonstrated the existence of two distinct sandstone horizons separated by marine shales. The upper sandstone horizon is at the base of the Ribstone Creek formation. The lower is within the Lea Park formation, has a thickness of 50 to 70 feet, and its base is 180 to 190 feet below the base of the upper or Ribstone Creek sandstone. Both sandstones carry water, but apparently the positions of the water horizons vary. The water well on the farm on Mr. Garton in Sec.24, Tp.46, Rangel, W.4th Mer., from which gas was escaping for many years prior to the discovery of the Ribstone structure, obtains both water and gas from the Lea Park sandstone. It was reported that the gas occured at a depth of 290 feet and the water at 315 feet."

In <u>The Geology of East-central Alberta</u>(10) further reference is made to the sand: "In Ribstone area there is a sand in some wells 70 feet thick, the top of which is 110 feet below what is considered to be the top of the Lea Park formation. . . In Vegreville Utilities No.2 well, sec. 36, tp.51, rge.15, (W.3rd mer.), the top of the Lea Park formation is with difficulty separated from the overlying Ribstone Creek beds. Sands altermating with shales continue to a depth of 630 feet and at 500 to 570 feet the shales contain foraminifera, below which is a sand from 570 to 630 feet with fragments of coal at 630 feet . . . In some wells, as at Vegreville, the sand here included in the Lea Park formation could have as readily been included with the Ribstone Creek formation. However, as in every well examined marine shale is known to occur above this so-called Lea Park sand . . . the base of the Ribstone Creek formation is drawn at the base of a sand that is apparently present in all wells. To the east of Ribstone area in Saskatchewan, at Altoba No. 2 well . . . the Lea Park sand is relatively thin and probably disappears eastward."

At a much earlier date, in 1925, the government geologists (6) mapping surface outcrops of apparently Ribstone Creek sand remarked on its strongly contrasting facies thus:"On Big gully the fossiliferous strata are assigned to the Ribstone Creek formation: (1) because the strata seem lithologically closely allied to the sediments found in this formation elsewhere; and (2) because such an interpretation is in accord with what is known concerning the regional structure.

The data given above indicate that the Ribstone Creek Lea Park contact must dip eastward from Ribstone to the Canadian Pacific railway section in range 27, W.3rd mer., south of the Battle river. Coal is reported to occur on the banks of Battle river south of Paynton, and an outcrop assigned to the Ribstone Creek was seen on the north bank of Battle river on the Little Pine and Lucky Man Indian reserve south of Maskwa hill in tp.46, range 22, W.3rd mer. As the elevation of these occurances of the Ribstone Creek formation is considerably lower than the exposures on the Canadian Pacific railway track in range 27, the dip must be considered to be eastward. This eastward dip is also proved by the fact that on Pipestone creek, a small tributary of Battle river flowing past Prongua, the base of the Ribstone Creek formation is approximately at an elevation of1,620 feet, so that there is an eastward dip of 220 feet between the Canadian Pacific railway track exposures on range 27 and the exposures on Pipestone creek on range 18 - a distance of 60 miles. If this value of the dip in an eastward direction be accepted as correct it follows that the marine sediments in township 47, ranges 25 to 27, already referred to, lie above the base of the Ribstone Creek and consequently, as assumed for other reasons, must belong to the Ribstone Creek formation.

The change eastward of the Ribstone Creek formation from non-marine on Ribstone creek to marine in part in township 47, ranges 25 to 27, would not be surprising if the Ribstone Creek formation continued eastward as partly marine. There is no evidence, however, that such is the case, since on Pipestone creek near Prongua no marine fossils could be found and small coal seams have been reported. To the north, on Big gully, there are many exposures of sands and sandstones carrying marine fossils, the same as those found in township 47, ranges 25 to 27. At one locality on the north bank of Big gully, on the west side of tp.49, range24, W.3rd mer., there is a most unusual occurence of fossils in many cases in masses of 5 inches or so in diameter, in a sand so soft that is may be scooped out of the bank by hand. The shells of Axinea sp. occur in many cases with both valves attached and in perfect preservation; the shells have the superficial appearance of having undergone no change whatever since their deposition. Along with these shells was found a baculite less perfectly preserved, although with it was an oxytoma shell so thin that it was transparent. It would appear from the number of unbroken shells with both valves attached that the shells had been engulfed in the sand deposits, for in a number of instances, although the interior of the shell was filled with sand, the valves were closed. This is considered good evidence for deposition in situ, although the poorer preservation of the baculite might indicate transportation."

Confusion of Lea Park sand with Ribstone Creek sand has been continuous into even the most recent stratigraphic work done in the region. Wickenden(24), describing the Muddy Lake well log, writes: "the Grizzly Bear and Ribstone Creek formations are placed arbitrarily on the basis of lithology and position."

Dr. Sanderson directed the writer to examine the outcrops of sandstones along Pipestone Creek and Battle River. Dr. Sanderson surmised that these sandstones might be correlative with the sand cored in Bata No. 16 and with the Lea Park sand near the 4th meridian. This was actually found to be the case and the regional geological map has been redrawn (in pocket).

The origin of the sand has been proposed, earlier in this paper, as a delta sand which was redistributed by long shore currents to form a subaqueous near-shore strip with possibly spit-like extensions and embayments. The sand has provided an environment favorable to marine life. In one of the rock specimens collected, a piece of fossilized wood and Baculites sp. were found close together. This rules out the use of plant remains as indicative of a non-marine environment within this sand. The wood might indicate proximity of the marine shore to a river mouth. Near North Battleford, lenses of sand which may be the extreme eastward fingerings of the Lea Park sand contain many carbonaceous plant fragments, which is certainly suggestive of non-marine sedimentation. Further study is necessary before the sands' complex origin can be stated with any certainty.

Meteoric water enters the bed in the region of the Battle river, and elsewhere where it has not been sealed off by overlying shales, and, influenced by the formational dip and gravity, migrates southeastward, The Lea Park sand is a splendid aquifer but, unfortunately, calcium carbonate of the cemented portions is dissolved by the groundwater which becomes hard. The practice of sealing it off with casing and cement in all gas wells of the region prevents it from flooding the gasiferous horizons.

It is suggested that, until a more complete section is cored and recovered, the Bata No. 16 well log be taken to represent the type stratigraphy. Some exposures of the Lea Park sand are described to furnish the reader with some idea of the variation of lithology within the beds:

1. Location: S.W.¼, sec.6, tp.44, rge.17.

Altitude of Battle River 1,550 feet.

Mouth of Pipestone Creek, and 300 feet north on Battle River. Locally slumped along cutbank.

Strata:

? Till

? Shale, yellowish

5' (estimated) Clay, black (carbonaceous) and white interbeds. White phase is perpendicularly jointed, trace of fine varves, extremely absorbant to tongue. Bedding is lens-like and not sharply defined. Grades downward into

20' Lea Park Sand and sandstone, somewhat blocky, extremely crossbedded and foreset from the west. Massive, Fine grained salt-and-pepper sand. Clean but traces of limonite staining on some beds. Top of this sand is estimated at 30 to 35 feet above the Battle River. The crossbedding may be aeolian in part.

2. Location: center, sec.33, tp.43, rge.18

Altitude about 1,800 feet.

At Pipestone Creek bridge, 1/4 mile north of Prongua.

Strata: 10' 0" Sandstone, banded on weathered surface. Some bands are peppered with black carbonaceous material. Large (3' by 1') sandstone concretions at the top. Sandstone grains are fine to medium, sub-angular to sub-rounded, quartz and chert. Somewhat consolidated. Bands vary from 1/8" to 1/2", are flaggy and especially prevalent below the concretionary layer. Traces of a white mica-like mineral. Beds above concretions more laminated. Few 1" ironstone nodules in lower part. Outcrop is limonite stained and weathers in curves with practically no flat tops but some flat overhangs. See Plate 11A.

3. Location: N.W.¼, sec.19, tp.47, rge.20.

Altitude about 1,750 feet.

Small coulee.

Exposure A. 1' 0" Lea Park sand, yellow, fine grain, few clay lenses, orange coloured nodules to 4", centres blue black.

1' 0" Clay, dull ash grey, traces of lignite and carbonaceous material.

4'0" Sand, massive, grey, fine to medium grain, subangular to subrounded.

Exposure B: 30 feet south and 5 feet lower than the above exposure.

? Till

1'0" Lea Park. Sandy clay, ashy texture, carbonaceous.

1'8" Sand, mauve grey with a lateral gradation to chocolate brown, fine grained, subangular grains.

