72-J-W

REPORT No. 32

GLACIAL GEOLOGY

of the

SWIFT CURRENT AREA

SASKATCHEWAN

by

E. A. CHRISTIANSEN

1959

DEPARTMENT OF MINERAL RESOURCES

Geological Sciences Branch

Sedimentary Geology Division

HON. A. C. CAMERON
Minister

J. T. CAWLEY
Deputy Minister

PROVINCE OF SASKATCHEWAN

Reprinted 1969

SASKATCHEWAN DEPARTMENT OF MINERAL RESOURCES

REPORT 32, 1959

GLACIAL GEOLOGY OF THE SWIFT CURRENT AREA, SASKATCHEWAN

E. A. CHRISTIANSEN

ABSTRACT

Three Wisconsin till sheets (Wymark Till, Aikins Till, and Leinan Till) and the end moraines of the latter two occur within the Swift Current area. These till sheets are separated by outwash and lacustrine sands, silts, and clays which were deposited during the retreats and advances of the ice sheets. The lack of weathering, except for oxidation, indicates that the three till sheets represent local fluctuations of the glacier during the major retreat. The montmorillonite (most abundant clay mineral) and illite in the tills were derived from the Upper Cretaceous Bearpaw Formation whereas the kaolinite was derived from the Whitemud Formation of the same series. The general direction of ice movement was from the northeast, although locally, the direction varied considerably.

A loess blanket, which is post-Aikinsian and pre-Leinanian, was derived from the outwash plain west of the city of Swift Current. The clay minerals of the loess, like those of the tills and lacustrine clays, are essentially montmorillonite and minor amounts of illite and kaolinite.

Slumping occurs in valleys where streams have cut through the drift into the Bearpaw Formation. When streams cut below this contact, the confining pressure is reduced sufficiently to cause the plastic shales to move laterally into the stream valley. The movement of the shale places the overlying competent drift in a state of tension, and fractures are formed. These fractures greatly reduce the internal shear resistance within the drift, and slope failure occurs. Valley widening by this process occurs very rapidly and is related to drift-shale stratigraphy rather than time.

Nonsorted polygons and circles in soils are recent and not periglacial in origin. They are large-scale shrinkage cracks formed by desiccation. During dry periods shrinkage cracks develop into which material from the A_1 horizon is deposited. The cracks and associated infillings cause soil development to take place laterally, and as a result, vertically-plated, solonetzic A'_2 horizons form adjacent to them. As the process continues, more and more of the parent B horizon within the polygon is transformed to A'_2 horizon until the nonsorted polygons become nonsorted circles.

CONTENTS

TEXT

ILLUSTRATIONS

TABLES

INTRODUCTION

Location

The Swift Current area, which comprises about 3000 square miles, lies between 107 and 108° West Longitude and between 50 and 51° North Latitude (Fig. 1). The city of Swift Current is about 140 miles west of Regina and about the same distance south-southwest of Saskatoon. The southern boundary of the area is 70 miles north of the International Boundary between Montana and Saskatchewan. Since the area lies west of the Third Meridian, all locations in the text are west of this meridian.

Previous Work

Fraser *et al.* (1935) published a map of the bedrock geology of southern Saskatchewan on a scale of one inch to eight miles.

Wickenden (1930), p. 68-70, in his study of glacial stratigraphy of southwestern Saskatchewan, published a description of two Pleistocene sections along Swift Current Creek (T. 19, R. 13). Johnston and Wickenden (1931), in their early work on surficial geology in southern Saskatchewan, dealt largely with moraines and glacial lake basins. Bretz (1943) included the Swift Current area in his reconnaissance study of the glacial history of southwestern Saskatchewan and southeastern Alberta. His conclusions were based entirely on moraines and the altitude of glacial lake outlets.

Edmunds (unpublished manuscript) conducted a study of the glacial history of a large area in central Saskatchewan based on glacial drainage and his interpretation of the surficial geology from soil maps. The northern portion of the Swift Current area was included in this study. Johnston *et al.* (1948) published a preliminary map on the surface deposits of southern Saskatchewan on a scale of one inch to 6 miles. A textural and mineralogical study was conducted on the Saskatchewan Landing and Swift Current Creek sections by Meneley (1956).

Mitchell *et al.* (1947) published a soil map on the scale of one inch to six miles. Because the surficial sediments can be interpreted, to a large degree, directly from this map, it has greatly facilitated the study of surficial geology in the Swift Current area. Moss (in Thorp and Smith, 1952, Map) showed that the Swift Current Plateau is covered with a thin blanket of loess up to 4-8 feet thick.

Present Studies

This report is based on field and laboratory studies conducted in 1956-1958. The mapping method is described as follows: before beginning field work, contacts of the surficial sediments, as interpreted from the soil map, were plotted on topographic sheets. With the aid of this technical map, aerial photographs, and mosaics, the landforms were classified. This preliminary interpretation was then checked and amplified in the field at which time the glacial stratigraphy was studied.

Mapping was done on a base map prepared by the Department of Mineral Resources, Regina, on a scale of one inch to two miles. Preliminary topographic sheets on a scale of 1:40,000, with a 25 foot contour interval, were available for the Swift Current and Wymark quadrangles (Fig. 2). It was necessary to rely largely on the Swift Current and Rush Lake sectional sheets for topographic control. These sheets have a scale of one inch to three miles and a 50 foot contour interval.

Aerial photographs greatly facilitate the study of land forms. They make it possible to delineate many land forms which are important in the interpretation of the glacial history.

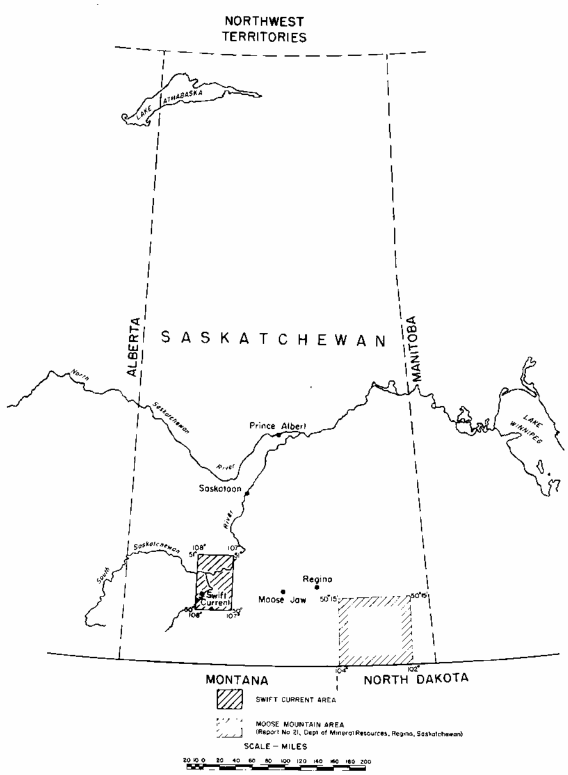
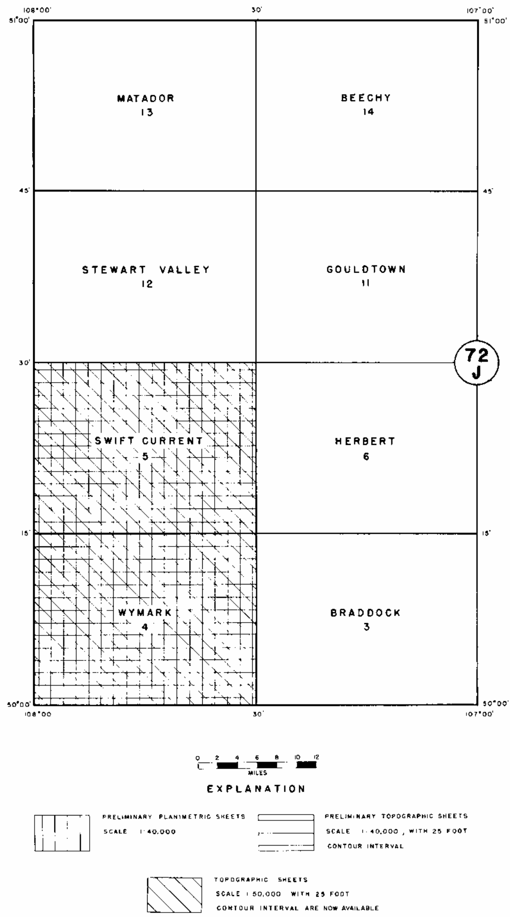


Figure 1.—Location of the Swift Current area



NOTE: Vertical air photographs, mosaics, and topographic maps at a scale of one inch to three miles with 50 foot contour intervals are available for the entire area.

Figure 2.—Index to maps of the Swift Current area

Acknowledgments

The writer wishes to thank Professor G. W. White, Head of the Geology Department, University of Illinois and Professors R. E. Grim, P. R. Shaffer, and D. U. Deere for their valuable assistance in this study.

Field work in 1958 was financed by the Saskatchewan Research Council for which assistance the author wishes to record his gratitude.

X-ray spectrometer traces were obtained with equipment made available through the courtesy of Professor R. T. Odell, Agronomy Department, University of Illinois, and with the assistance of Mr. P. R. Johnson who also determined the correlation coefficients. Professor Odell also offered many helpful suggestions which were greatly appreciated.

The author is grateful to Dr. W. O. Kupsch, University of Saskatchewan, for his assistance during the summer of 1956 and for critically reading the manuscript.

Graduate students in geology, particularly Mr. R. B. Ellwood and Mr. J. S. Scott, offered helpful suggestions in the preparation of the manuscript.

The author is grateful to Dr. J. L. Doughty, Dominion Experimental Station, Swift Current, Saskatchewan, who provided excellent office and laboratory facilities.

A field trip and subsequent discussions with Mr. H. C. Moss, Saskatchewan Soils Department, contributed much to the understanding of the soils in the Swift Current area.

Thanks are also due to Mr. A. M. Toth who ably assisted the author in the field and laboratory.

PHYSIOGRAPHY

Climate

The climate is characterized by great extremes in temperature between summer and winter and by low annual precipitation. Summer temperatures above 100° F and winter temperatures below –50° F have been recorded. There is frequently a wide variation in temperature between day and night, and from day to day in all seasons. The average annual temperature at Maple Creek, which is about 80 miles southwest from Swift Current, is 38° F (Mitchell *et al.*, 1947, p. 20). The average annual precipitation reported at the same station is about 14 inches. According to Mitchell *et al.* (1947, P. 18), the prevailing winds are westerly, the warm dry Chinook winds from the southwest and the colder northwesterly winds being the most common.

Soils

The Brown soil constitutes the zonal soil of the Swift Current area. Halomorphic soils are also present owing to the saline nature of the tills. This intra-zonal soil contains the following Great Soil Groups: Solonchak, Solonetz, Solodized-Solonetz, and Solod (Mitchell *et al.* 1947).

The soil association is the fundamental mapping unit in the classification of Saskatchewan soils. Soils that develop on similar parent material within the same soil zone constitute a soil association. The following soil associations were mapped in the Swift Current area: Haverhill, Chaplin, Hatton, Fox Valley, Sceptre, and Wood Mountain (Mitchell *et al.* 1947). Since all these associations lie within one soil zone, then by definition they are classified on the basis of parent material. This enables the geologist to interpret the surficial lithologies directly from the soil associations. For example, Haverhill Association contains Brown soils developed in till.

Topographic Features

The major topographic features are controlled by structure and erosion which antedates glaciation. Upon these basic elements the glacial deposits are superposed and, in most places, do not modify the bedrock topography to any appreciable extent. The Swift Current area may be divided into three physiographic divisions: Missouri Coteau, Herbert Lowlands, and Swift Current Plateau.

The Missouri Coteau is in the northeastern sector of the Swift Current area and extends southwestward to a line connecting Clearwater Lake (T. 22, R. 14) and a point about five miles north of Herbert (T. 18, R. 9). This range of hills is crossed by a broad lowland into which the South Saskatchewan River has entrenched itself to form a valley up to 700 feet deep (T. 20, R. 11). The coteau is developed upon outliers of the Eastend Formation which is capped in places by the Whitemud Formation (Fig. 13). The local relief exceeds 150 feet in only a few places.

The Herbert Lowland is developed upon weak, flat-lying shale of the Bearpaw Formation and Eastend Formation (Fig. 13). This lowland lies between the Missouri Coteau to the northeast and the Swift Current Plateau to the southwest. The present flatness of a large part of this area is due in part to a cover of lacustrine silts and clays. Part of the lowland, however, has a relief that ranges from 30-70 feet. The larger streams are sharply entrenched 200-400 feet below the surface of the lowland.

The Swift Current Plateau is developed upon the flat-lying, resistant gravel and conglomerate of the Cypress Hills Formation-Swift Current Creek Formation (Fig. 13). The plateau slopes gently toward the north. North of the city of Swift Current, the plateau is represented by scattered outliers of the Cypress Hills Formation-Swift Current Creek Formation once part of a much larger structural bench. The total relief is about 300 feet. The plateau south of Swift Current, however, is flat to gently undulating and has a relief of about 10-30 feet.

Drainage

Streams in the southeastern part of the Swift Current area drain into Old Wives Lake (T. 13, R. 1) which has no visible outlet. The remainder of the streams in the Swift Current area drain into the South Saskatchewan River which in turn drains into Hudson Bay by way of Lake Winnipeg.

Glacial Land Forms

Ground moraine, undulating

The undulating ground moraine comprises an area of low relief. The topography is best described by considering it under two forms: first order topography; and second order topography superposed upon the former. The first order topography consists of major swells, swales, and partially filled bedrock valleys. This order of topography, which reflects the topography of the bedrock surface, has 50-150 feet of relief. The second order topography has a relief that generally does not exceed 15 feet and commonly is less than 10 feet. This topography is superposed upon the first order topography and is interpreted as a topographic reflection of glacial deposition. The sediment is mainly till.

Ground moraine, hummocky

The hummocky ground moraine comprises an area of rolling to strongly rolling topography and is composed essentially of till. This hummocky ground moraine has a second order relief of 20-40 feet which is superposed upon the first order relief. The first order relief is 50-150 feet owing to large bedrock swells, swales, and valleys.

The hummocky ground moraine is characterized by knobs, kettles, rimmed kettles, moraine plateaus, and kames. The sediment is essentially till but includes minor amounts of stratified drift in the form of kames and lenses. This land form is interpreted as dead ice moraine (Christiansen, 1956, p. 12; Gravenor, 1955).

End moraine, ridged

Two accumulations of ridged end moraine occur in the Swift Current region: Clearwater Lake Moraine (T. 21, R. 13) and an area in Township 23, Range 14 (Figs. 3 and 4). Inasmuch as these two end moraines are similar, only the Clearwater Lake Moraine will be described.