3'0" Sand, green-grey (moist), fine to medium grains, mostly quartz, salt-and-peppering. Contains twig-like limy molds to 1" wide.

Exposure C: 100 feet south of bridge, roadcut 15 feet high.

Lea Park sand. Medium grain, subrounded, salt-and-pepper, abundant green minerals. Massive, faint bedding, mauve sandstone concretions at the top. Near the base is a lignitic lense, chocolate-brown, interdigited with sandstone, it tapers towards the south. Vertical lime fissure fillings.

4. Location: N.E.$\frac{1}{4}$, sec.11, tp.47, rge.25

Altitude around 1,875 feet.

Old cutbank on first terrace.

Strata: Post-Tertiary: 1'0" Gravel, river, Laurentian boulders to 4"

? Lineation of sandstone concretions to 2' long,

Lea Park: 15'0" Sand, loose, yellow, quartz and chert, traces of green mineral, fine grained, subrounded.

3'0" Sandstone, rusty mottled and light grey, arkosic, fine grained coherent, Abundant chert peppered in the altered feldspathic matrix. Contains concretions to 3 feet, ellipsoidal, light grey, arkosic, some spatterings of carbonaceous matter.

Exposure 100 feet easterly: Lateral gradation within the Lea Park beds of upper(15') sand stratum to a 4 foot band of hard, light grey arkose from which "sandstone balls" are derived. Contains concretions to 4 feet long, dark grey to buff medium grain arkose.

Another 25 feet easterly there is:

1'0" post-Tertiary gravel overlying Lea Park

1'0" Concretionary belt. Concretions to 4 feet long, fractured, calcic, stained tan and white, interiors are chocolate brown peppered with fine chert. Enclosed in a silty sandstone.

2'6" Sand, slightly mottled, splintery, coherent, yellow, fine grained, arkosic, contains crude cone-in-cone structure.

5. Location N.E.$\frac{1}{4}$,sec.32,tp.43,reg.16.

Altitude: about 1600 feet.

Roadcut 3/10 mile north of bridge (east end) on main highway. Outcrop 150 feet long.

See Plate IIB.

4'0" Shale, reddish-yellow, hackly, rather massive.

1'0" Shale, yellow and grey, silty, thinly bedded.

0'3" Cone-in-cone structure associated laterally with ironstone nodules and concretions.

2'0" Sandstone, beds and lenses, light grey, massive to thinly bedded, fine grained, well consolidated. Contains 1/16" to 1/8" fragments of brown and black plant fragments.

0'10" Shale, earthy, massive dull brown.

0' 4" Sandstone, fine grained, crossbedded.

0' 5" Sandstone concretions (grade laterally into a bed) fine grained; these one foot long concretions are enclosed by shale, dull grey brown, with a disrupted crushed texture.

1'6" Shale, yellow, red, dull blue grey etc., abundantly crossbedded, grades downward into sandstone.

1'0" Sandstone, weathers yellow. Fine black laminae probably of carbonaceous material. Mostly well rounded quartz grains. Relatively unconsolidated.

5'0" Shale, yellow, buff, red brown, medium grey laminae ½" to 2". Locally crossbedded on a fine scale-directions of beds patternless, paper-thin black lines. Silty to fine sandy. Blocky to coarsely hackly. Grades downward into siltstone.

Ribstone Creek Formation

The Ribstone Creek formation was named by Mr. S.E. Slipper (19). The type area is in the vicinity of Wainwright, Alberta. Slipper described the formation as "greenish yellow, massive, soft sandstone at top, green and carbonaceous shales and coal, light grey sandstone at base," and considered it to be of brackish water origin. Nauss (14) has studied the formation recently and he writes: "The lower contact of the Ribstone Creek sandstone is gradational. The silty shale of the Lea Park grades upward through laminated silt into the fine sand of the basal Ribstone Creek," and he further states: "The Ribstone Creek is divided into an upper and a lower part by the Vanesti tongue. The contact between this tongue and the lower Ribstone Creek is sharp. The upper Ribstone Creek is a thin sand member which is about 40 feet thick near Mannville and thins eastward. It is fairly porous and is the aquifer for numerous water wells in the Vermillion area." Dr. Nauss' lithological description: "This unit (Ribstone Creek formation) consists largely of medium-grained friable sandstone. In many localities it is cemented with calcite into a hard gray slabby rock which weathers to a buff or light yellow colour," compares closely with the outcrops along Blackfoot Creek.

Comparison of the accompanying map with earlier survey maps will show where the Lea Park sand had been included in the Ribstone Creek formation. It is not possible to tell the two sands apart by megascopic examination. The following exposures of Ribstone Creek beds were measured in the field:

1. Location: N.E.$\frac{1}{4}$, sec.12, tp.42, rge.17
Railway cut, 750 feet south of section fence; at track level.
Stratum: Sand, grey, weathers yellow, fine to medium grain, clean, quartz and chert; rather massive, loose, moist, with yellowish horizontal streaks; grains sub-rounded to rounded.

2. Location: E. center, sec.14, tp.42, rge.17.
Altitude: about 2,050 feet.

Exposure west side of Highway 4, roadcut. West of Porter.

Strata: 2'0" Clay, lumpy, shaly, post-Tertiary.

2'0" sand, Ribstone Creek, white, clean, quartz, minor chert peppering. No coloured quartzes. Mostly fine-grained, some medium, Subangular to subrounded. Porous and moist.

3. Location: S. boundary, sec.34, tp.46, rge.27. Altitude: about 2,025 feet. On railway cut.

Strata: 1'0" Sandstone, crossbedded, lensing, light grey, fine grain, arkosic, platy with 3/8" bedding planes.

3'0" Sand, yellow, fine-grained, selenitic.

Base obscured.

4. Location: N.E.¼, sec.1, tp.47, rge.27

Altitude: about 2,060 feet.

Northeast corner of section in railway cut.

Stratum: 15' Sand, light grey , grains angular to rounded, some reddish minerals. Contains large, brown weathering concretions of hard, blue sandstone. Grades laterally to a brown sand.

5. Location: Center, N.E.¼, sec. 11, tp.47, rge.27.

Altitude: about 2,075 feet.

Ten feet above railroad tracks on the north side.

Stratum: 10' Sand, massive, fine-grained, quartz and chert, slightly arkosic.

6. Location: N.E.$\frac{1}{4}$, sec.24, tp.46, rge.28

Altitude: about 2,150 feet

Outcrop on the west side of the road.

Strata: Post-Tertiary:

1'6" Till, earthy, boulders to 4".

1'0" Ironstone concretions, beautiful concentric banding, rusty shades, some bluish staining on one rock.

0'3" Gravel, Laurentian pebbles up to 2".

2'6" Sand, yellow, fine-grained, a few scattered pebbles.

0'3" Gravel, Laurentian pebbles to $\frac{1}{2}$" and ironstone fragments to 1" in a coarse, grey sand matrix.

Overlies Ribstone Creek sand:

2'0" Sand, yellow, massive fine-grained.

7. Location: S. end, sec.27, tp.46, rge.28.

Altitude: around 1,950 feet.

On the east bank of Blackfoot Creek.

Strata: Post-Tertiary: ? Till, shaly, yellow and grey.

Ribstone Creek: ? Sandstone, hard, platy, slumped.

1'0" Sand, shaly, quartz and chert, grey and yellow.

8. Location: N.end, sec.22, tp.46, rge.28.

Altitude: around 1,950 feet.

On the bank of Blackfoot Creek.

Strata: 3'0" Sandstone, hard, platy, yellow, salt-and-pepper, arkosic, slumped.

1'0" Sand, grey, fine to medium grain, subrounded, clean.

Grizzly Bear Formation

No known exposures of Grizzly Bear age occur in the area . This formational name was given by S.E. Slipper in 1917 for a, "dark blue, grey, marine shale, contains ironstone and sandstone nodules. Some beds of yellow incoherent sandstone" (19), surfaced near Wainwright, Alberta. Nauss(14) states: "The Grizzly Bear tongue is absent west of Minburn and Fabyan, from where it thickens eastward to a maximum of 110 feet. Still farther east the sand bed dividing the Grizzly Bear and Vanesti tongues probably disappears (log of Lloydminster No.3, Wickenden, 1941)".

An outcrop of shale in a railway cut on the N.E.1/4, sec. 29, tp.43, rge.18, a short distance west of Prongua had been thought to be of Grizzly Bear age (7). It is now believed this shale belongs to uppermost Lea Park. The exposure consisted of two feet of shale, earthy, crumpled, dirty medium brown grey. There was a trace of medium grain, clean quartz, sand pockets; some chert; selenite (?) flakes; a few ironstone nodules. Mother-of-pearl fragments were scattered abundantly through it, and some pieces of shells were uncovered but were toofragile for collection.