The Clearwater Lake Moraine is well defined in its western part and grades eastward into hummocky ground moraine. A pattern is formed by a rhythmic sequence of sub-parallel, generally arcuate ridges and intervening swales. Although the individual ridges cannot be traced continuously, the pattern as a whole can be traced for 15 miles in aerial photographs. The ridges rise from 10-100 feet above the adjacent swales. Small lakes rest in the lower part of the swales. With the exception of some recent gullying along the northern boundary (T. 22, R. 14) of this area, little modification has taken place in these swales since glaciation. Bedrock exposures were not encountered. The ridges are restricted to areas underlain by Eastend Formation.

Samples from shallow exposures and a test hole drilled 42 feet into a ridge (S. 18, T. 22, R. 13) show that the sediment in the moraine is composed essentially of till and minor amounts of gravel and sand.

The general pattern shown in aerial photographs and the association of the moraine with the kame complex toward the south suggest that these ridges are end moraines representing various positions of the ice front during its retreat. Except for the size of the ridges and the number per mile (six), they have the same pattern in aerial photographs as the minor end moraines in the Moose Mountain area (Christiansen, 1956, p. 13 and 14). If they are annual in origin, the ice retreated from this area at an average rate of 880 feet per year as compared to about 310 feet per year in the Moose Mountain area (Christiansen, 1956, p. 14). The exact origin and the relationship between the occurrence of these ridges and the Eastend Formation is not understood.

***Figure 3.*—Ridged end moraine in S. 14, T. 23, R. 13. Lake indicated by arrow same as that indicated by arrow in Figure 4**

End moraine, hummocky

The hummocky end moraine is similar to the hummocky ground moraine except the former topographic unit shows a linear trend characteristic of end moraines.

Two hummocky end moraines were deposited in the Swift Current area: Aikins Moraine and Leinan Moraine. The Aikins Moraine, which is about seven miles east of Swift Current (T. 15, R. 12), is about 10 miles long, three miles wide, and trends in a northwesterly direction. The hummocky surface of the Aikins Moraine rises about 100 feet above the surrounding terrain. Near Aikins (T. 16, R. 13) along Highway No. 1, the hummocky Aikins Moraine is superposed on the southeast bluff of the bedrock valley which is occupied by Swift Current Creek (Fig. 5). This relationship indicates that this bedrock valley predates the moraine. The topography, which is characterized by knobs, kettles,

Figure 4.—Ridged end moraine in S. 14, T. 23, R. 13. Lake indicated by arrow same as that indicated by arrow in Figure 3. Air photo. A6747-1, courtesy R.C.A.F.

rimmed kettles, and kames, has a relief of 20-40 feet. The Aikins Moraine is composed essentially of till and minor amounts of stratified drift in the form of kames and lenses.

The Leinan Moraine is about 12 miles north of Swift Current and trends in an easterly direction. The moraine, which is about eight miles wide, extends from the western boundary of the map area (T. 18, R. 15) to Fauna (T. 16, R. 11), a distance of about 28 miles. This moraine completely plugs the bedrock valley that contains Waldeck (T. 16, R. 12) and Rush Lake (T. 17, R. 11) and indicates that this valley also predates the Leinan Moraine. The second order relief (10-20 feet) is superposed upon the first order relief which ranges from 50-200 feet. The sediment in it, the landscape on it, and the origin of the Leinan Moraine is similar to that of the Aikins Moraine.

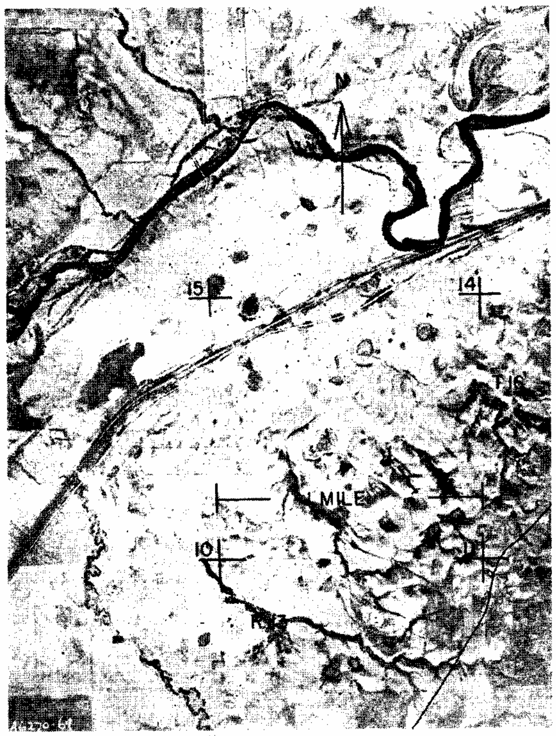


Figure 5.—Hummocky end moraine superposed upon the southeast bluff of an ancient valley in S. 11, T. 16, R. 13. Air photo. A6270-69, courtesy R.C.A.F. —Top of bluff

Woldstedt (1954, p. 95) points out that hummocky moraines are marginal deposits of the ice and may take the place of true end moraines which are linear wall-like features. The Aikins and Leinan moraines are interpreted as end moraines formed, at least in part, by dead ice deposition.

Kame complex

Hummocky topography composed mainly of stratified drift is mapped as kame moraine. The topography is gently to strongly rolling and has a local relief of 10-100 feet; commonly it is 20-40 feet. The landscape is characterized by kames, rimmed kettles, knobs, and a few small eskers. The general surficial appearance is similar to that of the hummocky ground moraine.

Shallow exposures in gravel pits and in road cuts along Highway No. 4 show the sediment to be mainly sand and gravel. Locally, the hummocks are composed of till aggregated in knobs. These till knobs were not differentiated because it is impossible to do so in aerial photographs and only a few hummocks contain exposures.

Contorted structures, heterogeneity of the sediments, and the relationship of kame moraines to end moraines (Leinan Moraine and Clearwater Lake Moraine) suggest that the deposit is ice contact stratified drift which formed along the ice front and, consequently, is similar in origin to end moraines.

Crevasse fillings

Crevasse fillings are restricted to the southwestern sector of the Swift Current area and are particularly well developed on the Swift Current Plateau. These features are easily recognized in aerial photographs by their diagnostic pattern. The pattern is formed by the intersection of two sets of ridges (Fig. 6). The average trend of the well developed set is N60°E; the average trend for the poorly developed set is N35°W.

The crevasse fillings range in height from 5-30 feet but are commonly 10 feet. The ridges are about 200 feet wide at the base, up to 5 miles long, and have an uneven crest line which follows the general topography.

A few exposures in road cuts show the crevasse fillings to be composed of till. In a road cut through a crevasse filling one half mile south of the northeast corner of Section 19, Township 14, Range 13 along the west ditch of Highway No. 4, two feet of light grey, calcareous, friable till overlies six feet of light brown, calcareous, clayey till.

Two problems must be considered in the explanation of crevasse fillings: (1) origin of the crevasse in the ice; and (2) mechanism by which the material was deposited in the crevasse.

The fact that the main trend of the crevasse fillings in the Swift Current area and Lloydminster area (Ellwood, 1958, personal communication) is normal to the direction of ice movement, as evidenced by flutings, suggests that the trend of these features was controlled in some way by the movement of the ice.

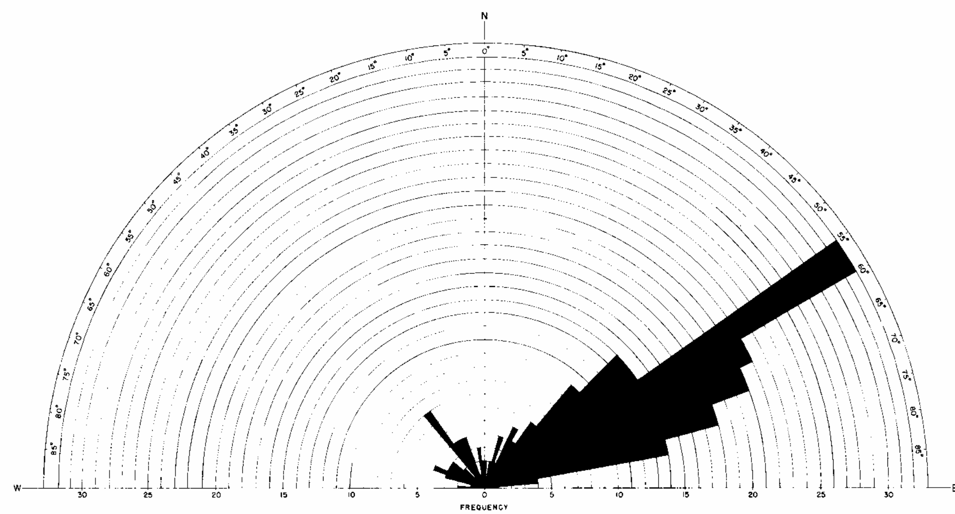


Figure 6.—Rosette of crevasse filling trends

Two main hypotheses have been proposed to explain the mechanism by which the material was deposited in the crevasses: (1) squeezing up of plastic material from beneath stagnant ice (Colton, 1955, personal communication) or moving ice (Hoppe, 1952); and (2) deposition from the surface of a stagnant glacier (Gravenor, 1958, personal communication).

It is believed that both mechanisms operated in the formation of the crevasse fillings of the Swift Current area. It is believed that the upper more friable till was let down by the melting of stagnant ice, and that the underlying more compact clayey till was squeezed up from beneath. Further study is necessary, however, before any firm conclusion can be drawn on the origin of crevasse fillings.

Fluting

Fluting is used here to describe a field of narrow, straight, parallel ridges and grooves. These features are very apparent in aerial photographs but are difficult to discern in the field. The ridges, which are up to 3 miles long, rise from 2-5 feet above the adjacent grooves and are about 200 feet wide at the base. Surface exposures indicate that the ridges are composed of till.

Lemke (1958) concluded that these features are formed at the base of actively flowing glaciers, and that they trend in the direction of ice movement. The exact mechanism of formation, however, is not understood.

Proglacial Land Forms

Glacial lake basins

The glaciers in the Swift Current area retreated in the direction of regional slope (northeast), hence, closures were formed at the ice margin into which meltwater flowed to form glacial lakes. Since glacial lake shorelines are rare in the Swift Current area, glacial lake boundaries were determined largely from the altitude of the drainage outlets.

The glacial lake deposits are divided into those composed mainly of silt and clay (Glbc), and those composed essentially of silt and sand (Glbs). Lake Stewart Valley Basin, Lake Herbert Basin, and Lake Beechy Basin are the three major glacial lake basins in the Swift Current area.

Lake Stewart Valley Basin.—The Lake Stewart Valley Basin lies on a bench that follows the South Saskatchewan River. Glacial lake shorelines in Township 19, Range 12 and 14, follow approximately the 2400 foot contour line. The altitude of the drainage outlets also suggests that the lake level was about 2400 feet above sea level.

The topography is flat to gently undulating and has a local relief that rarely exceeds 10 feet. The lake basin slopes gently toward the South Saskatchewan River. The sediment in the basin is essentially silt and clay and is varved in places (top of south bluff of South Saskatchewan River along west side of Highway No. 4 and also northwest corner of Section 31, Township 18, Range 13 along east side of Highway No. 4).

This lacustrine sediment reaches a maximum thickness of 15 feet where Highway No. 4 intersects the uppermost part of the south bluff of the South Saskatchewan River. Lacustrine silt and clay are absent where the relief is excessive and along recent gullies where the lacustrine sediments have been removed by erosion. A strip of till about a quarter mile wide commonly lies between the strandline and the lacustrine clay. This strip, which is very stony, is interpreted as an area where wave erosion has removed the fine sediments leaving a concentration of stones behind as a lag deposit.

Lake Herbert Basin.—Glacial lake shorelines are not present around Glacial Lake Herbert, hence, the boundary of the basin was determined entirely by the altitude of the drainage outlet (2400 feet). The topography is undulating to gently rolling and has a local relief of 10-20 feet. Where partially filled valleys cross the lake basin, however, the local relief may reach 30 feet. The sediment is composed of sand, silt, clay, and eroded till. A small delta, which is composed of sand, occurs at the mouth of Handsome Lake Channel. Recent, flat-bottomed lake basins such as Rush Lake lie within the Lake Herbert Basin.

Lake Beechy Basin.—The 2200 foot contour line encloses all of the lacustrine and fluvial sediments in the Lake Beechy Basin. The sediments in the western portion of the basin are essentially lacustrine silt and clay (Glbc) whereas the sediments in the eastern portion of the basin are predominantly silt and sand (Glbs).

In the area west of a north-south line through Beechy (T. 22, R. 10), the topography is undulating to rolling and has a relief of 10-25 feet. East of this line the basin mapped as Glbc is flat to undulating and slopes gradually toward Snakebite Creek. Shallow, flat-bottomed, alkali lakes lie 10-20 feet below the general surface of the basin. The sediment is essentially clay which is absent where relief is excessive, and where gullying has exposed the underlying till. The lacustrine sediment attains a maximum thickness of 15 feet in the southeast quarter, Section 5, Township 22, Range 10, along the north bluff of Snakebite Creek.

The portion of the Lake Beechy Basin mapped as Glbs lies along the South Saskatchewan River east of the Lake Stewart Valley Basin. The topography is undulating to gently rolling and has a relief of 10-20 feet. The sediment is sand, silt, and till. In many places the till surface is covered with a lag deposit of boulders. A delta composed of sand and gravel occurs three miles south of Demaine (T. 22, R. 10).

Outwash plains

Outwash plains are restricted to an area west of Swift Current. The topography is flat to undulating and has a relief of 10-15 feet. The sediment is mainly sand which is commonly less than 10 feet thick. Locally, particularly in the outwash plain north of Swift Current, the sand has been reworked to form small dunes, blowouts, and cover sand. A portion of this outwash plain may be a shore facies of the lacustrine sediment which it encloses.

Glacial lake shorelines

Glacial lake shorelines occur along the southern boundary of Glacial Lake Stewart Valley (T. 19, R. 11, 12, 14, and 15). The shoreline west of Stewart Valley (T. 19, R. 14 and 15) and the one in Township 19, Ranges 12 and 13 is marked by sharp changes in topography which are particularly apparent in aerial photographs. Because these breaks in morphology are consistent with the altitude of the drainage outlet, they have been interpreted as glacial lake shorelines.

A beach deposit in Township 19, Ranges 11 and 12 can be traced in the field for a distance of about two miles at an altitude of 2435 feet. The beach is composed of about five feet of poorly sorted sand and gravel which forms a contact between moraine toward the south and lake basin toward the north. A strip of lake basin about one quarter mile wide, which extends lakeward from the beach, contains a lag deposit of pebbles and cobbles which apparently resulted from wave-erosion.