Tertiary(?) Deposits

A deposit of questionable age was examined in S.E. 1/4, sec. 15, tp.47, rge.25, on the north bank of the Battle River near water level. The section was:

?	Till
1'0"	Sand, light grey, fine to medium grain, crossbedded, clean, channeled into underlying sand.
3'0"	Sand, mottled, fine grain, yellow and grey. And close by there was:
8'0"	Sand(sandstone), blue-grey, few scattered boulders to5", local carbonaceous bands with dips to 30°.

Mixture of fossils: baculites, pelecypods, bone. The bone has been identified by Dr. I. McTaggart Cowan as belonging to the anatomy of the Family Bovidae. The beds have been derived in part from Upper Cretaceous rocks and are possibly either late Tertiary or Interglacial. However the slumping of glacial drift onto Recent beds could give the same sequence, so at present their age remains undetermined.

Pleistocene Deposits and History

The Pleistocene history of this region has not been worked out in detail. The physiographic features, remnants of the Glacial time, include terminal and recessional moraines, ground moraines, sand plains of pro-glacial lake beds, diversion channels and smaller coulees. Soils reflect the nature of Pleistocene parent materials therefore the writer's map of glacial features is substantially in agreement with the Soil Survey report (13). Post-Pleistocene deformation associated with the withdrawal of the icesheet would be reflected in isostatic crustal balancing. These movements might possibly be able, under a large enough differential stress, to result in structure building within the Lower Cretaceous gasiferous sands but the writer does not see how a stress large enough could be built up to activate doming after this fashion.

The thickness of the ground moraine varies a good deal throughout the area. It is entirely absent in some parts but is extremely deep in others. Along Drummond Creek it was seen to reach a maximum thickness for the leases. Hume and Hage (7) report it up to 175 feet thick in the vicinity of Cutknife village. No drumlin belts were recognized; all drumlin-like forms lay roughly parallel to what was the apparent glacial front. Widespread moraines were observed south of Rockhaven. The many random lakes in township 41, range 16, are nested in morainal topography. Cooper Creek has the typical inter-locking spurs of Recent origin. It is a post-glacial adjustment to the physiography but has made little progress in draining the morainal belt. There was no water in the upper gully at the time examined. Cooper Creek valley varied from a 30 to 50 foot disection in S.E.$\frac{1}{4}$, sec. 9, tp.42, rge.16, to a 50 to 75 foot deep gorge at the bridge in S.E.$\frac{1}{4}$, sec.15, tp.42, rge.16. The creek bedwas bottomed with sandy gravel containing boulders less than 6 inches in diameter.

Although"in southern Saskatchewan . . . the Coteau moraine appears to mark the limits of a late Wisconsin advance of the ice" (12), the Eagle Hills do not seem to represent the terminal moraine, so much as a temporary depositional

zone of the impeded advancing ice-sheet. The Hills buffered the glacial front by decreasing its velocity until the altitude differences between the North Saskatchewan River valley and the crest of the escarpment were brought to a common level by ice accumulation. Then the ice was able to advance southwestward along a "shearing plane" developed within the glacier mass at a horizon determined by flow outlets along and above the Eagle Hills escarpment. A protective, stagnant phase or stratum of the continental glacier within the North Saskatchewan valley would explain the absence of any great glacial deposits there. The most effective stage of advance in the area is assumed, but not proven, to be late Wisconsin.
Dr. Crickmay(10) has reported "two distinct boulder clays of different character separated by stratified sands...around Frog Lake in the northeast corner of Kitscoty map-area" On the north bank of Big Gully Creek the following upright section was measured:

5'0" Gravel, sandy and clayey.
12'0" Gumbo till, mostly clay with scattered pebbles.
4'0" Outwash: Laurentian boulders to 8"; sand matrix, grey with yellow specklings, mostly quartz, grains coarse up to small (1/8") pebbles, clean, porous, loose. No observable bedding. Base obscured.

This sequence suggests two advances of the ice-sheet.

Cross-sections of late Pleistocene pro-glacial lakes were mapped in the course of this investigation. These lakes had lain between the northern ice front and southern moraines and an escarpment. Margins of the sands associated with these lakes have been mapped by the Soil Survey and are incorporated in Map No.2 of this report. Meota[1] light textured soil is associated with the sandhill region of Manito Lake and is characterized by the sandy, stone free nature of the soil together with evidence of wind erosion.

In sharp contrast is the Blaine Lake medium to heavy textured soils found east of Range 18, in the North Battleford area. This is a thin deposit underlain by boulder clay. The difference between the Meota and the Blaine Lake sand types appeared to be, to the writer, one of degree and nature of weathering rather than of parent material. The east and north cliffs of Manito Lake are composed of glacial till and on a small promontory, in N.E. $\frac{1}{4}$ sec. 12, tp.44, rge.27. there is an erosion remnant outlier of till some 75 feet high. On the east side the remnant is aproned by Laurentian boulders up to 4 feet in diameter. The beach plain surrounding it is composed almost wholly of sands with only traces of gravel size particles. The sand is fine to coarse grained, contains quartz, reddish minerals, and micas, and is angular to rounded. No Cretaceous sand exposures are known in the area. It would appear that most of the sand was derived from the breakdown of glacial deposits and by later cleansing by wind and water of much of their clay materials. Manito Lake has lasted from late Pleistocene time, when it presumably extended southwestward into Alberta and southeastward into the Vera area, to the present.

1. Meota is a soil type-locality name.

It is not known when Lake Battleford[1] was abandoned, but it appears to have become dismembered soon after the North Saskatchewan River re-occupied its valley. The lakes, Atten and Bushy, between Cutknife Creek and Battle River are the last relics of Lake Battleford south of the Battle River. The early slackening of lacustrine and aeolian agencies in the Battleford region left those sands less worked over than the Manito sands, and explains satisfactorily the differences in soil texture as a function of time. It is interesting to note that Manito Lake may be deepening at the present time with loss of sand by shore dune formation and drift.

The valley of the North Saskatchewan River during Lake Battleford time is of some importance. Apparently the pro-glacial lake was bisected by the valley (see map). Under lacustrine conditions the valley could not have been occupied by a river, therefore it may have been filled by stagnant ice frozen to the sub-stratum. The North Saskatchewan River valley, which determined Lake Battleford bottom level, was steadily lowered during the melting of the ice and finally the high level portions of the lake were abandoned.

Varved clays were seen at a few localities; - near the northeast end of the North Battleford bridge; overlain by

---

1. Lake Battleford: it is proposed that the indicated pro-glacial lake be thus termed because of its location in the vicinity of the Battlefords.

till and underlain by Lea Park sand, 300 feet north of the mouth of Pipestone Creek along Battle River; near S.E.$\frac{1}{4}$, sec.19, tp.43, rge.16, on the bank of Battle River; east end of Highway 40 bridge over the Battle River. These clays may be all that is left of a lacustrine deposit laid down in an interglacial period. They do not appear to be related to the sandy pro-glacial lakes.

Diversion channels were adjustments in drainage patterns brought about by the flood-waters of late Pleistocene time. They served to carry away the overflow of waters from the pro-glacial lakes. It has been advocated by Dr. L.F. Wills (27) that: "The existance of these river valleys (in the United Kingdom) where no river now runs is best explained on the assumption that mush of their excavation took place under tundra-conditions in the Pleistocene; for if the sub-soil were perennially frozen, these rocks would lose their permeability, and the thaw-waters and the rainfall would run off at the surface. Probably also the greater precipitation under Glacial conditions would mean a higher water-table in the rocks." The major channels encountered were the Marsden - Unwin channel, Buzzard Coulee, and possibly Battle River. It is thought that water flowed from Manito Lake northwestwardly into the linear topographic depression near Marsden and northward to a Battle River outlet near Unwin. This is a gorge-like feature which winds about considerably as if originally controlled by an earlier valley, rather than formed by a cutting back of a post-glacial channel. It is characterized throughout its length by gravel fill which was brought down from Manito Lake. Consequently the spillway's history may include piracy by Manito Lake waters, sudden deepening by flushing waters with deposition of sediments in the Battle River gorge, later increased deposition along the channel itself, rejuvenation, and finally abandonment. If the first floods from Manito Lake clogged up the Battle River valley below Unwin, or if it became ice-jammed at that point, it is possible that Buzzard Coulee may have been modified and become the normal drainage way for Battle River waters for a time. The line up of the Marsden - Unwin channel with the upper part of Buzzard Coulee would suggest a genetic relationship.