Meltwater channels

Because the ice retreated down the regional slope of the Swift Current area (northeast), meltwater streams drained toward the southeast along the ice margin, consequently, they have been referred to as side-hill channels (Bretz, 1943). As the ice retreated newer and lower channels were formed and older and higher ones were abandoned. There are two types of meltwater channels in the Swift Current area: (1) valleys which are entirely glacial in origin; and (2) valleys which are pre-Wymarkian in age (p. 28) and were used by meltwater.

The Braddock Channel (T. 14, R. 11), Beverley Channel (T. 15, R. 14), the channel southeast of Waldeck (S. 4, T. 16, R. 11), Pelletier Channel, and the South Saskatchewan River Channel were formed mainly by meltwater erosion.

These channels range from 50-700 feet deep, are commonly 50-200 feet deep, and have steep bluffs which can not be seen until the top of the bluff is encountered. The valley bottoms are 1000-2000 feet wide and may be occupied by small underfit streams. Long, narrow lakes also occur within the valley bottom. The sediment consists of gravel, sand, silt, clay, eroded till, colluvium, and bedrock which is not differentiated on the map.

Meltwater channels also occupy valleys which are pre-Wymarkian in age (p. 28). In most places the meltwater caused little modification of these pre-existing valleys. The recognition that these channels antedate at least one glaciation is important because of their influence on the altitude of glacial lakes which they drained.

The valley in which the Swift Current Creek flows, Java Channel (T. 15, R. 14), Handsome Lake Channel (T. 18, R. 11), the valley occupied by Rush Lake Creek (T. 16, R. 11), and the valley northwest of Swift Current (T. 16, R. 14) are pre-Wymarkian in age (p. 28).

These valleys are 100-200 feet deep and one quarter mile to three miles wide. The two most diagnostic characteristics are the gentle slope of the valley sides and till in morainic form which is draped over the ancient valley walls.

Except for a few areas of lacustrine sediments, the deposits within these meltwater channels include gravel, sand, silt, clay, till, eroded till, colluvium, and bedrock which are not differentiated on the map.

Aeolian Land Form

Loess plain

A thin blanket of loess up to 3 feet thick covers undulating ground moraine in the southwestern section of the Swift Current area. The topography of the loess plain is a reflection of the topography of the till surface which, in turn, is a reflection of the bedrock surface. Except in partially filled valleys, the drift is 5-10 feet thick. In areas of excessive relief, the loess has been removed by erosion which has exposed the underlying till. The loess thickness decreases with distance from the outwash plain west of Swift Current. A more detailed discussion about the loess is given in Chapter 3.

Postglacial Land Forms

Slump area

Slumping has occurred along the South Saskatchewan River, along the lower part of Swift Current Creek, and along tributaries to both streams. Inasmuch as the slumping is best developed along Swift Current Creek, this area is described.

The slump blocks, which are 5-30 feet high, form a sequence of sub-parallel, arcuate ridges along the valley bluffs (Figs. 7 and 8). Down-cutting in the slumped area began during the Thunder Creek Phase of the glacial history (Fig. 30). Prior to this time, the Neidpath Channel (altitude 2400 feet) was the drainage outlet, and the area was part of the bottom of Lake Stewart Valley (Fig. 29). During the Thunder Creek Phase (Fig. 30), however, the base level dropped from 2400 feet to 2200 feet, and finally to 2000 feet when Thunder Creek became a graded stream. This change in base level caused severe down-cutting to take place along the South Saskatchewan River (about 300 feet at the mouth of Swift Current Creek assuming a gradient of 2 feet per mile upstream from Thunder Creek) which, in turn, caused Swift Current Creek to down-cut toward a new profile of equilibrium. As a result of this outlet change, the water which formerly flowed through the Neidpath Channel, was captured by the Swift Current Creek-South Saskatchewan River-Thunder Creek system.

Field observations show that the occurrence of slumping is stratigraphically controlled. Slumping occurs only where Swift Current Creek has cut through the drift into the Bearpaw Formation. This relationship was demonstrated recently in the tributary exposing sections 1, 2, and 3 (Fig. 7), where no slumping had occurred in 1955; however, in 1956, the stream cut into the plastic Bearpaw Formation and slumping occurred.

Figure 7.—Slumped area along Swift Current Creek. Air photo. A6328-66, courtesy R.C.A.F.

Terzaghi (1955, p. 602), in discussing landslide topography, refers to lateral expansion of shales toward the valley bluffs. Peterson (1958, p. 1118) refers to studies which demonstrate that the horizontal pressure in the hard Bearpaw Formation is approximately 150 per cent of the vertical pressure.

On the basis of the above observations and subsequent discussions with D. U. Deere, the following hypothesis for the origin of the slumping is proposed. When down-cutting by the stream penetrates the drift-bedrock contact, the confining pressure is reduced sufficiently to cause the plastic shales to move laterally into the stream valley. The movement

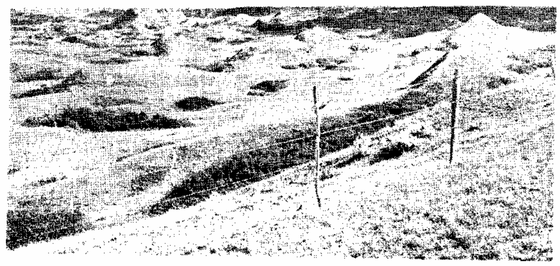


Figure 8.—**Slumped area along west bluff of Swift Current Creek in S. 15 and 16, T. 19, R. 13**

of the shale places the overlying competent drift in a state of tension, and fractures are formed. These fractures greatly reduce the internal shear resistance within the drift, and as a result of this weakening, slope failure occurs. Future studies of the landslide problems should include laboratory studies of the shear parameters of the drift and Bearpaw Formation. Field measurements of pore water pressure at various slide locations should also be made in order to analyse the slides by principles of soil mechanics.

The occurrence of slumping is very significant geologically because it enables one to estimate within certain limits the altitude of the drift-bedrock contact. The importance of mass wastage as a mechanism of slope retreat is also well illustrated along Swift Current Creek. The development of these valleys may take place very rapidly and is related to stratigraphy rather than time.

Postglacial lake shorelines

Postglacial lake shorelines, marked by wave-cut cliffs, occur in Township 17, Range 10; Township 15, Range 14; and Township 17, Range 14. The wave-cut cliffs rise to 50 feet above the lake plain. Between the wave-cut cliff and the lacustrine clays, which occur in the central part of the lake, is a strip of till covered with boulders which represents a lag deposit formed by wave erosion (S. E. 1/4, S. 5, T. 17, R. 10).

Patterned ground

Nonsorted polygons (Washburn, 1956) occur in till, loess, and lacustrine clays within the Swift Current area. They range in diameter from 1-3 feet (Fig. 9), and the wedges penetrate 1-3 feet into the ground. The pattern is formed by a polygonal network of dark grey wedges 1-5 inches wide which penetrate the B and C horizons. In till the dark grey wedges are surrounded by 2-4 inches of vertically-plated, grey material (Figs. 9 and 10). The central parts of the polygons are commonly elevated 4-6 inches to form mounds which are best developed in poorly-drained, depressional areas.

Nonsorted circles (Washburn, 1956) have been observed in poorly-drained depressions in till (Fig. 11). The dark colored circles (B horizon), which are 1-2 feet in diameter, are surrounded by vertically-plated, grey material (A'_2 horizon).

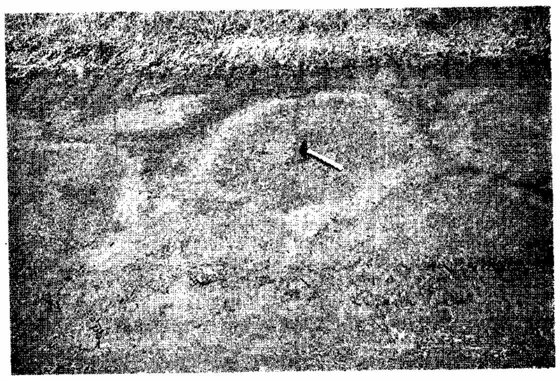


Figure 9.—Nonsorted polygons in till along ditch in S. 11, T. 18, R. 9

Ellis and Shafer (1928), in discussing Red River valley soils, described tongued intrusions of dark surface material (A horizon) which penetrated into the underlying horizons. They also demonstrated that these features were formed by desiccation.

The fact that the organic A_1 horizon can be traced down into the wedges indicates that the polygons are recent in origin and not periglacial features. The presence of open cracks along some of the wedges (Fig. 9) indicate that these features are now in the process of formation. Extreme variations in moisture, particularly in depressed areas, and the montmorillonitic nature of the drift cause large volume changes in the sediments. During dry periods shrinkage cracks develop into which material from the A_1 horizon is deposited. As a result of this, soil development takes place laterally, as evidenced by the vertically-plated, solonetzic A'_2 horizon (Figs. 9 and 10) which surrounds the infilling. As the process continues, more and more of the parent B horizon within the polygon is transformed to A'_2 horizon until the nonsorted polygons

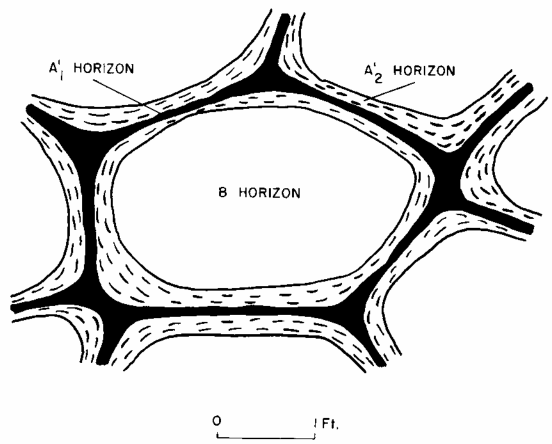


Figure 10.—Diagrammatic sketch of oblique section of nonsorted polygon

become nonsorted circles (Fig. 11). Solonetzic A_2 horizons are absent in loessial and lacustrine soils because the soluble salts have been removed by meltwater in lacustrine lakes and outwash plains (source of loess). A'_2 horizons are, therefore, absent adjacent to the dark grey wedges in these soils.

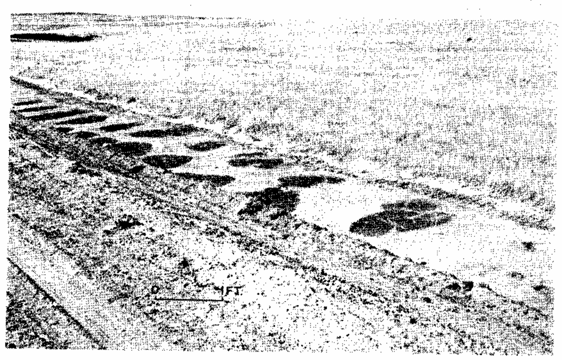


Figure 11.—Nonsorted circles in till along ditch in S. 11, T. 18, R. 9

Bedrock Land Forms

Bedrock hills

Bedrock hills, which are kame-like in form but are composed of gravel, conglomerate, and sandstone of the Cypress Hills Formation-Swift Current Creek Formation, occur in the southern portion of the Swift Current area. These hills are 50-150 feet high and are commonly covered with a few feet of till; in some areas, however, a few erratics are the only evidence of glaciation (S. 4, T. 16, R. 10).

Stream valleys

Stream valleys predate at least one glaciation and are used by present drainage. The valley bluffs, which are gently sloping, are covered with moraine indicating that the valley antedates the moraine. The stream valleys are about 1000 feet wide and are commonly 60 feet deep. Prior to the Wymark glaciation these valleys were occupied by consequent streams which flowed down the northeastern slope of the Swift Current Plateau escarpment.

Partially filled valleys

Two types of partially filled valleys occur in the Swift Current area: (1) those which are almost completely filled with drift and which are recognized in aerial photographs by the alignment of lakes (Fig. 12); and (2) broad, open valleys which are blanketed with a thin veneer of till in the form of undulating ground moraine and hummocky end moraine (Fig. 5); there are all gradations between these two types.

Partially filled valleys of the first type, called stream-trenches by Gravenor and Bayrock (1956), occur in hummocky end moraine and hummocky and undulating ground moraine areas where the drift is more than 50 feet thick. They are either partially or completely filled with drift. Where the valleys are only slightly modified by a thin fill, they are about 1000 feet wide and 30-70 feet deep (Fig. 12). This type of partially filled valley is important from the ground-water standpoint because they contain confined aquifers.

The broad, open valleys of the second type, which contain a thin veneer of drift, are up to 3 miles wide and have gently sloping sides. Since these valleys were used as meltwater channels, they are described under that land form (p. 20-21).

The following evidence is pertinent regarding the age of these partially filled valleys: (1) partially filled valleys of both types form a normal integrated dendritic drainage pattern which shows no control; (2) some of the broad, open valleys of the second type contain the Wymark Till; and (3) the entire drainage pattern shows no relationship to ice marginal positions.

Two possibilities for the age of partially filled valleys are presented: (1) they are contemporaneous with the last glaciation as are those de-

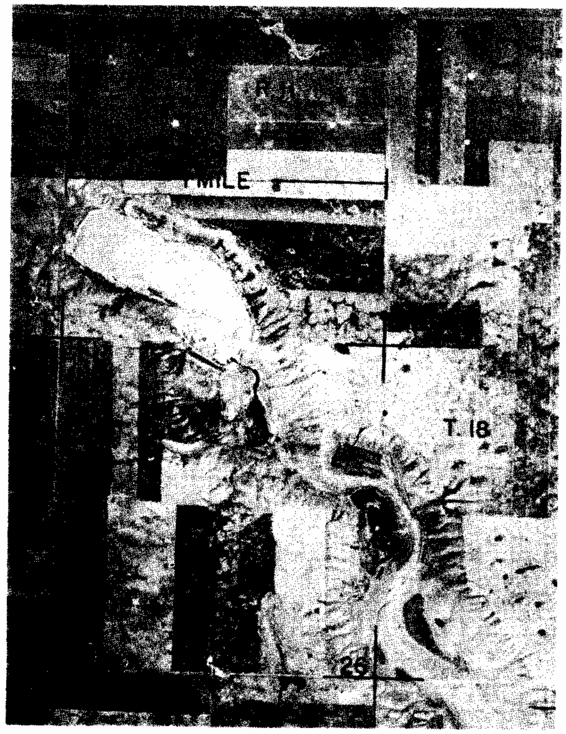


Figure 12.—**Partially filled valley in S. 26, T. 18, R. 11**

scribed by Gravenor and Bayrock (1956); and (2) they are pre-Wymarkian.

Gravenor and Bayrock (1956), in discussing the origin of stream-trench systems in Alberta, demonstrated that they were formed contemporaneously with the last glaciation. They suggested that streams were confined by deep, narrow, ice-walled trenches which followed ice cracks. When down-cutting ceased, the ice and its included debris slumped into the trench and partially or completely filled it. Bayrock (1958, p. 29) suggested that the ice was locally remobilized during a late phase of deglaciation and flowed into the trench rather than slumping into it.

Although the partially filled valleys in the Swift Current area are similar in form to those described by Gravenor and Bayrock (1956), they show no evidence of ice control which is so typical in Alberta.

If one assumes that all partially filled valleys are genetically related (a complete integration of the dendritic drainage pattern indicates that the assumption is valid), then the presence of the Wymark Till in many of these valleys (e. g. S. 24, T. 15, R. 14 and S. 9 and 10, T. 19, R. 13) indicates that they are pre-Wymarkian in age.

Bedrock topography

With the exception of bedrock valleys which are filled with drift, the present surface closely reflects the bedrock topography. This is particularly true in the southern one half of the Swift Current area where the drift is less than 50 feet thick. In the northern one half of the area, however, the bedrock topography has been subdued as a result of glaciation. In this area many bedrock valleys are expressed as low surficial sags. Near the mouth of Swift Current Creek and at Saskatchewan Landing a bedrock valley is filled with 200-300 feet of drift. In general, however, exposures show less than 50 feet of drift.

STRATIGRAPHY

Upper Cretaceous Series

Belly River Formation

The Belly River Formation, which is the oldest exposed unit in the Swift Current area, crops out only in a narrow belt along the South Saskatchewan River (Fig. 13). The formation is composed of non-marine, yellowish-brown sand. It is difficult to estimate the thickness because the unit is poorly exposed. In Range 18, however, the Belly River Formation is at least 50 feet thick (Fraser *et al.* 1935, p. 19).

Bearpaw Formation

The Bearpaw Formation is the most wide-spread bedrock in the Swift Current area (Fig. 13). It is well exposed along the bluffs of the South Saskatchewan River and its tributaries, and along the bluffs of meltwater channels in the southern portion of the area (Beverley Channel, Braddock Channel, and the channel southeast of Waldeck).

The sediment is composed of dark grey, plastic, montmorillonitic shale. In Townships 15 and 16 of Ranges 14 and 15 the upper 5-30 feet of the Bearpaw Formation is oxidized to a light-yellowish grey color. Beds of grey sand occur in some places particularly near the top of the formation.

Since the upper and lower contacts of this unit are not exposed in any one section, it is difficult to estimate the true thickness. If the lower contact is approximately horizontal, measurements from the topographic map indicate that the Bearpaw Formation is about 700 feet thick.

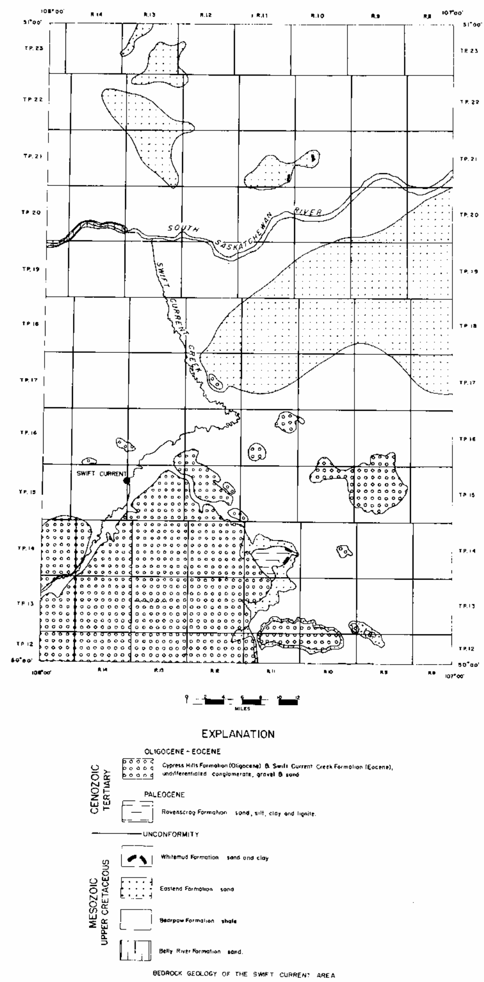


Figure 13.—**Bedrock geology of the Swift Current area. Geology based on Fraser *et al.* 1935, G.S.C. Mem. 176**

Eastend Formation

The Eastend Formation, which is restricted to the northern portion of the Swift Current area (Fig. 13), has only a few exposures, and consequently, Fraser *et al.* (1935) determined its areal extent largely from physiographic and subsurface information. The sediment is essentially sand and minor amounts of clay. The Eastend Formation is gradational between the underlying, marine Bearpaw Formation and the overlying, non-marine Whitemud Formation (Fraser *et al.* 1935, p. 25).

Whitemud Formation

A few small, scattered exposures of the Whitemud Formation occur southeast of Swift Current and north of the South Saskatchewan River (Fig. 13). The sediment consists of light grey, sand, silt, and clay which is essentially kaolinitic. The formation attains a maximum thickness of 30 feet (N. E. 1/4, S. 14, T. 14, R. 11).

Tertiary System

Ravenscrag Formation

Exposures of the Ravenscrag Formation are restricted to an area southeast of the city of Swift Current (Fig. 13). The formation is composed of 40 feet of interbedded sand, silt, clay, and lignite (N. E. 1/4, S. 14, T. 14, R. 11).

Cypress Hills Formation-Swift Current Creek Formation

Because it is impossible to separate these two formations on physical properties and because fossils, which are used to separate them, are rare, these two units have been mapped as one (Fig. 13). Although Fraser *et al.* (1935) consider these formations to be Eocene-Oligocene in age, it is possible that part of these formations may include even younger sediments.

Based on new exposures at (1) Swift Current T. V. Station (N. W. 1/4, S. 7, T. 16, R. 13), (2) a road cut 500 feet north of S. W. corner S. 4, T. 16, R. 14, and (3) a road cut about 500 feet north of S. W. corner S. 22, T. 17, R. 12, the Cypress Hills Formation-Swift Current Creek Formation has been extended north beyond the boundary shown by Fraser *et al.* (1935).

The sediment is composed of well-rounded, percussion-marked, quartzite pebbles and cobbles, locally cemented to form conglomerate. In some places, however, the sediment is largely sand or clay. In the northwest corner of Section 35, Township 15, Range 13 the unit is at least 40 feet thick.

Pleistocene Series

General statement

The stratigraphic interpretations of the Pleistocene drift sheets of the Swift Current area are based on the stratigraphic sequence of tills and proglacial deposits and on till margins as determined from end moraines and ice marginal channels. Three till sheets and the end moraines for the upper two of them occur in the Swift Current area. These drift sheets are Wisconsin, probably late-Wisconsin in age. Inasmuch as the three till sheets in the Swift Current area are mappable, they have been given the status of stratigraphic units. These units, however, have not been given a stratigraphic rank as it seems premature to do so at this time. The best developed sections are in pre-Wymarkian, bedrock valleys where the sediment was protected from the erosional action of subsequent glaciers. The bedrock interfluves commonly contain only one till which is believed to be the youngest till. The stratigraphic succession is indicated in Table 1.

Table 1.—Pleistocene stratigraphy of the Swift Current area

Epoch	Age	Stratigraphic units
Pleistocene	Wisconsin	Upper stratified drift Leinan Till Loess Middle stratified drift Aikins Till Lower stratified drift Wymark Till

Wymark Till

The name Wymark Till is proposed for the unit which is exposed south of the margin of the Aikins Till (Fig. 14) and which lies between the lower stratified drift and the bedrock north of this margin. The name is taken from the village of Wymark which is in the centre of the type locality of the Wymark Till. The reference section is in an excavation ¼ mile east of the southwest corner of Section 27, Township 12, Range 13, about 6 miles south and one mile east of Wymark (Appendix, Section 2).

The Wymark Till is calcareous, light-greyish brown where oxidized and grey where unoxidized, montmorillonitic, clay loam to sandy clay loam, and plastic. Most of this unit is unoxidized. Where oxidation occurs it is restricted to the upper part of the unit.

Since the Wymark Till south of the southern margin of the Aikins Till is covered with only a thin blanket of loess, the surface form is a result of the Wymark Till. Measured thicknesses range from 3-60 feet. South of the Aikins Moraine on the Swift Current Plateau the Wymark Till is commonly less than 5 feet thick. The till is up to 60 feet thick, however, in some of the bedrock valleys.

Lower stratified drift

The lower stratified drift lies between the underlying Wymark Till and the overlying Aikins Till north of the southern margin of the Aikins Till (Fig. 14); south of this margin, however, the lower stratified drift cannot be differentiated from the younger stratified units. The lower

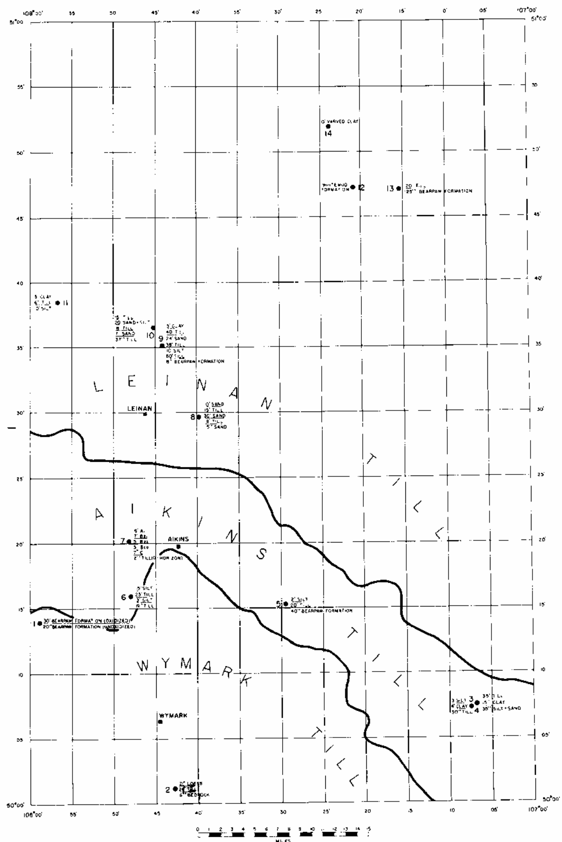


***Figure 14.*—Map showing location of sections and generalized stratigraphy**

stratified drift contains lacustrine marls, silts, and clays and fluvial gravels and sands. Exposures of this unit are restricted to valley fills where measured thicknesses range from 3-225 feet. The lack of weathering upon the Wymark Till below the lower stratified drift suggests that this unit is a proglacial sediment which was deposited during the retreat of the glacier that deposited the Wymark Till.

Aikins Till

The name Aikins Till is proposed for the unit which is between the middle and lower stratified drifts north of the southern margin of the Leinan Till and which is exposed where stratified drift is absent south of this margin (Fig. 14). The name is taken from the railroad siding of Aikins. The reference section is in the north bluff of Swift Current Creek about 300 feet west and 350 feet north of the southeast corner of Section 24, Township 15, Range 14 (Appendix, Section 6).

The Aikins Till, which is 15-40 feet thick, is calcareous, pale brown where oxidized and light-greyish brown where unoxidized, montmorillonitic, clay loam, and plastic. Most of the till is oxidized. Where unoxidized till occurs, it is restricted to the basal part of the unit. The heavy mineral content (Meneley, 1956), clay mineral composition, texture, and plasticity show no variation between the Aikins Till and the Wymark Till.

Middle stratified drift

The middle stratified drift lies between the Aikins Till and the Leinan Till north of the southern boundary of the Leinan Till (Fig. 14); south of this margin the stratified drifts were not differentiated.

The middle stratified drift, which is 10-30 feet thick, is composed of lacustrine silt and clay and fluvial gravel and sand. The lack of weathering of this unit and the surface of the underlying unit (Aikins Till) suggests that it is a proglacial sediment deposited during the retreat of the glacier which deposited the Aikins Till.

Loess

The loess, which is herein restricted to the southwestern portion of the Swift Current area, covers the Wymark Till south of the Aikins Till and the Aikins Till south of the Leinan Till (Fig. 15). The reference section is 500 feet west of the northeast corner of Section 12, Township 16, Range 14 (Appendix, Section 7).

Loess thickness and depth of leaching were determined by auger and test pits in suitable topographic locations. The author reasoned that, in gently undulating areas with local highs and adjacent depressions, the true loess thickness and depth of leaching could be obtained at a position where a convex slope merged with a concave slope. Such an area corresponds to the position of no vertical curvature (Aandahl, 1948). Theoretically, it should act as a surface of transport between the eroded area (convex slope) and the depositional area (concave slope) and, therefore, should provide the true thickness and depth of leaching of the loess. Thickness of the A_1 horizon also served as a guide, in that a six-inch A_1 horizon seemed to be normal for the cultivated soil in this semi-arid region of Brown soils.

The thickness of loess decreases with distance eastward from an outwash plain which is west of Swift Current (Figs. 15 and 16). The equation of the line fitted to the points is $Y = 32.16 - 10.9 \log X$ where Y equals loess thickness in inches and X equals distance from outwash plain in miles (Fig. 16). The correlation coefficient (r) is .9101 and is highly significant.

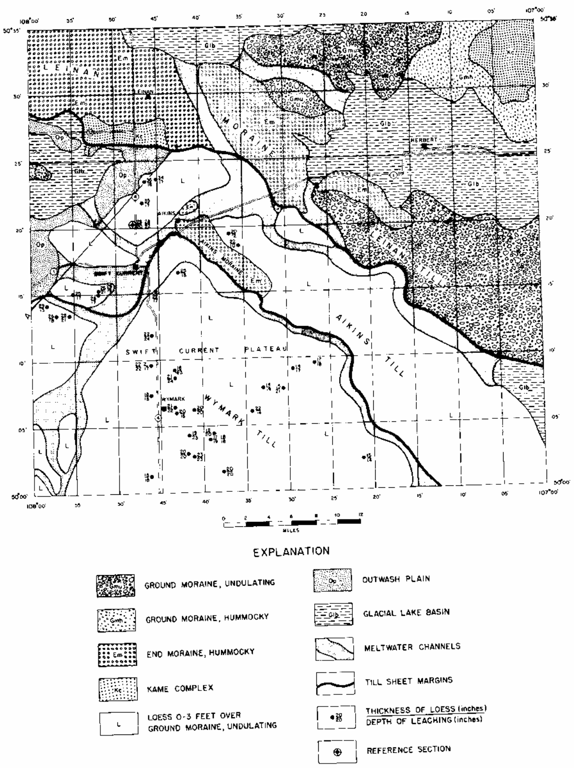


***Figure 15.*—Distribution, thickness, depth of leaching of loess, and associated glacial features in the southwestern sector of the Swift Current area**

Inasmuch as the loess thickens from the southeast toward the outwash plain, it is believed that this outwash deposit was the source of the major portion of the loess. Because of this relationship all distances were measured in a southeasterly direction from a reference line AA′ (Fig. 15). The sand plain extends for about 25 miles west and northwest from the Swift Current area (Mitchell *et al.*, 1947) and thus constitutes a much larger source area than that shown in Figure 15.