On the west bank of Cooper Creek, in sec.2, tp.42, rge.16, an abundant spring flowed out of a Pleistocene sand and gravel bed. The water was issuing from a coarse grained sand that overlay a medium grained sand. It was tasteless and odorless but appeared to be cementing gravels with calcium carbonate. The water was numbing to the hand and felt to be near freezing temperature. Proximity of artesian water temperatures to the mean annual temperature of the region (35°F.) has been taken to indicate deep seated origins (18). This was the only large spring seen in the field.

Regional Structure

The Lea Park and Ribstone Creek formations lie on the east limb of a very broad geosyncline. There is, in general,

DRILL HOLES NUMBERED IN FIGURES 1 AND 2

1. Northwest Mannville No. 1

2. Lloydminster Gas Well No. 2

3. Colony No. 2

4. Altoba No. 1

5. Altoba No. 2

6. Meridian No. 1

7. Ribstone Oils No. 2

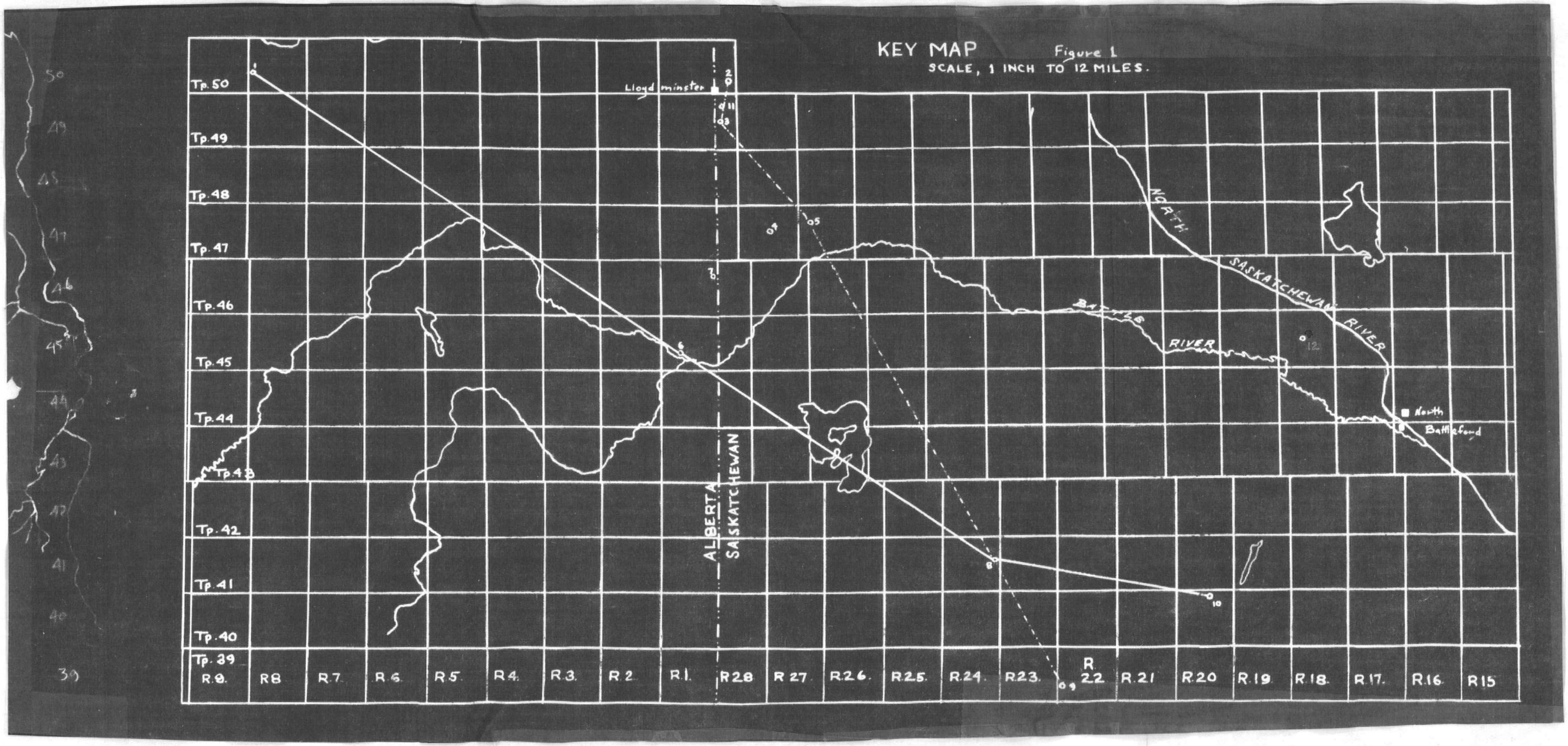
8. Bata Petroleums No. 16

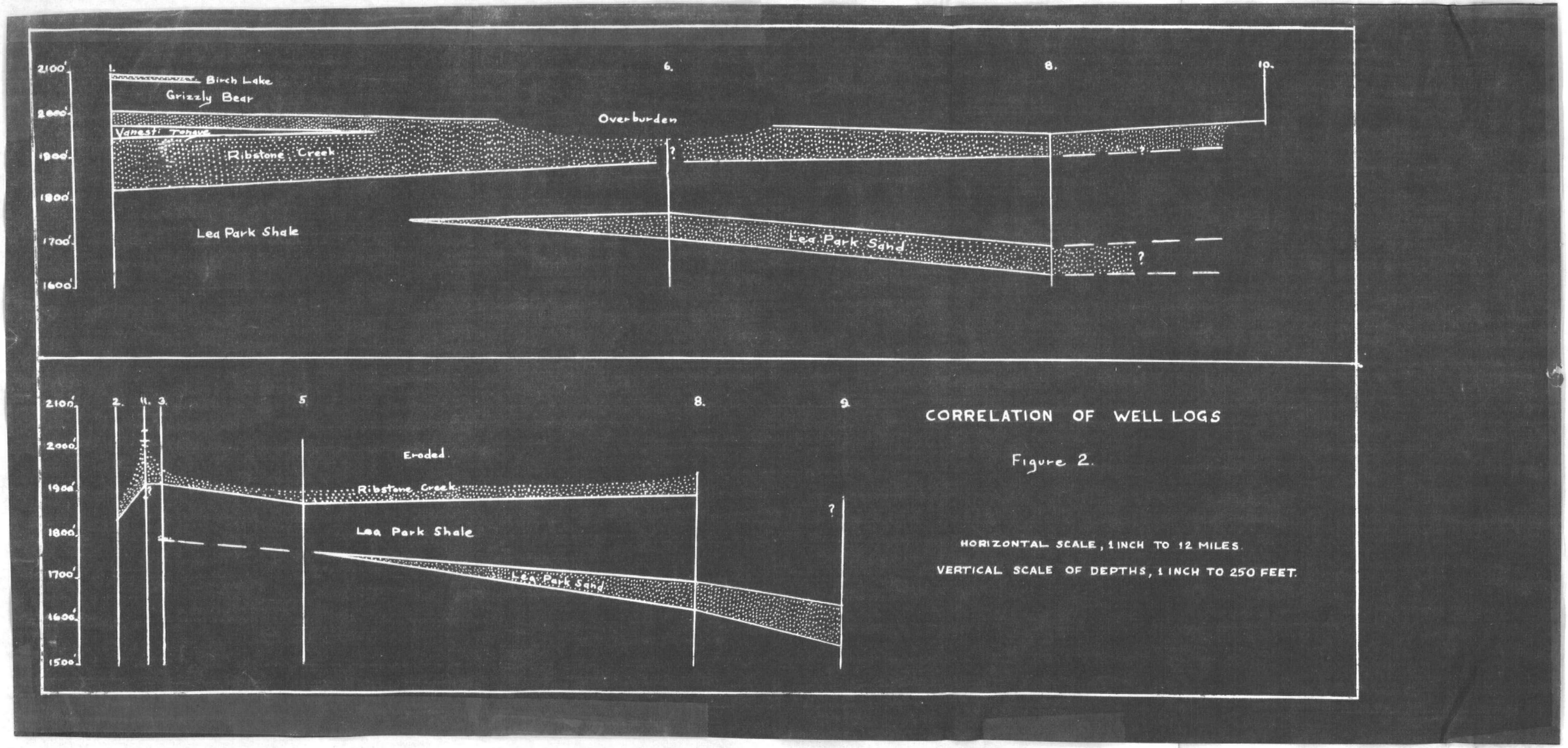
9. Muddy Lake Well (Northwest Co.)