The depth of leaching is not related to distance from the outwash

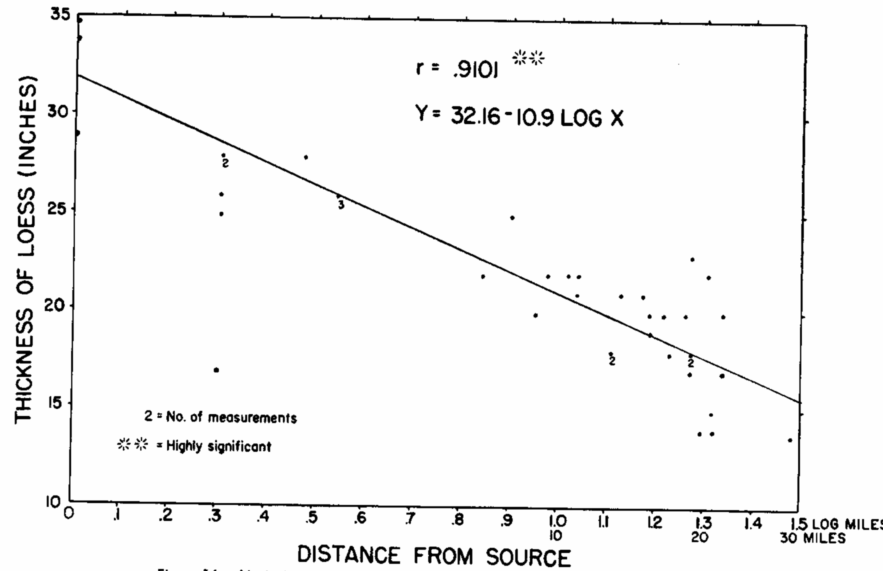


Figure 16.—Variation in loess thickness with distance from outwash plain (source)

plain. This is indicated by the correlation coefficient of .23 which is not significant. Smith (1942, p. 169) has demonstrated that partial leaching of loess in Illinois increases with distance from source, and consequently, depth of leaching shows the same relationship. From this he concluded that the loess was deposited over a long interval of time. The fact that there is no significant relationship between depth of leaching and distance from source in the loess of the Swift Current area suggests that this loess was deposited over a short interval of time.

Calcareous loess in the reference section contains 22.6 per cent sand (2.0 - .05 mm.), 54.9 per cent silt (.05 - .002 mm.), and 22.5 per cent clay (less than .002 mm.). This texture is a silt loam and is similar to loess in Illinois near the source (Smith, 1942). The underlying till is sandy clay loam which contains 47.8 per cent sand, 25.4 per cent silt, and 26.8 per cent clay. With the exception of a few coarse grains which have worked up into the loess from the underlying till (Fig. 17), the sand fraction is fine to very fine-grained.

Four mechanical analyses of samples of loess taken along a southeast traverse across the Swift Current Plateau did not show any trend. After the entire loess area is mapped, however, a more detailed study will be made of the variation in texture.

The clay minerals of the calcareous loess, like those of the till, are chiefly montmorillonite and minor amounts of illite and kaolinite. This is to be expected since the Cretaceous Bearpaw Formation, which is the bedrock underlying most of the area and which was the major source material for the till and the subsequent outwash, is very rich in montmorillonite.

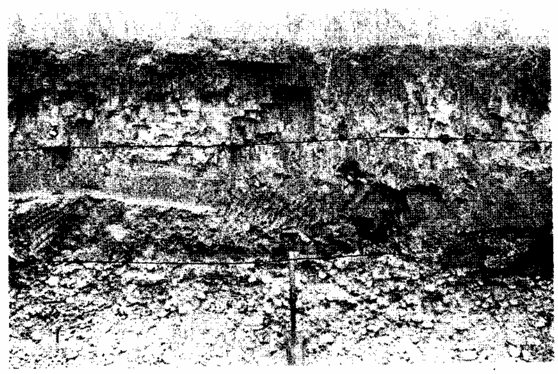


Figure 17.—Loess over till in excavation for Swift Current T.V. Station about 300 yards from reference section: (1) Cypress Hills Formation—Swift Current Creek Formation; (2) till; and (3) Loess

The following factors are pertinent regarding the age of loess in the Swift Current area: (1) lack of weathering on the top of the Wymark and Aikins tills which underlie the loess; (2) uniform thickness of loess across the Aikins Moraine (Fig. 15); (3) lack of correlation between depth of leaching and distance from source; and (4) absence of loess upon the Leinan Till (Fig. 15).

The lack of variation in loess thickness across the Aikins Moraine and the fact that the loess terminates abruptly in front of the Leinan Moraine suggests that the loess is post-Aikinsian and pre-Leinanian in age. Since it seems unlikely that such an extensive sand area (Mitchell *et al.*, 1947, Map), which was the source of the loess, could have been deposited during the advance of the glacier that deposited the Leinan Till, it is concluded that this sand was deposited during the retreat of the ice from the Aikins Moraine.

On the basis of the above observations, three hypotheses regarding the age of the loess must be considered: (1) deposition of loess during the retreat of the ice from the Aikins Moraine and while the outwash plain was being formed; (2) deposition of loess during the advance of the ice that deposited the Leinan Moraine while the pre-existing outwash plain was devegetated by the cold climate; and (3) deposition during retreat of ice that deposited the Aikins Till and during advance of ice that deposited the Leinan Till.

The lack of weathering upon the Wymark and Aikins tills, beneath the loess, indicates that the hiatus between these sediments was short and that the age difference between the Wymark and Aikins tills is small. It is impossible, therefore, to assign to the loess an age more precise than post-Aikinsian and pre-Leinanian. It seems most likely, however, that the loess was deposited during and shortly after the deposition of the outwash when the area was most susceptible to wind erosion.

Leinan Till

The name Leinan Till is proposed for the unit which is between the middle and upper stratified drifts (Fig. 14). The name is taken from the village of Leinan. The reference section is in the east bluff of Swift Current Creek about 200 yards west and 180 yards south from the northeast corner of Section 1, Township 18, Range 13 (Appendix, Section 8).

The stratigraphic significance of the Clearwater Lake Moraine is not understood because no complete sections were found north of this moraine. The Clearwater Lake Moraine and the drift north of it is considered, therefore, as part of the Leinan Till and either represents a pause in the retreat of the ice or a local re-advance. It is possible, however, that the Clearwater Lake Moraine marks the terminus of a fourth till sheet. More field work must be done before this problem can be solved.

The Leinan Till is calcareous, pale yellow to pale brown, oxidized, montmorillonitic, plastic, and clay loam. Except for the greater degree of oxidation, this till has the same physical properties as the Wymark Till and Aikins Till.

Upper stratified drift

The upper stratified drift, where present, is the surficial sediment. South of the southern boundary of the Leinan Till the upper stratified drift is not differentiated from the older stratified units. The sediment overlying the Leinan Till is composed of lacustrine silt and clay and fluvial sand and gravel. Measured sections show that this unit ranges from 5-20 feet in thickness. The lack of weathering on the surface of the Leinan Till beneath the upper stratified drift suggests that this unit is a proglacial sediment to the Leinan Till.

Drift and bedrock studies

Textural, plasticity, and clay mineral studies have been made on the glacial deposits of the Swift Current area. Figure 14 shows the distribution of the till sheets and the location and general description of each section. These studies were conducted in order to find some physical criterion by which the stratigraphic units might be differentiated and correlated.

The calcareous loess and the three tills were analysed by the hydrometer method following the procedure described by Bouyoucos (1951). The texture of the calcareous loess is silt loam whereas the tills are sandy clay loam to clay loam (Table 2, Fig. 18).

Atterberg limits were determined on tills, lacustrine clays, loess, and the Bearpaw Formation (Table 3). These values were plotted on a plasticity chart (Fig. 19). The oxidized portion of the Bearpaw Formation has higher limits than the unoxidized portion. This relationship can be explained by the fact that the oxidized portion contains more montmorillonite than the unoxidized portion.

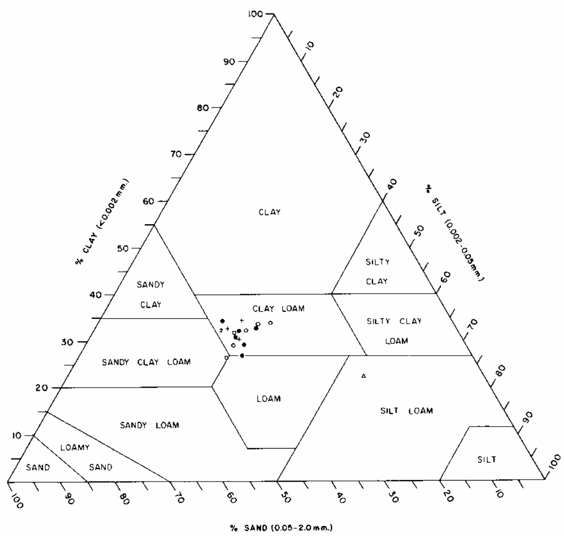
The clay minerals of the tills, lacustrine clays, loess, Bearpaw Formation, and Whitemud Formation (Table 4, and Figs. 20 and 21) were identified. The proportions of clay minerals in these sediments were determined using the procedure developed by Johns *et al.* (1954). The large amount of montmorillonite in the drift and Bearpaw Formation indicates that this formation was the major source of the clay minerals in the drift. The presence of minor amounts of kaolinite in the drift and its absence in the Bearpaw Formation compels one to look to some other source for this mineral. There are scattered occurrences of the Whitemud Formation in the northern portion of the Swift Current area in which the clay mineral content is essentially kaolinite. It is therefore concluded that Whitemud Formation is the source of the kaolinite in the drift.

The clay mineral content, texture, plasticity, and heavy minerals of the three tills are similar in gross aspect. Any differences are subtle and will require many more analyses and additional samples from wider areas for their characterization. Such studies are proposed for the future.

Table 2.—Percentage sand, silt, and clay in tills and loess

Section no.*	Stratigraphic unit**	% sand 2.0-.05 mm.	% silt 0.5-.002 mm.	% clay ∠0.002 mm.
11	Leinan Till (O)	41.6	27.9	30.5
	Aikins Till (O)	46.0	27.6	26.4
	Wymark Till (O)	42.8	30.2	27.0
	Wymark Till (U)	37.4	29.6	33.0
9	Leinan Till (O)	42.6	24.8	32.7
	Aikins Till (O)	36.8	29.8	33.4
	Aikins Till (U)	33.9	32.1	34.0
	Wymark Till (U)	42.0	27.0	31.0
10	Leinan Till (O)	42.6	24.6	32.8
	Aikins Till (O)	39.3	28.3	32.4
	Wymark Till (U)	41.2	29.6	29.2
8	Leinan Till (O)	39.1	26.4	33.8
	Aikins Till (U)	43.2	27.6	29.2
6	Aikins Till (O)	41.4	26.4	32.3
	Wymark Till (U)	40.6	27.0	32.4
2	Wymark Till (O)	42.4	23.1	34.5
7	Loess (C Horizon)	22.6	54.9	22.5

* Refer to Figure 14 for index to section numbers.
** (O) oxidized.
** (U) unoxidized.



EXPLANATION

+ LEINAN TILL

△ LOESS

○ AIKINS TILL

● WYMARK TILL

2+ TWO TEXTURES

Figure 18.—**Texture of tills and loess**

Table 3.—Atterberg limits of till, lacustrine clay, loess, and Bearpaw Formation

Section no.*	Stratigraphic unit**	Liquid Limit	Plasticity Index
11	Leinan Till (O)	33.3	16.3
	Aikins Till (O)	30.5	14.4
	Wymark Till (O)	33.2	17.8
	Wymark Till (U)	37.6	20.9
9	Leinan Till (O)	34.5	18.0
	Aikins Till (O)	38.8	20.6
	Aikins Till (U)	37.5	20.0
	Wymark Till (U)	41.9	22.6
10	Leinan Till (O)	35.5	18.6
	Aikins Till (O)	33.5	17.4
	Wymark Till (U)	23.8	10.0
8	Leinan Till (O)	35.8	16.9
	Aikins Till (U)	29.0	14.2
6	Aikins Till (O)	32.9	16.9
	Wymark Till (U)	33.2	16.8
2	Wymark Till (O)	35.2	16.7
11	Lacustrine clay (U)	94.1	53.7
14	Lacustrine clay (U)	84.1	45.2
7	Loess (C Horizon)	29.8	4.7
Location			
SE. ¼ 17-15-11	Bearpaw Formation (U)	63.2	30.5
NW. ¼ 25-15-14	Bearpaw Formation (U)	66.0	27.1
SW. ¼ 4-16-14	Bearpaw Formation (U)	50.8	28.2
SW. ¼ 11-15-15	Bearpaw Formation (U)	73.8	34.0
SW. ¼ 16-15-14	Bearpaw Formation (O)	77.0	40.3
SW. ¼ 4-16-14	Bearpaw Formation (O)	55.4	29.2
SW. ¼ 11-15-15	Bearpaw Formation (O)	73.0	37.2

* Refer to Figure 14 for index to section number.
** (O) oxidized.
** (U) unoxidized.