10. Grainlands Ltd. Water Well

11. Lloydminster No. 3

12. Messander Royalties No. 1


KEY MAP
Figure 1
SCALE, 1 INCH TO 12 MILES.
Tp. 50
Tp. 49
Tp. 48
Tp. 47
Tp. 46
Tp. 45
Tp. 44
Tp. 43
Tp. 42
Tp. 41
Tp. 40
Tp. 39
R.9.
R8
R.7.
R.6.
R.5.
R.4.
R.3.
R.2.
R.1.
R28
R 27
R.26.
R.25.
R.24.
R.23.
R 22
R.21
R.20
R.19
R.18.
R.17.
R.16.
R15
Lloydminster
ALBERTA
SASKATCHEWAN
NORTH
SASKATCHEWAN RIVER
BATTLE
RIVER
North
Battleford


2100'
2000'
1900'
1800'
1700'
1600'
1.
6.
8.
10.
Birch Lake
Grizzly Bear
Vanesti Tongue
Overburden
Ribstone Creek
Lea Park Shale
Lea Park Sand
2100'
2000'
1900'
1800'
1700'
1600'
1500'
2.
11.
3.
5.
8.
9.
Eroded.
Ribstone Creek
Lea Park Shale
Lea Park Sand
CORRELATION OF WELL LOGS
Figure 2.
HORIZONTAL SCALE, 1 INCH TO 12 MILES.
VERTICAL SCALE OF DEPTHS, 1 INCH TO 250 FEET.

a low measurable dip to the west or southwest. Minor structures have been developed contemporaneously with strata deposition, or have been superimposed on the formation. Lateral gradations in lithology prevent attempts to measure dips by surface surveys. Subsurface horizons prove to be the most useful from which to plot structure contours. The base of the Ribstone Creek is of not much value in such work, and even if only used locally it may be misleading.

The Lea Park sand might be useful in the Bata lease areas for structure drilling correlations (cf3). It would be essential to investigate its relation to the Lower Cretaceous gas-bearing sands by means of convergence studies before an attempt to predict structure at depth could be made. It would tend to reflect only the post-late Lea Park deformations, however compaction of underlying sediments would also effect it.

Foraminiferal studies are extremely reliable for correlation of beds. If the species isolated by Nauss from 30 feet and 200 feet below the top of the Lea Park are at all widespread they would be useable for shallow structure drilling in areas north of Muddy Lake. Haplophragmoides rugosa seems to be diagnostic of a thin shale member extending (?) from Muddy Lake to Rush Lake.

The deflection of the North Saskatchewan River at North Battleford may reflect structure although normally we would not expect the river to be controlled by structure in a region of nearly horizontal strata.

Figure 2 illustrates the structure present in the surface and near-surface beds of the area. The structure of these beds does not conform very closely with the structure of the Lower Cretaceous - Upper Cretaceous contact. The Ribstone Creek and Lea Park sands have an initial dip as well as acquired deformational dips.

Dr. Sanderson(16) has pointed out: "The drilling in the Unity area has revealed another important feature that is a little surprising - that is, the occurence of closed structures over local areas several thousand acres in extent, the range of closure being from 70 to 100 feet. The origin of such structures within this vast area - nearly wholly lacking in structural deformation - remains to be explained." The Battle River region is only a short distance north of the Unity area and should be just as favorable structurally for gas traps. Dr. Nevin (15) has written: "It should be remembered that all the effects of actual uplift could be given by a regional subsidence, during which local areas lagged behind."

Deformed beds of Pleistocene deposits were commonly seen throughout the field area. Varved clays, on the roadcut near the east end of the North Battleford bridge, are crushed and folded (see Plate III). In the S.E.¼, sec.25, tp.42, rge.17. Lea Park sands and shales are distorted and tilted up to 30° but this crumpling does not seem to be due to slumping. Ice action, either as the moving glacier front or as floating ice-bergs or as ice shove along pro-glacial lake shores caused these minor structures (5). The sands and clays do not appear to have been frozen at the time of deformation because the beds are plastically folded rather than competently faulted.

Palaeontology

We are concerned mainly with palaeozoology. Coal and plant fragments occur in the Lea Park and Ribstone Creek formations but no studies have been made of them. Foraminifera are the most reliable index fossils obtained from drill cuttings of marine beds. These protozoa by a dispersal and maintenance of numbers together with species evolution characterize horizons in the marine sediments. Later changes in population often took place by extinction although opportunities for migration or adaptation were open. When a species occupies a wide geographical range and a narrow stratigraphic range it becomes valuable for long distance correlations. Nauss (14) has listed foraminifera species occuring in the Lea Park formation within the Vermilion area. Wickenden (4,23,24,25,26) has studied species occuring in the Prairie Provinces but has not published complete check lists.

Dr. P.S. Warren (22) has expressed an opinion that *Pholadomya subventricosa* M. and H. is the best index fossil of the Lea Park formation, and that *Baculites ovatus* Say, *Baculites ovatus var. haresi* Reeside, *Baculites aquilaensis* Reeside, *Baculites aquilaensis var. separatus* Reeside are all "good" indices to the Lea Park. No megafossil indices are known from the Ribstone Creek formation but oysters are found in at least one horizon.

Dr. Hume (10) collected *Baculites sp.*, *Liopistha undata*, *Corbula? sp.*, and *Protocardia borealis* Whiteaves from an exposure of the Lea Park shale on a railroad embankment along the Battle River in tp.45, rge.27, West 3rd meridian.

The following collections listed (10) as occuring in the Ribstone Creek formation should be referred to the Lea Park sand:

Sec. 21, tp.46, rge.24	Baculites cf grandis
Sec. 9, tp.47, rge.25	Goniomya americana Oxytoma nebrascana Protocardia cf pertenuis Astarte sp. Baculites cf grandis
Sec. 15, tp.47, rge.25	Pecten n. sp. cf silentiensis Baculites cf grandis
Sec. 36, tp.46, rge.27	Pecten n. sp. cf silentiensis Callista sp.

Sec. 19, tp.49, rge.24 and sec.24, tp. 49, rge.25 on Big Gully:

Axinea sp.
Oxytoma sp.
Lunatria concinna
Protocardia cf pertenuis
Modiola meeki
Baculites sp.

Small collections of fossils made by the writer were composed of cephalopo~~d~~s and pelecypo~~d~~s. The species identified were:

N.E.$\frac{1}{4}$, sec.22, tp.48, rge.21 on the bank of the North Saskatchewan River from Lea Park shale: Baculites grandis H. and M.

South $\frac{1}{2}$, sec.16, tp.47, rge.25 on the north bank of the Battle River from Lea Park sandstone:

Baculites ovatus var. haresi Reeside
Pecten n.sp. cf silentiensis
Protocardia pertenuis (M. and H.)
Pteria nebrascana (E. and S.)
Pteria linguiformis (E. and S.)
Inoceramus sp. adolescent.

APPENDIX

LOGS OF DEEP WELLS

Northeast Mannville Well No. 1.

Location: l.s.1, sec.18, tp.50 rge.8, W.4th mer.

Altitude (rotary table): 2,094 feet.

Sample descriptions by Nauss (14, p.1609)

		Depth(feet)
Birch Lake sandstone:	Buff sand and oyster shells	0 - 10
Grizzly Bear tongue:	Grey and buff shale and sand	10 - 80
Upper Ribstone Creek formation:	Grey shale and coal	80 - 90
	Coarse, grey sand	90 - 110
	Grey sand, some shale	110 - 120
Vanesti tongue:	Grey shale	120 - 150
Lower Ribstone Creek formation:	Coarse, grey sand	150 - 190
	Fine sand and silt	190 - 230
	Coarse sand	230 - 240
	Fine sand	240 - 270
Lea Park formation:	Grey shale, microfauna	270

Lloydminster Gas Well No. 2.

Location: S.W.¼, sec.12, tp.50, rge.28, W.3rd mer.

Altitude: 2,105 feet.

Sample descriptions by Nauss (14, 1616)

		Depth (feet)
Glacial drift:	Grey clay and brown sand	0 - 150
Ribstone Creek:	Greenish grey fine-grained sand	150 - 170
Lea Park Shale:	Massive grey shale, microfossils and pyrite	170 - 950

Colony No. 2.

Location: l.s.16, sec.23, tp.49, rge.28, W.3rd.mer.

Altitude 2,139 feet.

Horizons from Hume and Hage (10)

Depth to Ribstone Creek - Lea Park contact: 220 feet

Sand in Lea Park formation at 350 feet.

Depth to Lea Park - Alberta formation contact: 1,020 feet.