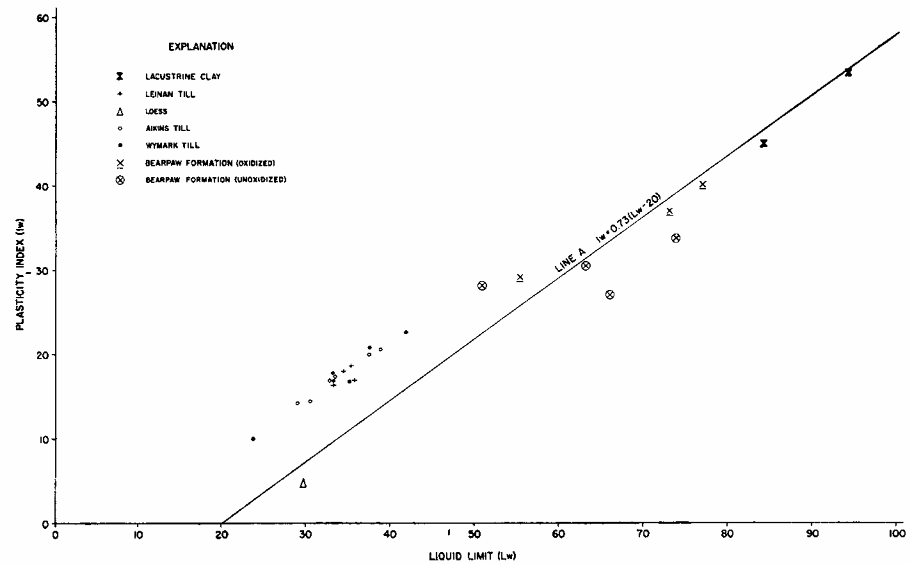
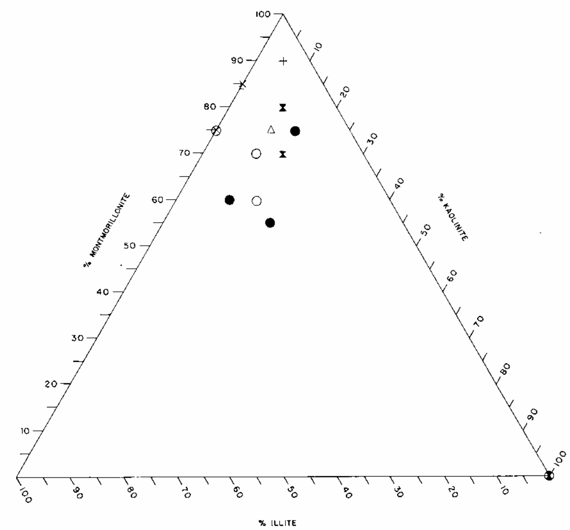


Figure 19.—Plasticity characteristics of till, lacustrine clay, loess, and Bearpaw Formation

Table 4.—Percentage montmorillonite, illite, and kaolinite in till, lacustrine clay, loess, Bearpaw Formation, and Whitemud Formation

Section no.*	Stratigraphic unit**	Treatment	% mont.	% illite	% kaol.
10	Leinan Till (O)	Na	90	5	5
	Aikins Till (O)	Na	70	20	10
	Wymark Till (U)	Na	55	25	20
6	Aikins Till (O)	Na	60	25	15
	Wymark Till (U)	Na	60	30	10
2	Wymark Till (O)	Na	75	10	15
11	Lacustrine clay (U)	Na	80	10	10
14	Lacustrine clay (U)	Na	70	15	15
7	Loess (C Horizon)	Na	75	15	10
12	Whitemud Formation	None	—	—	100
Location					
SW. ¼ 11-15-15	Bearpaw Formation (O)	None	85	15	trace
SW. ¼ 11-15-15	Bearpaw Formation (U)	None	80	20	trace

* Refer to Figure 14 for index section numbers.
** oxidized (O).
** unoxidized (U).



EXPLANATION

- ⧗ LACUSTRINE CLAY
- + LEINAN TILL
- △ LOESS
- ○ AIKINS TILL
- ● WYMARK TILL
- ⊕ WHITEMUD FORMATION
- × BEARPAW FORMATION (Oxidized)
- ⊗ BEARPAW FORMATION (Unoxidized)

Figure 20.—**Percentage montmorillonite, illite, and kaolinite in till, lacustrine clay, loess, Bearpaw Formation, and Whitemud Formation**

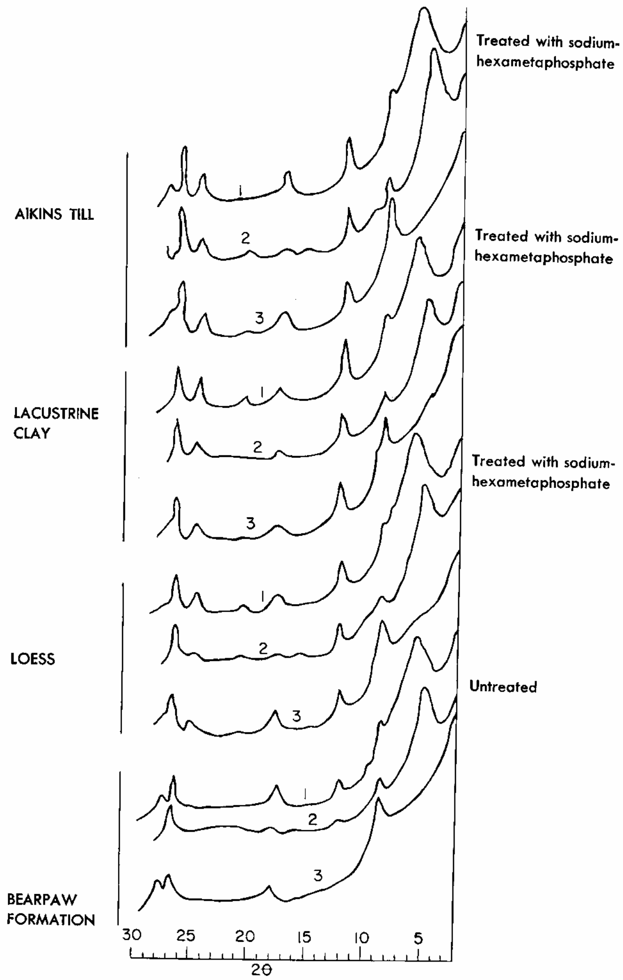


Figure 21.—Smoothed spectrometer traces made on XRD-3 General Electric Recording Spectrometer using copper radiation: (1) sample air dried; (2) sample treated with ethylene glycol; and (3) sample heated to 440°C for 10 minutes

Swift Current Creek Section

Wickenden (1930), during a study of Pleistocene sections in southern Saskatchewan, described a section along a tributary of Swift Current Creek (S. 10, T. 19, R. 13). Subsequent mapping has revealed new evidence which necessitates a new interpretation of this section. Wickenden (1930, p. 69) recognized three tills in the Swift Current Creek Section (Fig. 22). He concluded that the upper and middle tills were separated by an interglacial deposit and that the upper 8 feet of the lower till represents a weathered zone.

Recent mapping has shown that these units are widespread, and consequently, the tills have been named (Fig. 23). The lack of leaching of carbonate, the lack of weathering of heavy minerals in the middle stratified drift, and the lack of leaching in the underlying till led Meneley (1956) to conclude that the sorted material is a proglacial deposit related to the underlying till rather than an interglacial deposit as suggested by Wickenden (1930, p. 68-70). The silty texture, marly nature, lack of pebbles, heavy mineral content (Meneley, 1956), and stratification indicate that the weathered till of Wickenden is a proglacial deposit probably related to the Wymark till. The lower stratified drift (Fig. 23) changes laterally from 10 feet of marly silt to at least 40 feet of sand in the eastern part of the section. Farther down the tributary (northeast), in the centre of a pre-Wymarkian valley, the unit is composed of 225 feet of sand. It is believed, therefore, that the marly silt represents a flood-plain deposit which was deposited contemporaneously with the sand in the deeper part of the old valley. It is concluded, therefore, that these sediments are Wisconsin and do not belong to an earlier glaciation as suggested by Wickenden (1930, p. 71).

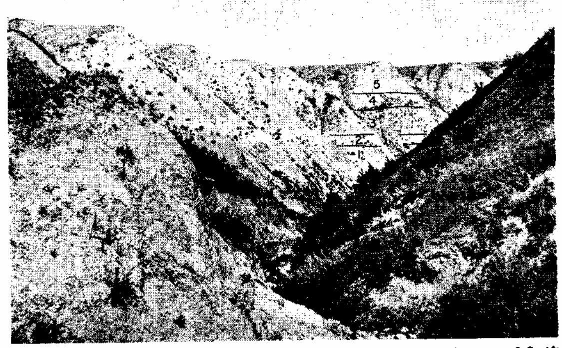


Figure 22.—Swift Current Creek Section along north bluff of tributary of Swift Current Creek in S. 10, T. 19, R. 13: (1) Wymark Till; (2) Lower stratified drift; (3) Aikins Till; (4) Middle stratified drift; and (5) Leinan Till. Depth of valley is about 150 feet.

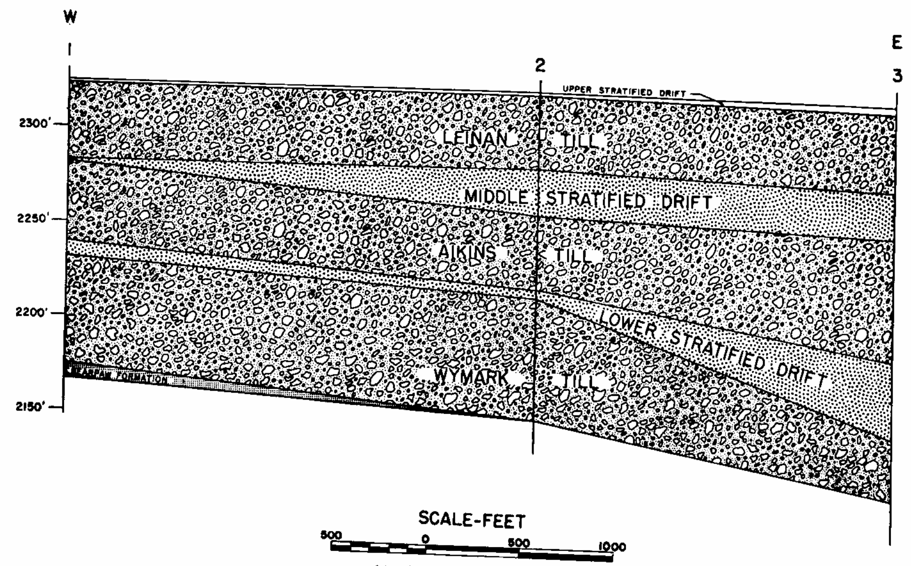


Figure 23.—Geologic cross section of Swift Current Creek Section based on sections as indicated by numbers 1, 2, and 3 in Figure 7

Stratigraphic interpretation

Figure 24 shows a summary of the Pleistocene stratigraphy in the Swift Current area based on surficial geology and five sections which are shown graphically in Figure 25 and described in the Appendix.

The similarity in clay mineral content, heavy mineral content (Meneley, 1956), plasticity, and texture indicate that the tills in the Swift Current area were derived from the same source. The lack of weathering, except for oxidation and some leaching upon the surface of the upper-most unit, furthermore suggests that the tills were deposited over a short interval of time. The progressive increase in degree of oxidation in the younger tills suggests that all of the tills were deposited before oxidation commenced. The lack of weathering on the surface of the Wymark Till and Aikins Till beneath the loess and the pronounced youthfulness of the moraine in the three tills strengthens the idea that these tills were deposited over a short interval of time.

Age and Correlation

The pronounced youthfulness of the topography and the lack of weathering, except for oxidation and a few inches of leaching in the surficial sediments, indicate that these tills are Wisconsin in age, probably late-Wisconsin. This conclusion is supported by a radio-carbon date (S-41) obtained from a willow 11 feet below surface in stratified silts above the Leinan Till. Two dates were obtained by the Saskatchewan Research Council from this sample: 10,200 ± 300 years B.P. and 9900 ± 350 years B.P. or a mean of 10,050 ± 300 years B.P. This is a minimum date of the Leinan Till. According to Elson (1957), the southern limit of the Mankato-Port Huron glaciation may be south of the Swift Current area. If this hypothesis is true then the tills in the Swift Current area are Mankato-Port Huron in age. The writer has seen no evidence in the Swift Current area that would dispute this hypothesis.

Bretz (1943) demonstrated by means of ice marginal channels that the ice margin stood in the Swift Current and Lethbridge areas at the same time. This does not require that the ice retreated from Lethbridge to Swift Current for these tills to be correlative as suggested by Horberg (1952, p. 323). There is a good possibility that the three tills of Horberg (1952) may be correlative with those in the Swift Current area. It is dangerous, however, to correlate on the basis of stratigraphic sequence alone. Any definite correlation must await further studies in the intervening areas.

GLACIAL HISTORY

General Statement

Five significant phases dominate the glacial history of the Swift Current area. Each of these phases is shown in a map (Figs. 26-30) in which the ice front at a particular time is drawn. The ice margins were reconstructed to explain the origin of the prominent glacial features. The stratigraphy, ice marginal channels, and end moraines are the three most important criteria for determining the glacial history. Since three

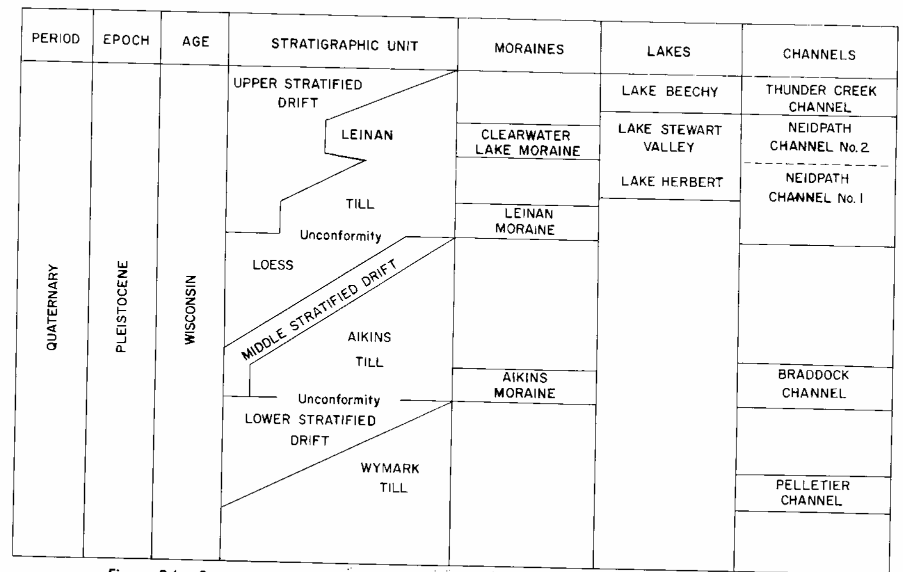


Figure 24.—Summary of Pleistocene stratigraphy and glacial history of the Swift Current area

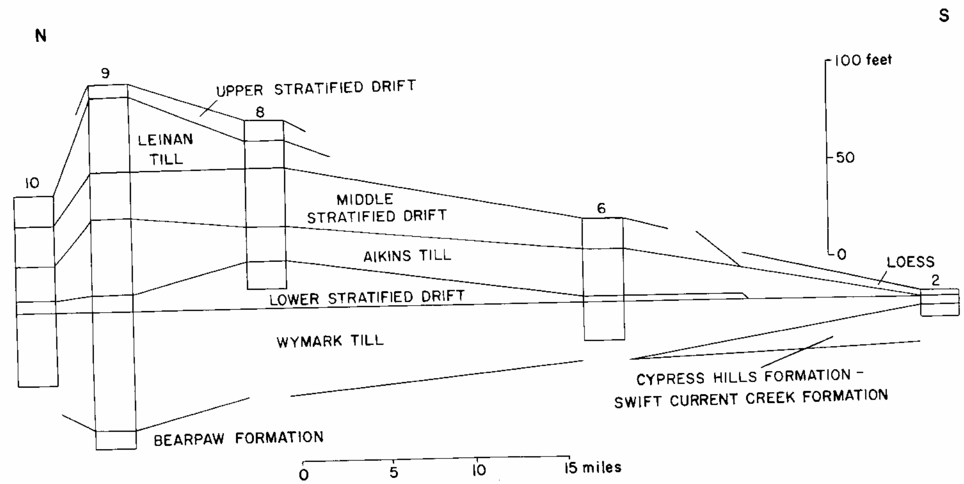


Figure 25.—Pleistocene sections in the Swift Current area. Locations are shown in Figure 14, and descriptions are given in the Appendix

tills are involved, the glacial history has a stratigraphic significance. No attempt has been made to estimate the time occupied by these various phases.