Altoba(Manitou) No.2.

Location: l.s.9, sec.29, tp.47, rge.26, W.3rd mer.

Altitude: 2,017 feet.

Horizons from Hume and Hage (10)

Depth to Ribstone Creek - Lea Park contact: 140 feet

Depth to Lea Park - Alberta formations' contact: 910 feet

Meridian No.1.

Location: l.s.4, sec.16, tp.45, rge.1, W.4th mer.

Altitude: 1,938 feet.

Sample descriptions by Hume and Hage (10)

	Depth(feet)
Glacial drift	0 - 60
Lea Park formation:	
Grey shale, a little sand	60 - 70

Grey shale, fossil shells at 80 feet.		70 - 170
Lea Park sand:	grey, shaly sand	170 - 200
	Fine, grey sand	200 - 230
Grey shale		230 - 930
Alberta formation		930

Ribstone Oils No.2

Location: l.s.5, sec.25, tp.46, rge.1, W.4th mer.

Altitude: 2,087 feet.

Horizons from Hume and Hage (10)

Ribstone Creek - Lea Park contact at a depth of 140 feet.

Base of Lea Park sand occurs at a depth of 320 feet.

Lea Park - Alberta formations' contact at 1,030 feet.

Bata Petroleums No.16

Location: l.s., sec.24, tp.41, rge.24, W.3rd mer.

Altitude:1,923 feet (ground); 1,930 feet (Kelly bushing).

Sample descriptions by Hughes : see graphic log.

Muddy Lake Well (Northwest Co,)

Location: l.s.11, sec.7, tp.39, rge.22, W.3rd mer.

Altitude: 1,894 feet; date,

Total depth:

Sample descriptions by Wickenden (24). Formation boundaries by Hughes, 1947.

	Depth (feet)
Missing	0 - 40
<u>Belly River beds</u>	
Shale, sandy, light grey; coal fragments	40 - 70
Missing	70 - 80
Coal, little shale	80 - 90
Shale, medium to light grey, some sand and coal	90 - 150
Missing	150 - 165
<u>Lea Park formation</u>	
Shale, medium grey, <u>Haplophragmoides rugosa</u>	165 - 250
Lea Park sand equivalent. Shale, sandy, medium grey, glauconitic	250 - 300
Missing	300 - 340
Shale, medium grey	340 - 550
Shale, dark buff and grey, <u>Verneuilina sp.</u>	550 - 560
Shale, medium grey	560 - 570
Shale, dark buff and grey	570 - 660
Shale,medium grey	660 - 850
Wickenden's Lower Lea Park zone:	
Shale, medium grey, but darker than above ; <u>Epistomina caracolla</u>	850 - 1,150

Alberta formation: white speckled, calcareous shale.

Grainlands Ltd. Water Well

Location: N.W.¼, sec.34, tp.40, rge.20, W. 3rd mer.

Altitude: 2,190 feet; date, 1914.

Total depth: 226.5 feet

Sample descriptions by Carter and Smith, Consulting Mining Engineers, Toronto, and Hume and Hage, (7)

	Thickness	Depth (feet)
Surface soil and yellow clay	16	16
Gravel with water	1	17
Blue clay	23	40
Sand and Blue clay	69.5	109.5
Fine sand with water	1.5	111
Blue clay	14.5	125.5
Sand and gravel (3 inches pebbles), water	1	126.5
Considered to be the base of the drift.		
Sand and clay	65.5	192
Fine sand, thin seam of coal (possibly 6 inches to 1 foot thick; water)	3	195
Blue clay with fine sand	13	208
Blue clay (water shut off by casing)	6	214
Dark chocolate clay with fine sand and small pieces of coal	3	217
Blue clay with thin seams of coal 1/16" to 1/4" thick	5	222
Fine grey sand, flow of water. Water rose to 6 feet from the surface	4.5	226.5

Top of Ribstone Creek formation considered by Hughes to be near an elevation of 1,968 feet. At 222 feet deep.

Lloydminster No.3.

Location: l.s.16, sec.26, tp.49, rge.28, W.3rd mer.

Altitude: 2,120 feet

Sample descriptions by Wickenden (25) and Hume and Hage (10).

	Depth (feet)
Missing	0 - 80
Shale, some glauconite. Grizzly Bear? Water from 95 to 112 feet.	80 - 100

Shale, sandy, medium grey. Traces of plant remains. Ribstone Creek? Water 160 - 163 feet.	100 - 200
Cement - traces of shale? Water from 217 to 220	200 - 230
Lea Park, upper member. Foraminifera.	230 - 760
Lea Park, lower member. <u>Epistomina caracolla</u>.	760 - 1,010

Messender Royalties No.1.

Location: l.s.1, sec.21, tp.45, rge.18, W.3rd mer.

Elevation: 1,863 feet.

Total depth: 2,020 feet

Sample descriptions not reported.

Rush Lake Well

Location: l.s.2, sec.20, tp.19, rge.11, W.3rd mer.

Altitude: 1,750 feet approximately.

Sample descriptions by Hume (8)

Formation boundaries by Hughes (1947)

	Thickness	Depth (feet)
Drift	20	20
Belly River beds(?)		
Shale, medium grey	20	40
Missing	10	50
Sand, grey, pepper and salt	20	70
Sandy shale, medium to light grey	40	110

Lea Park formation:

Shale, medium grey; gas at 318 feet.		
Haplophragmoides rugosa fauna	230	340
Sand, medium grey; little shale	10	350
Sandy shale, brownish grey	50	400
Sand, fine grained	20	420
Shale, somewhat sandy, medium grey	490	910
Shale, Epistomina caracolla	650	1560

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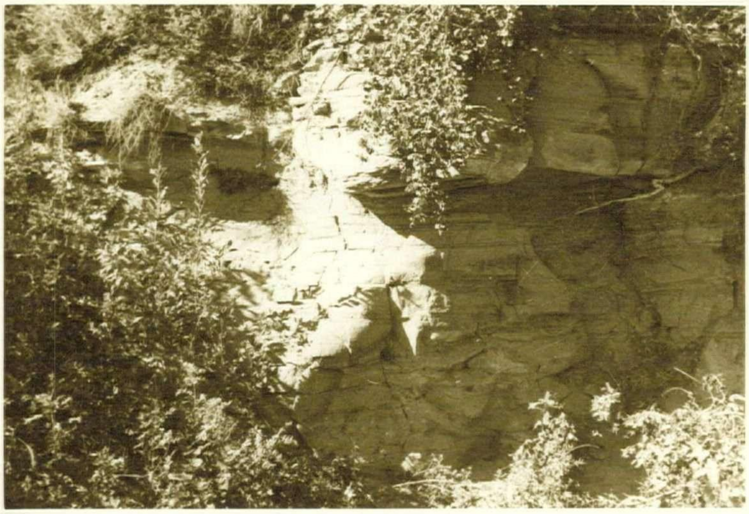
<u>MAPS</u> Geol. Surv., Canada; Dept. of Mines and Resources: Geology.

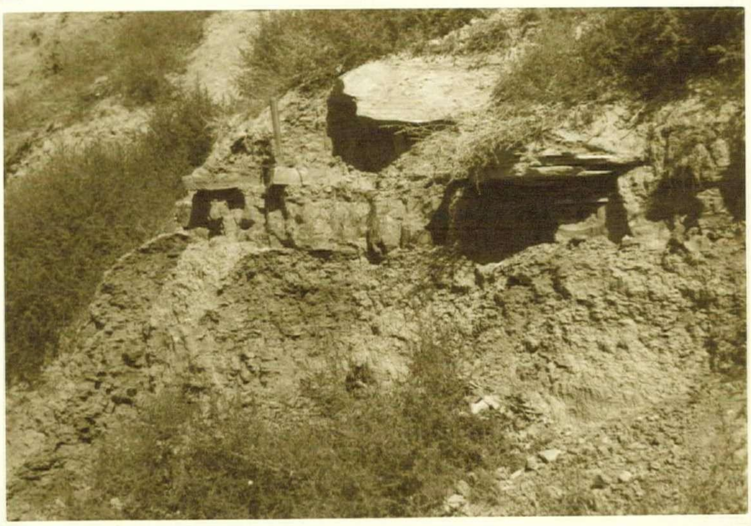
Fort Pitt (Sask.),	East half,	Map 489A
	West half,	Map 490A
Battleford(Sask.),	East half,	Map 491A
	West half,	Map 492A
Ribstone Creek (Alberta)		

A. Morainal topography between Prongua and Lindequist, looking east from knob in S.W.$\frac{1}{4}$, sec.35, tp.43, rge.18, W.3rd mer.

B. Looking west over alkali lake toward Prongua below Eagle Hills skyline, from S.W.$\frac{1}{4}$, sec.35, tp.43, rge.18, W.3rd mer.



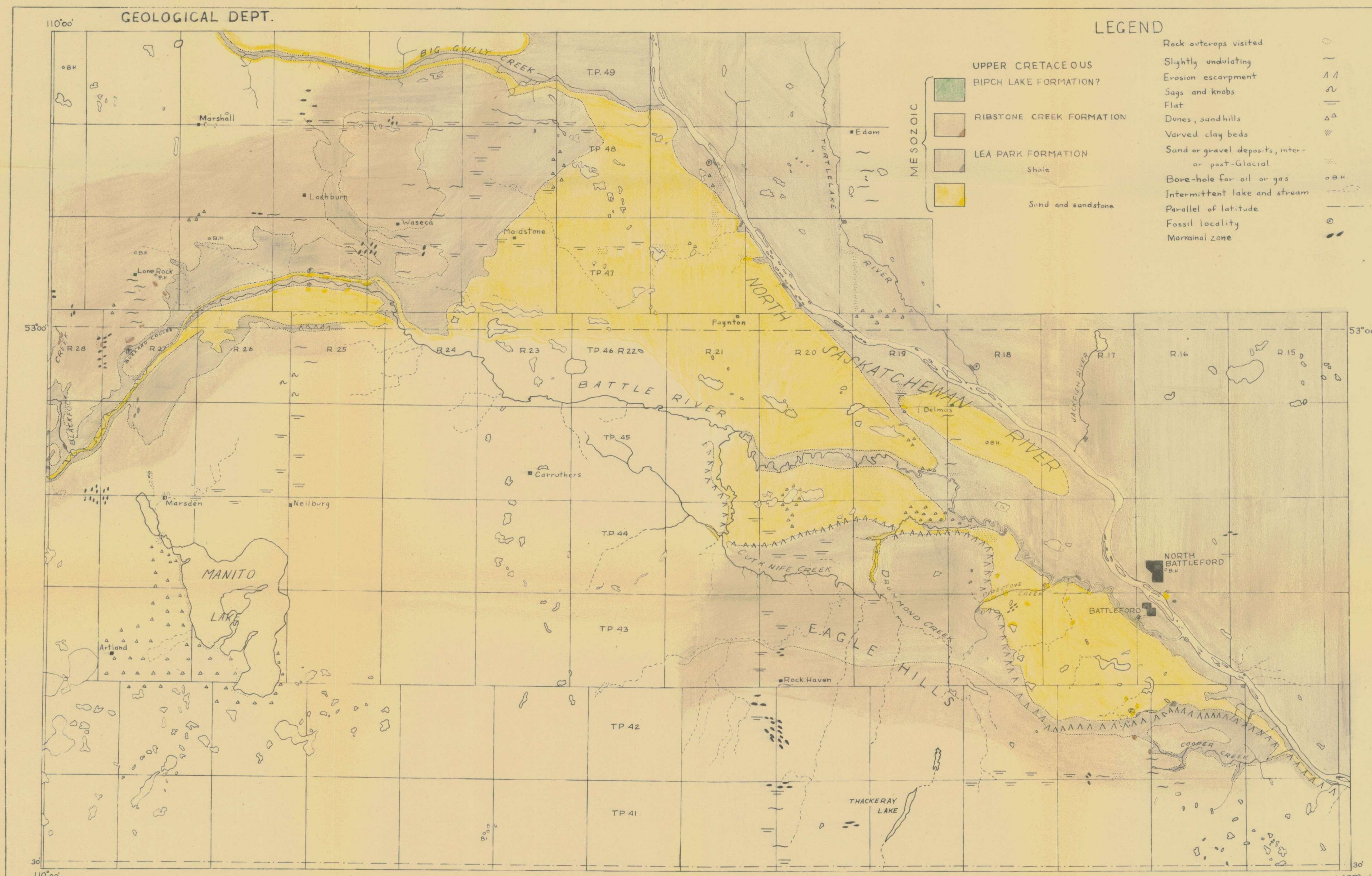
A. "Lea Park sandstone" alongside Pipestone Creek bridge, north from Prongua.



B. Sandstone beds in the Lea Park shale near North Battleford, N.E.$\frac{1}{4}$, sec.32, tp.43, rge.16, W.3rd mer.

PLATE III

Distorted varved clay beds near North Battleford, N.E.$\frac{1}{4}$, sec.32, tp.43, rge.16, W.3rd mer.



Scale 1 inch to 4 miles

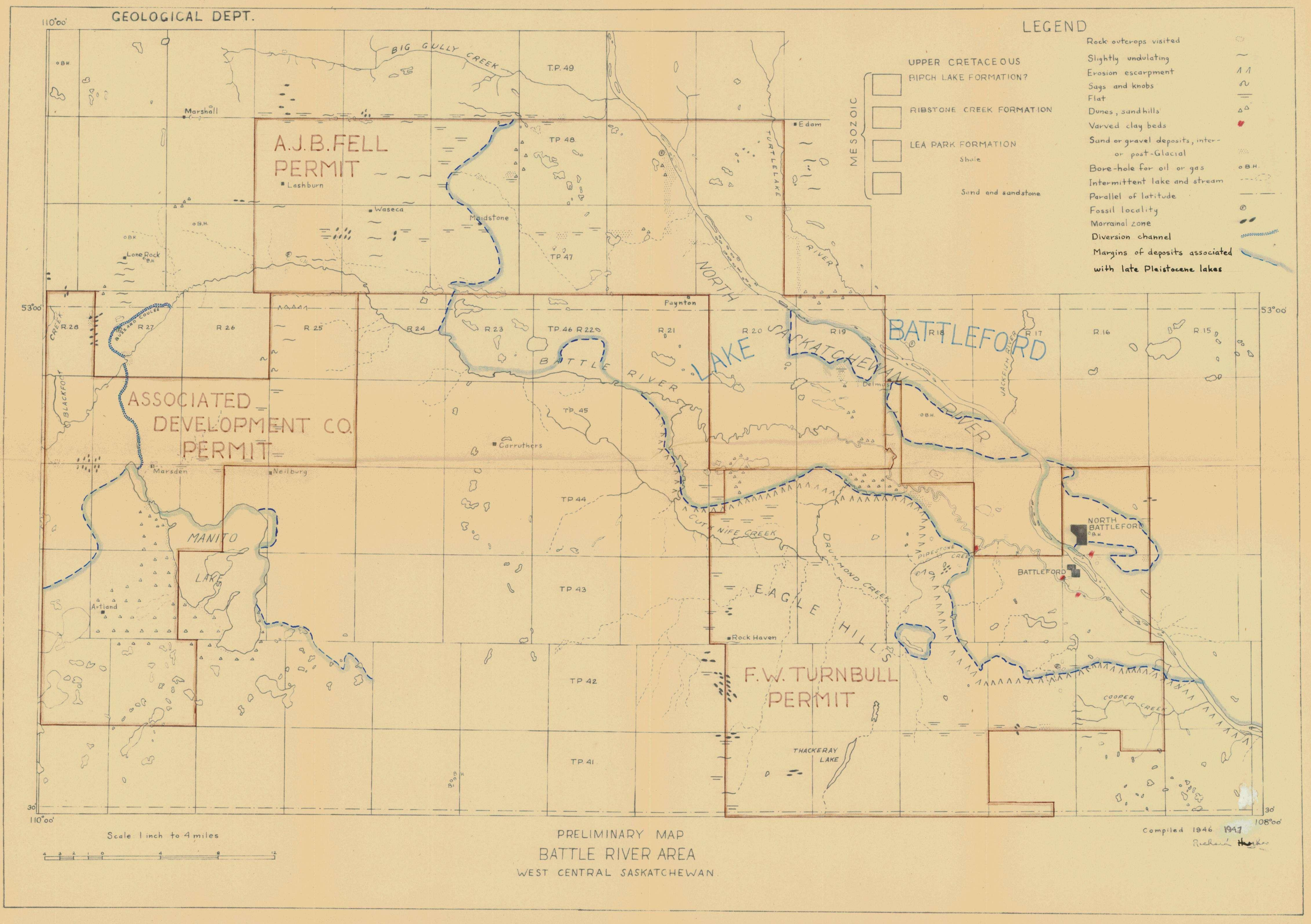
PRELIMINARY MAP

BATTLE RIVER AREA

WEST CENTRAL SASKATCHEWAN.