Pelletier Channel Phase

Prior to the Pelletier Channel Phase, the glacier advanced beyond the southern boundary of the Swift Current area. Figure 26 marks the first phase of this deglaciation in the Swift Current area. During the Pelletier Channel Phase, the ice front diverted the northward flowing Swift Current Creek southward to form the Pelletier Channel (Fig. 26). The geomorphology, the altitude of the sand and gravel at the confluence of these streams, and the altitude of the Pelletier Channel necessitate that the glacier formed the closure to the north compelling the water to flow southward through the Pelletier Channel.

Braddock Channel Phase

During the interval between the Pelletier Channel and Braddock Channel phases, the ice retreated at least as far north as the South Saskatchewan River and then re-advanced to a position as indicated in Figure 27 which marks the southern margin of the Aikins Till. The glacier stood at the Aikins Moraine in front of which was the Braddock Channel at an altitude of 2600 feet. This ice marginal channel is in a side-hill position, and therefore, the ice must have stood along the northeast bluff of this channel. Since the base of the Beverley Channel is at an altitude of about 2600 feet, this channel has been correlated with the Braddock Channel, and thus completing the ice margin at this time. The Braddock and Beverley channels were connected by means of the bedrock valley near Swift Current.

Neidpath Channel Phase No. 1

During the interval between the Braddock Channel Phase and the Neidpath Channel Phase No. 1, the glacier retreated at least as far north as the South Saskatchewan River and then re-advanced to a position as indicated in Figure 28. The Neidpath Channel, which was named by Bretz (1943), has an altitude of about 2400 feet. During this phase the ice stood at the Leinan Moraine which extends from the western boundary of the Swift Current area to Fauna where it completely plugs the bedrock valley in which Swift Current, Aikins, and Waldeck are located. The ice margin stood between the two channels south of Fauna (T. 16, R. 11) compelling the meltwater to cut the channel southeast of Waldeck (Fig. 28). The meltwater then flowed through the Neidpath Channel into the glacial lake in the southeastern portion of the Swift Current area. The glacial lake northwest of Swift Current drained into the Neidpath Channel by way of the ancient valley northwest of Swift Current and the ancient valley in which Aikins is located. During the interval between the Braddock Channel Phase and Neidpath Channel Phase No. 1, westerly winds deposited loess in the Swift Current area.

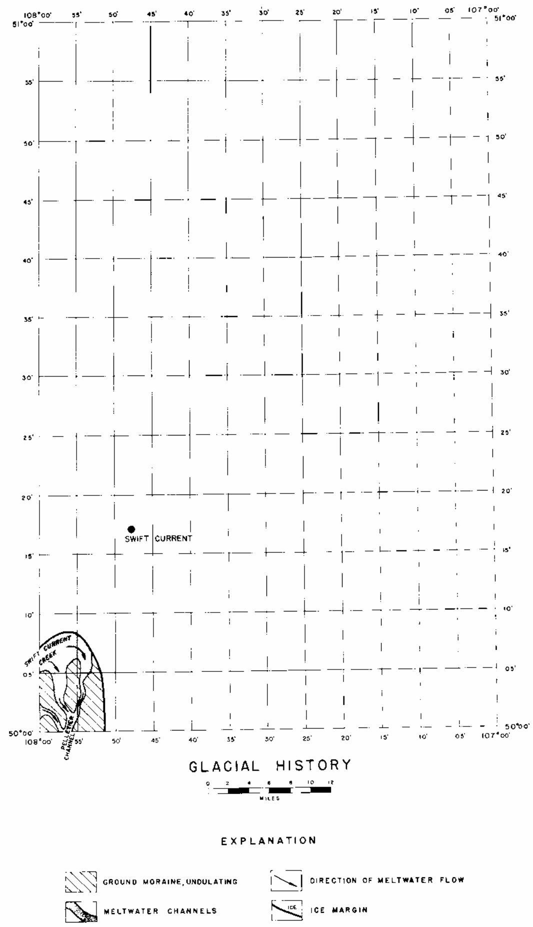


Figure 26.—**Pelletier Channel Phase**

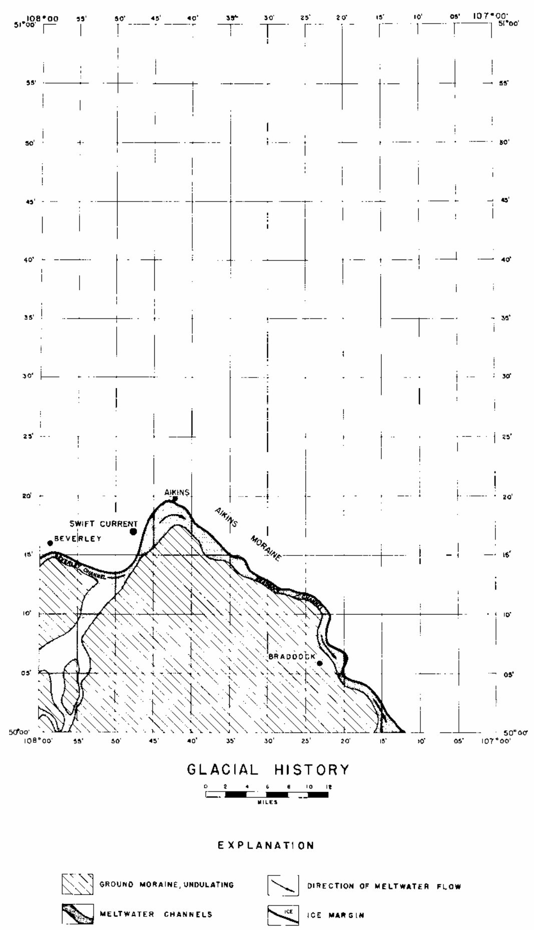


Figure 27.—**Braddock Channel Phase**

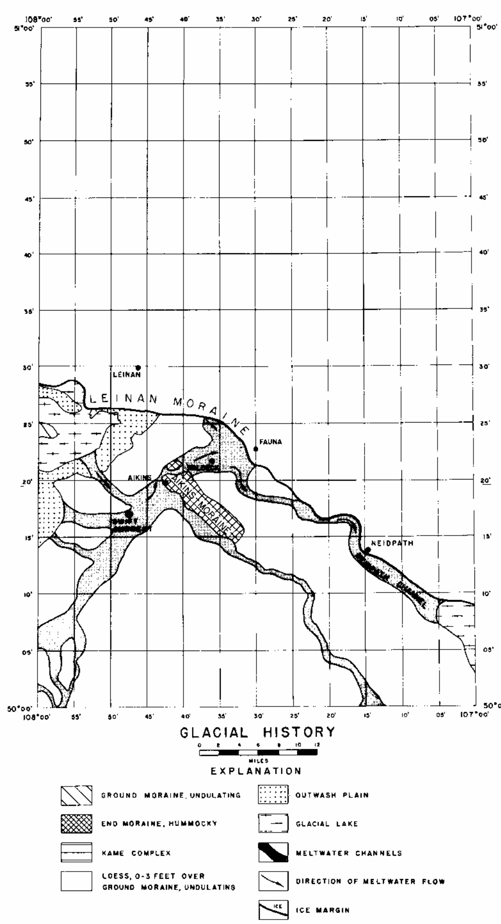


Figure 28.—Neidpath Channel Phase No. 1

Neidpath Channel Phase No. 2

During Neidpath Channel Phase No. 2, the glacier stood at the Clearwater Lake Moraine (Fig. 29). Farther southeast beyond the Swift Current area the ice stood near Ernfold where it plugged the ancient valley which contained Lake Herbert. Lake Stewart Valley drained southward by way of the channel now occupied by lower Swift Current Creek, the channel southeast of Waldeck, and finally the Neidpath Channel. Part of Lake Stewart Valley drained into Lake Herbert by way of Handsome Lake Channel. Lake Herbert drained into the Neidpath Channel by way of the channel southeast of Fauna. With the exception of the Beverley Channel, Braddock Channel, and the one southeast of Waldeck, all of the meltwater Channels in Figure 29 are pre-Wymarkian in age. Most of these ancient channels were partially filled rather than cut during glacial time. The recognition of this is important in determining the drainage history. The shallow development of the Neidpath Channel led Bretz (1943, p. 49) to conclude that the channel seems too small to have been used twice. More detailed mapping shows, however, that this channel connected lakes of about the same altitude, and therefore, was a graded stream for most of its duration. It is not known whether the glacier retreated far enough north to drain Lake Stewart Valley and Lake Herbert during the interval between the Neidpath Channel phases No. 1 and No. 2.

Thunder Creek Phase

The Thunder Creek Phase (Fig. 30) is correlative with the Early Lake Regina stage of Edmunds (unpublished manuscript) and represents a pause in the retreat of the glacier from the Clearwater Lake Moraine. Immediately before and during the Thunder Creek Phase the outlet channel was lowered from about 2400 feet (Neidpath Channel) to about 2000 feet. This change in base level took place over a short interval of time during which the glacier retreated down the north-facing escarpment of the Missouri Coteau (T. 21, R. 6). Lake Stewart Valley was drained, and the South Saskatchewan River and the Swift Current Creek channels were captured by the Thunder Creek Channel which also was the outlet for Lake Beechy. Lake Herbert diminished in size to become Rush Lake which persisted until it was artificially drained early in this century. Although the Chaplin-Johnston Lake drainageway has an altitude lower than the base of the Neidpath Channel, there is no evidence that this drainage course was used during the last retreat of the ice. It is believed that the course was plugged in part with dead ice. The hummocky moraine in the Chaplin-Ernfold area supports this hypothesis. This course and others between the Neidpath Channel and the Thunder Creek Channel may have been used during pre-Wymarkian, Wymarkian, and Aikinsian time, and then partially or completely filled with drift from subsequent glaciations.

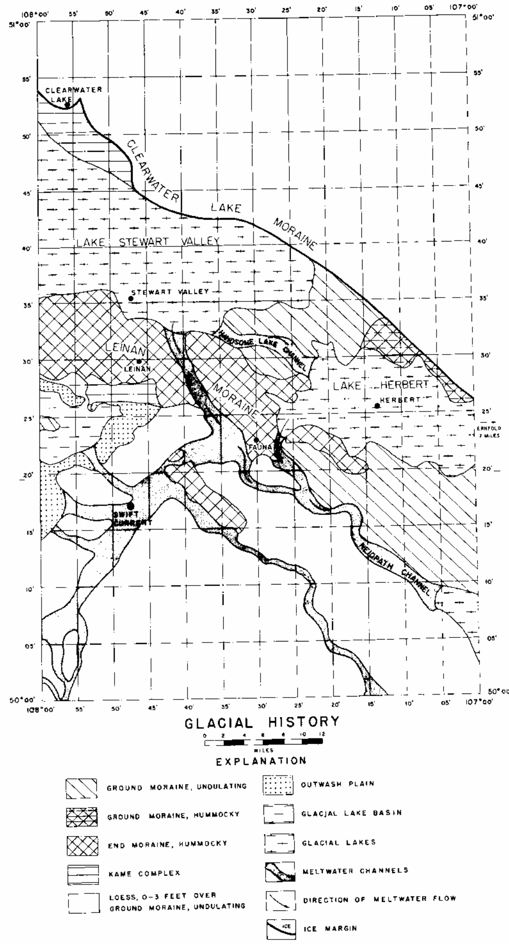


Figure 29.—**Neidpath Channel Phase No. 2**

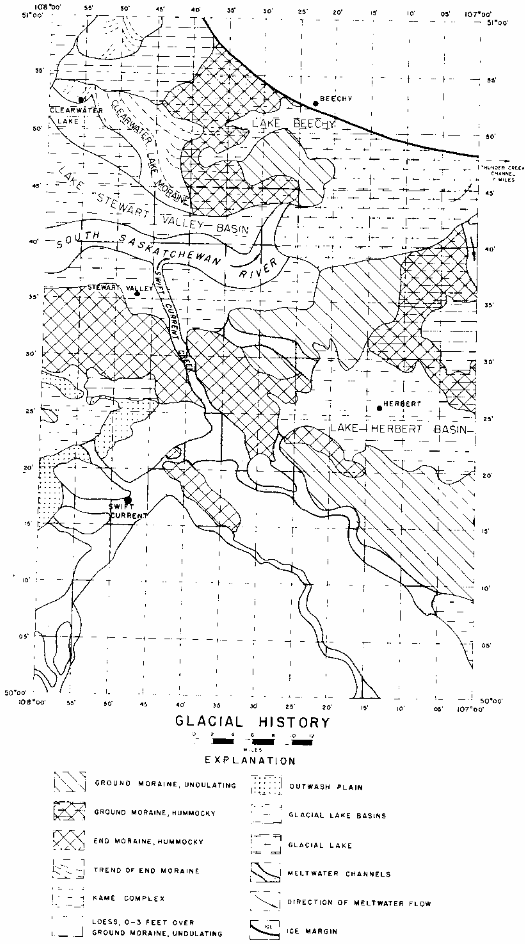


***Figure 30.*—Thunder Creek Phase**

LITERATURE CITED

Aandahl, A. R., 1948, The characterization of slope positions and their influence on the total nitrogen content of a few virgin soils of western Iowa: Soil Sci. Soc. America Proc., v. 13, p. 449-454.

Bayrock, L. A., 1958, Glacial geology Alliance-Brownfield District, Alberta: Research Council of Alberta, Prelim. Rept. 57-2, 56 p.

Bouyoucos, G. J., 1951, A recalibration of the hydrometer method for making mechanical analysis of soils: Agromony Jour., v. 43, p. 434-438.

Bretz, J. H., 1943, Keewatin end moraines in Alberta, Canada: Geol. Soc. America Bull., v. 54, p. 31-52.