Compiled 1946 1947

Richard Hughes

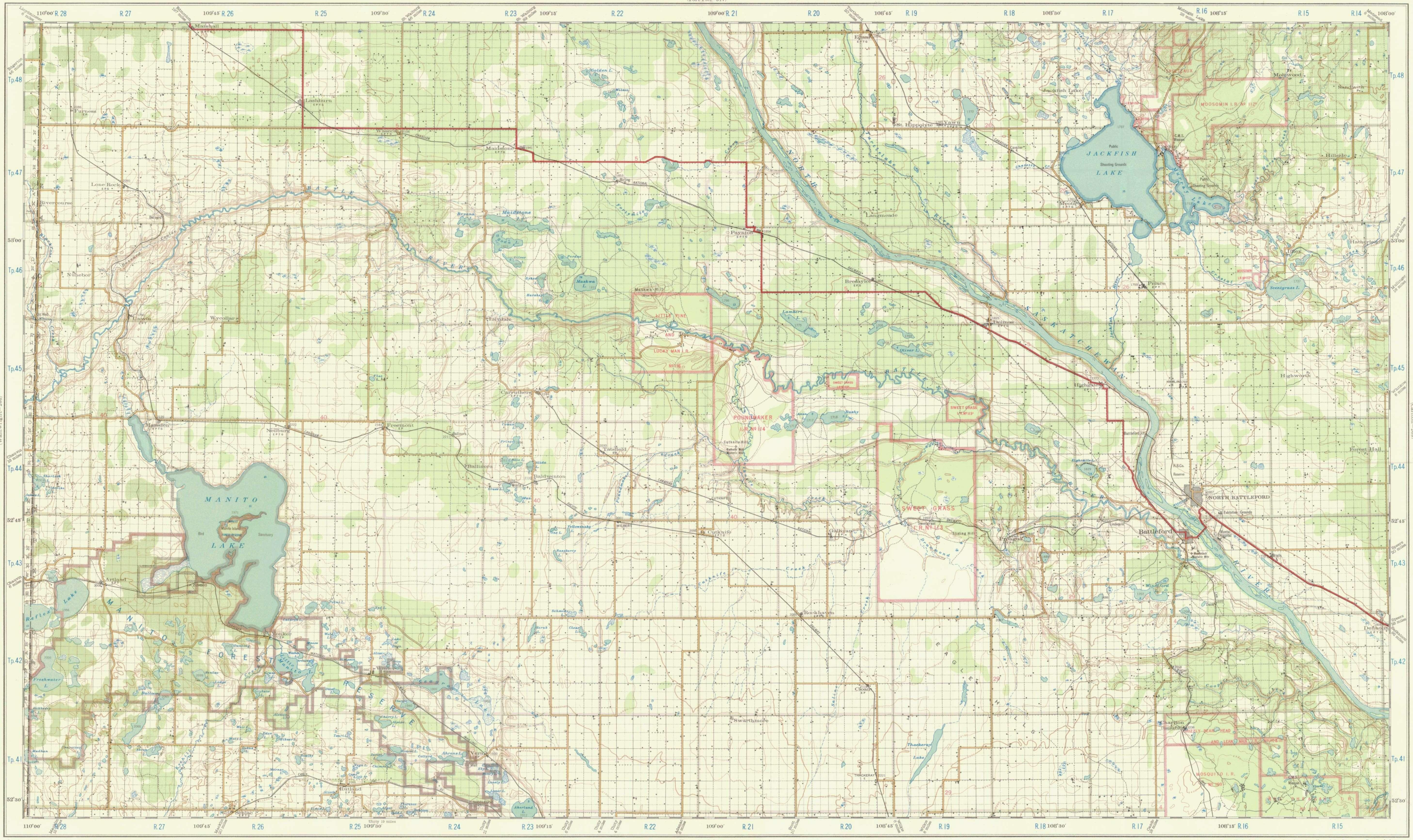

GEOLOGICAL DEPT.
110°00'
LEGEND
UPPER CRETACEOUS
MESOZOIC
BIRCH LAKE FORMATION?
RIBSTONE CREEK FORMATION
LEA PARK FORMATION
Shale
Sand and sandstone
Rock outcrops visited
Slightly undulating
Erosion escarpment
Sags and knobs
Flat
Dunes, sandhills
Varved clay beds
Sand or gravel deposits, inter- or post-Glacial
Bore-hole for oil or gas
Intermittent lake and stream
Parallel of latitude
Fossil locality
Morrainal zone
Diversion channel
Margins of deposits associated with late Pleistocene lakes
BIG GULLY CREEK
T.P. 49
Marshall
Edom
A.J.B. FELL PERMIT
TP 48
Lashburn
Waseca
Maidstone
Lone Rock
TP 47
TURTLELAKE RIVER
NORTH SASKATCHEWAN RIVER
53°00'
Paynton
R 28
R 27
R 26
R 25
R 24
R 23
TP 46 R 22
R 21
R 20
R 19
R 18
R 17
R 16
R 15
LAKE BATTLEFORD
BATTLE RIVER
BLACKFOOT CREEK
Delmas
JACKFISH RIVER
ASSOCIATED DEVELOPMENT CO. PERMIT
TP 45
Carruthers
Marsden
Neilburg
TP 44
CUT KNIFE CREEK
MANITO LAKE
NORTH BATTLEFORD
PIPESTONE CREEK
DRUMMOND CREEK
BATTLEFORD
TP 43
EAGLE HILLS
Artland
Rock Haven
TP 42
F.W. TURNBULL PERMIT
COOPER CREEK
THACKERAY LAKE
TP 41
30'
110°00'
108°00'
Scale 1 inch to 4 miles
PRELIMINARY MAP
BATTLE RIVER AREA
WEST CENTRAL SASKATCHEWAN.
Compiled 1946 1947
Richard Hughes

Canada
Department of Mines and Resources
HONOURABLE T. A. CRERAR, Minister; C. CAMSELL, Deputy Minister
SURVEYS AND ENGINEERING BRANCH
J. M. WARDLE, Director

SASKATCHEWAN, CANADA

SECTIONAL SHEET No 267

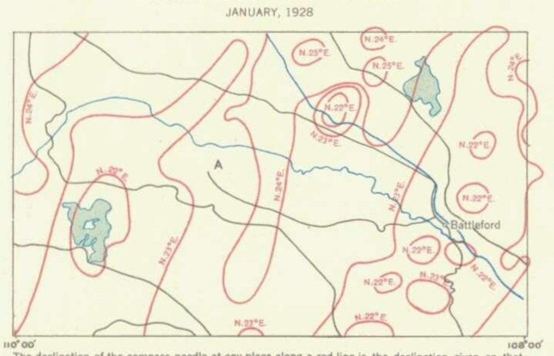
(Fort Pitt—317)



(Tramping Lake—217)

Reprinted, 1938

THE DECLINATION OF THE COMPASS NEEDLE
JANUARY, 1928



The declination of the compass needle at any place along a red line is the declination given on that red line. At other places the declination is between those given on the neighbouring red lines; thus at the place marked A, because it is halfway between the two red lines marked N. 23° E. and N. 24° E., the declination of the compass needle is N. 23°30′ E.
The declination of the compass needle is decreasing 7 minutes annually.

DIAGRAM OF TOWNSHIP

Reference

- Railway, steam, double track
- " " single track (Station, Siding or stop)
- " electric
- Road, class 1, trunk road
- " " 2, secondary thoroughfare
- " " 3, local road well travelled
- " " 4, " " slightly travelled
- Pack trail or path
- Telegraph or telephone
- " " " along road
- Power transmission line
- Non-perennial stream
- Canal, irrigation
- Drainage ditch
- Fall
- Rapid
- Glacier
- Alkaline flat

BATTLEFORD

WEST OF THIRD MERIDIAN

Scale 3 miles to 1 inch or 1:190,080

Miles 1 0 5 10 Miles

Contour interval 50 feet

Datum is mean sea level

Highway routes 40, etc.

Price 25 cents.
In folder form or linen backed 50 cents.

Reference

- Marsh, bog or open muskeg
- Wooded muskeg or swamp
- Non-perennial lake
- Sand
- Woods
- Post office .... P
- Telegraph office .... T
- Building
- Church
- School
- Elevator
- Mine or quarry
- Contours
- Depression contour
- Height in feet 2050
- Depth in feet 10
- Triangulation station
- Garage .... G

Compiled, drawn and printed at the office of the Surveyor General, Ottawa, July, 1928, from surveys by the Topographical Survey of Canada; and from information supplied by Dominion and Provincial Departments and by Railway Companies.
Revision of map of March, 1915