Christiansen, E. A., 1956, Glacial geology of the Moose Mountain area, Saskatchewan: Saskatchewan Dept. Mineral Resources, Rept. 21.

Ellis, J. H., and Shafer, W., 1928, The nitrogen content of Red River Valley soils: Scientific Agriculture, Canada Soc. Tech. Agriculture, Ottawa, v. 9, p. 231-248.

Elson, J. A., 1957, Lake Agassiz and the Mankato-Valders problem: Science, v. 126, p. 999-1002.

Fraser, F. J., McLearn, F. H., Russell, L. S., Warren, P. S., and Wickenden, R. T. D., 1935, Geology of southern Saskatchewan: Geol. Survey Canada, Mem. 176, 137 p.

Gravenor, C. P., 1955, The origin and significance of prairie mounds: Am. Jour. Sci., v. 253, p. 475-481.

Gravenor, C. P., and Bayrock, L. A., 1956, Stream-trench systems in east-central Alberta: Research Council of Alberta, Prelim. Rept. 56-4, 11 p.

Hoppe, Gunnar, 1952, Hummocky moraine regions with special reference to the interior of Norrbotten: Geografiska Annaler, v. 34, p. 1-72.

Horberg, Leland, 1952, Pleistocene drift sheets in the Lethbridge region, Alberta, Canada: Jour. Geol., v. 60, p. 303-330.

Johns, W. D., Grim, R. E., and Bradley, W. F., 1954, Quantitative estimations of clay minerals by diffraction method: Jour. Sed. Petrology, v. 24, p. 242-251.

Johnston, W. A., and Wickenden, R. T. D., 1931, Moraines and glacial Lakes in southern Saskatchewan and southern Alberta, Canada: Royal Soc. Can., Trans., 3rd ser., v.25, sec. 4, p. 29-44.

Johnston, W. A., Wickenden, R. T. D., and Weir, J. D., 1948, Preliminary map; Surface deposits, southern Saskatchewan (two sheets): Geol. Survey Canada, Paper 48-18.

Lemke, R. W., 1958, Narrow linear drumlins near Velva, North Dakota: Am. Jour. Sci., v. 256, p. 270-283.

Meneley, R. A., 1956, Pleistocene stratigraphy of the Saskatchewan Landing area: Bachelor's Thesis, Saskatoon, University of Saskatchewan, 34 p.

Mitchell, John, Moss, H. C., and Clayton, J. S., 1947, Soil survey of southern Saskatchewan from Township 1 to 48 inclusive: Saskatchewan Soil Survey Rept. 12, 259 p.

Peterson, R., 1958, Rebound in Bearpaw shale, western Canada: Geol Soc. America Bull., v. 69, p. 1113-1124.

Smith, G. D., 1942, Illinois loess: University of Illinois Agricultural Experimental Station Bull. 490, p. 139-184.

Terzaghi, K., 1955, Influence of geologic factors on the engineering properties of sediments: Harvard Soil Mechanics Ser. 50, p. 602-603.

Thorp, James, and Smith, H. T. V., 1952, Map of the Pleistocene aeolian deposits of the United States, Alaska, and parts of Canada: Geol. Soc. America.

Washburn, A. L., 1956, Classification of patterned ground and review of suggested origins: Geol. Soc. America Bull., v. 67, p. 823-865.

Wickenden, R. T. D., 1930, Interglacial deposits in southern Saskatchewan: Geol. Survey Canada, Summary Rept., pt. B., p. 65-71.

Wolstedt, Paul, 1954, Das Eiszeitalter (Erster Band): Stuttgart, Ferdinand Enke, 375 p.

APPENDIX

Pleistocene Sections*

Section 2.—Excavation for basement ¼ mile east of S.W. corner S. 27, T. 12, R. 13

Deposits	Thickness (Inches)
Loess	
Loess, noncalcareous, brown to brownish grey, oxidized except for A_1 horizon, silt loam to silty clay loam, contains A_1, B_{21}, and B_{22} of soil profile. Contact with underlying till is sharp.	21
Wymark Till	
Till, calcareous, light grey (10YR7/2) when dry, oxidized, clay loam, stony and massive. Contact with underlying unit is sharp.	28
Cypress Hills Formation-Swift Current Creek Formation	
Sand, calcareous, very light grey, fine grained, stratified. Base is not exposed.	6+

* The sections are shown graphically in Figure 25 and their location is shown in Figure 14.

Section 6.—North bluff of Swift Current Creek, 300 feet west and 350 feet north of S.E. corner of S. 24, T. 15, R. 14

Deposits	Thickness (Feet)
Silt, very calcareous, very pale brown (10YR7/3) when dry, oxidized, interbedded with 1-4 beds" beds of grey silt and thin pebble zones, cliff forming. Contact with underlying till is sharp.	15
Aikins Till	
Till, calcareous, upper part of unit is pale brown (10YR6/3) when dry, oxidized, lower part of unit is light-brownish grey (2.5YR6/2) when dry, unoxidized, oxidation along joints in upper part of unoxidized zone, clay loam. Contact with underlying unit is sharp.	25
Lower stratified drift	
Silt, calcareous, light grey when dry (2.5Y7/2), oxidized, locally sandy, stratified, indurated, contains lenses of brownish-grey clay 1-6 inches thick.	3
Wymark Till	
Till, calcareous, greyish brown (2.5Y5/2) when dry, unoxidized except for oxidation along joints in upper two feet of unit, clay loam. Lower 3 feet consists of till beds 1-4 inches thick interbedded with sand beds ¼-3 inches thick. Top of this 3 ft. unit contains a striated boulder whose striae trend N. 40°W.	19+

Section 7.—Reference section in loess 500 feet west of northeast corner of S. 12, T. 16, R. 14

A_1 horizon: 0-6 inches loess, dark brown (10YR3/3, dry) noncalcareous, silt loam, medium-grained weakly developed subangular blocky structure, very friable. The upper 4 inches constitutes the Ap horizon. The A_1 horizon thickens in depressions and thins over topographic highs.

B_{21} horizon: 6-13 inches loess, brown (10YR5/3, moist) noncalcareous, silty clay loam, fine to medium well developed prismatic structure, organic coating on peds, firm; sharp color, structural, and textural break with A_1 horizon.

B_{22} horizon: 13-18 inches loess, yellowish brown (10YR5/4, moist), noncalcareous, silt loam, coarse to very coarse weakly developed prismatic structure, friable, slight amount of organic coatings.

Bca horizon: 18-21 inches loess, pale brown (10YR6/3, moist) strongly calcareous, silt loam, massive. This horizon is interpreted as a layer of carbonate accumulation.

C horizon: 21-28 inches loess, very pale brown (10YR7/4, moist), calcareous, silt loam, very coarse weakly developed prismatic structure. Lower 1-2 inches contain sand and pebbles which represent a lag deposit upon the till surface (Fig. 17).

D horizon: 28-30+ inches till, yellowish brown (10YR5/6, moist), white specks, strongly calcareous, sandy clay loam, oxidized, massive; base not exposed.

Section 8.—In east bluff of Swift Current Creek about 200 yards west and 180 yards south from N.E. corner of S. 1, T. 18, R. 13

Deposits	Thickness (Feet)
Upper stratified drift	
Gravel and sand, calcareous, variegated color, dominantly oxidized, but some locally unoxidized, upper 1-2 feet is aeolian sand.	10
Leinan Till	
Till, calcareous, pale brown (10YR6/3) to light-brownish grey (10YR6/2) when dry, oxidized, clay loam, jointed.	15
Middle stratified drift	
Sand, calcareous, variegated color, dominantly oxidized, but some locally unoxidized, stratified.	30

Aikins Till	
Till, calcareous, greyish brown (2.5Y5/2) when dry, clay loam, massive. Unoxidized, except in top 4 inches which is oxidized.	18
Lower stratified drift	
Sand, calcareous, light-brownish grey, oxidized, fine grained, pebbly in places, slope former, exposed by excavation. Base of unit not exposed.	15+

Section 9.—North bluff of tributary to Swift Current Creek in S.W. ¼, S. 10, T. 19, R. 13 between Section 1 and 2 (Fig. 7)

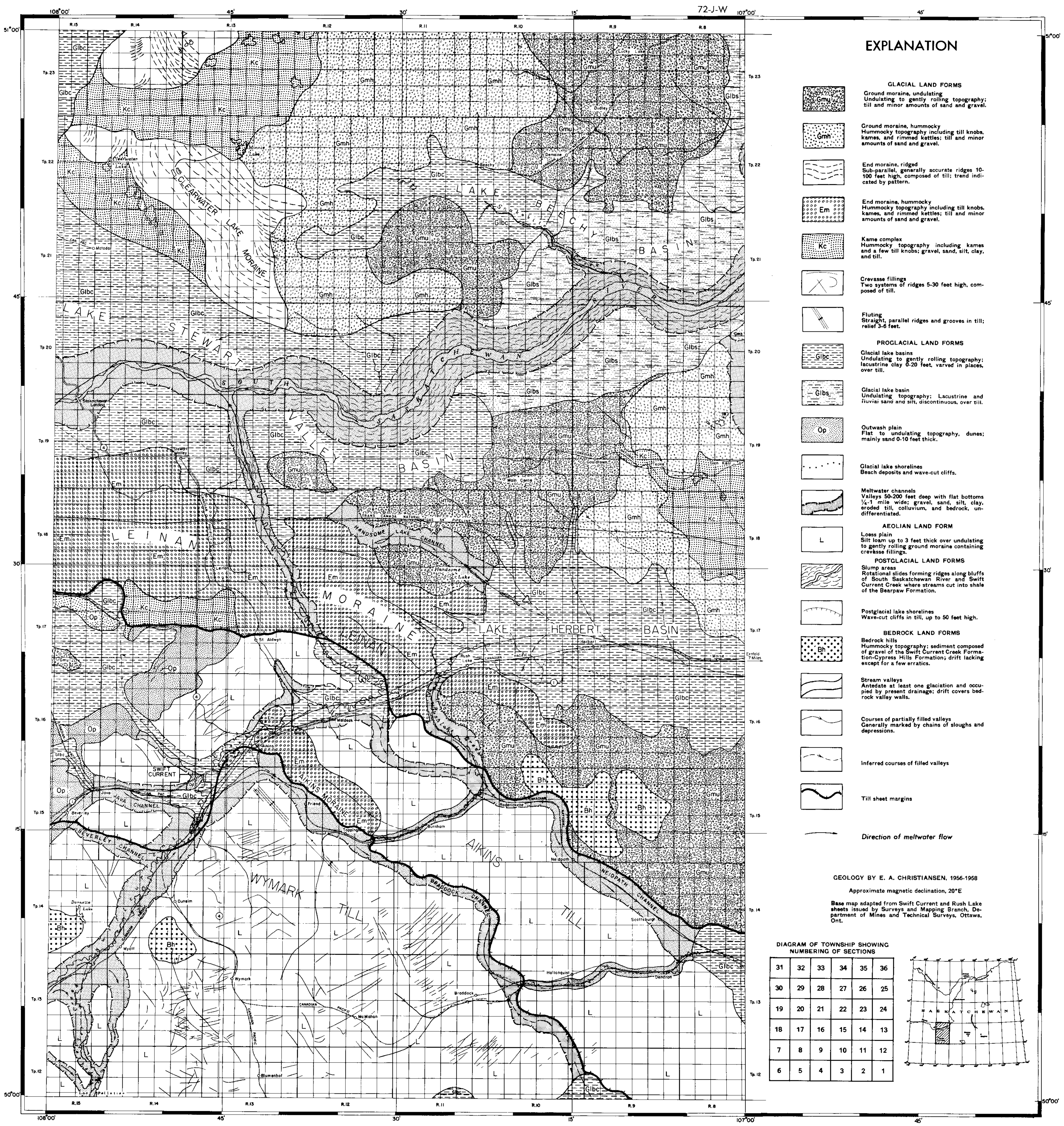
Deposits	Thickness (Feet)
Upper stratified drift	
Clay,noncalcareous, grey, stratified, formed in glacial Lake Stewart Valley.	5
Leinan Till	
Till, calcareous, light-yellowish brown (2.5Y6/4) when dry, oxidized, clay loam, massive. Upper contact is sharp and regular.	40
Middle stratified drift	
Sand, calcareous, yellowish brown, oxidized, changes vertically and laterally in texture. Lenses of gravel (channel fills) penetrate the underlying till surface.	24
Aikins Till	
Till, calcareous, light-brownish grey (2.5Y6/2) when dry, unoxidized, clay loam, thickens toward east.	38
Lower stratified drift	
Silty clay loam, very calcareous (marl) light grey (2.5Y7/2) when dry, unoxidized except for upper 1-2 feet, weakly stratified, locally well-stratified sands and clays occur. This unit thickens toward the east where it becomes a sand up to 225 feet thick.	10
Wymark Till	
Till, calcareous, light-greyish brown (2.5Y6/4) when dry, oxidized, clay loam. Base exposed near Section 1 (Fig. 7).	60
Bearpaw Formation	
Shale, grey, unoxidized, iron oxide staining along joints, montmorillonitic, plastic, and highly fractured by slumping. Base is not exposed.	8+

Section 10.—Northeast bluff of tributary valley to Swift Current Creek, ¼ mile north and ⅛ mile west of centre of S. 16, T. 19, R. 13

Deposit	Thickness (Feet)
Leinan Till	
Till, calcareous, pale yellow (2.5Y7/4) when dry, oxidized, clay loam, massive.	15
Middle stratified drift	
Sand and silt, calcareous, light-yellowish brown (2.5Y6/4) when dry, oxidized.	20
Aikins Till	
Till, calcareous, light-yellowish brown (2.5Y6/4) when dry, oxidized, clay loam, weakly jointed. Lower 3 feet of unit consists of 4 inch till beds interbedded with ¼-½ inch sand beds.	18
Lower stratified drift	
Sand, silt, and gravel, calcareous, variegated color, mainly pale yellow (2.5Y7/4) when dry, oxidized, well stratified.	7
Wymark Till	
Till, calcareous, grey (2.5Y6/0) to light grey (2.5Y7/0) when dry, unoxidized, clay loam, weakly jointed with oxidation taking place along joints.	37+

REGINA, SASKATCHEWAN
Printed by LAWRENCE AMON, Printer to the Queen's Most Excellent Majesty.
1959

Reprinted 1969



GLACIAL GEOLOGY OF THE SWIFT CURRENT AREA SASKATCHEWAN

SCALE

Miles 0 1 2 3 4 5 6 7 8 9 10 Miles

To accompany
Report No. 32

Sedimentary Geology Division
Geological Sciences Branch
Department of Mineral Resources
Government of Saskatchewan