# GLACIAL GEOLOGY

*of the*

# MOOSE MOUNTAIN AREA

# SASKATCHEWAN

*by*

***E. A. Christiansen***

**Regina**

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# GLACIAL GEOLOGY OF THE MOOSE MOUNTAIN AREA, SASKATCHEWAN

E. A. CHRISTIANSEN

ABSTRACT

The glacial drift in the Moose Mountain area exhibits linear elements such as crevasse fillings, fluting, and minor recessional ridges in the ground moraine. Knob and kettle topography and rimmed kettles are believed to have resulted from the melting of "dead ice."

The main direction of ice movement was from the northwest, although locally, the direction of ice movement varied considerably. Preglacial topography had a pronounced influence on the direction of ice movement. The Moose Mountain preglacial topographic high compelled the ice to flow around it, forming the large Weyburn Lobe that occupied the Weyburn Lowland. Minor recessional ridges and the lobate ice marginal channels outline successive positions of the retreating ice front. The Missouri Coteau and the Moose Mountain preglacial topographic highs were the first areas to be deglaciated.

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## INTRODUCTION

### Location

The Moose Mountain area, which comprises approximately 8,000 square miles, lies between 102 and 104 degrees of west longitude, and between 49 and 50 degrees, 15 minutes north latitude (Figure 1). The western boundary is six miles west of Weyburn (township 8, range 14); the eastern boundary coincides with the Second Meridian, and, therefore, all locations given in the text are west of this meridian. The southern limit is defined by the boundary between Saskatchewan and North Dakota and the northern boundary is defined by the northern limit of township 14.

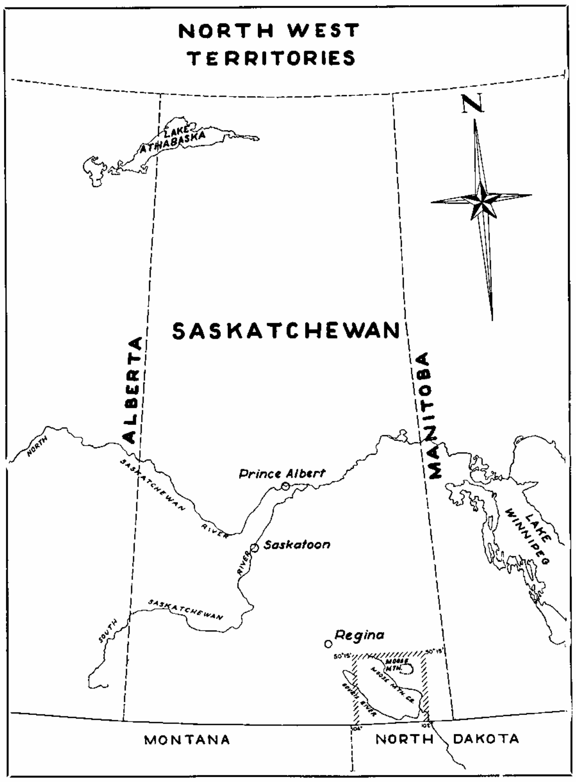


FIGURE 1. — LOCATION OF MOOSE MOUNTAIN AREA

## Previous Work

With the exception of the work done by Johnston and Wickenden (1930, 1931), Johnston *et al.* (1948), and Mitchell *et al.* (1944), little has been done on the subject of glacial geology in southeastern Saskatchewan.

Johnston and Wickenden (1930, 1931) dealt largely with major land forms such as glacial lake basins and moraines. Johnston *et al.* (1948) published a preliminary map on the surface deposits of southern Saskatchewan on a scale of one inch to six miles.

Mitchell *et al.* (1944) published a map showing the soils of southern Saskatchewan. Inasmuch as the surface textures closely reflect the parent material, this map is extremely useful for the study of the glacial geology of the area.

Vertical photographs have greatly facilitated the study of glacial land forms. Without these photographs it would be impossible to identify many land forms, the recognition of which is important for the interpretation of the glacial history.

## Present Studies

This report is based on laboratory investigations conducted during the winter of 1954-1955 and on field work done during the following summer. Before beginning the field work, the entire area was studied by means of vertical photographs furnished by the Royal Canadian Air Force. From these photographs the land forms were plotted on base maps supplied by the Map Distribution Office, Department of Mines and Technical Surveys, Ottawa. The field work was carried on primarily to check the air-photo interpretation.

It must be emphasized that the field mapping was of a reconnaissance nature and that most of the land form boundaries have been determined by air-photo interpretation. The maps of Mitchell *et al.* (1944) and Johnston *et al.* (1948) were useful guides in determining lithological boundaries. Although this study is primarily one of geomorphology, a general lithological investigation of each land form was attempted in the field.

Mapping was done on preliminary planimetric sheets on a scale of about 1 : 40,000. Planimetric sheets were not available for townships 13 and 14; it was necessary, therefore, to use a less accurate base map for these townships (Figure 2).

Preliminary topographic maps on a scale of one inch to a half mile with 25 foot contours were available for only part of the area (Goodwater, Bromhead, Hitchcock, Estevan, Oxbow, and Alameda quadrangles). It was necessary to rely largely on the Moose Mountain and Weyburn maps, which are on the scale of one inch equals three miles and which have 50 foot contours for topographical control. Mosaics of air photographs were available only for the southern part of the area (Estevan, Oxbow, Alameda, and Lampman quadrangles). These mosaics are very useful for the identification of the linear direction of some of the larger land forms that is not apparent in individual air photographs.

## Acknowledgments

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Field trips and subsequent discussions with R. B. Colton and R. W. Lemke, both of the United States Geological Survey, and with J. A. Elson of the Geological Survey of Canada, contributed much to the interpretation of observed glacial features.

Thanks are also due to J. Banford, who ably assisted the author in the field, and to A. P. Edwards, who devoted a great deal of time to the preparation of the photographic illustrations in this report.

The manuscript was read critically by R. B. Colton and R. W. Lemke of the United States Geological Survey, and by J. A. Elson of the Geological Survey of Canada, all of whom offered suggestions which were greatly appreciated by the writer.

The University of Saskatchewan has kindly granted permission for the publication of this report which is taken from the thesis submitted by the author for the degree of Master of Science.

# GEOGRAPHY

## Physiography

The Moose Mountain area may be divided into three physiographic divisions: Moose Mountain, Weyburn Plain, and Missouri Coteau.

Moose Mountain, which is in the northeast sector of the mapped area, rises abruptly to a height of about 500 feet above the plain to the south. To the north, however, the slope is much more gradual. The surface is rugged; it is often referred to as knob and kettle topography, and has a local relief of 20 to 300 feet.

The broad and rather flat Weyburn Plain, which approximately parallels the Souris River, lies between the Moose Mountain to the northeast and the Missouri Coteau to the southwest. Much of the surface, particularly the Lake Regina Basin, is nearly level to gently undulating. In places, however, there is local relief of 50 to 100 feet.

The northeast facing escarpment of the Missouri Coteau crosses the International Boundary about 45 miles west of Portal, and extends to the northwest. The Coteau is 15 to 20 miles wide at the International Boundary (Lemke, 1956, personal communication). There is generally an abrupt rise of about 400 feet from the plain to the upland of the Coteau, but in places there are large re-entrants that have gradual slopes. The local relief of this morainic upland exceeds 100 feet in only a few places.

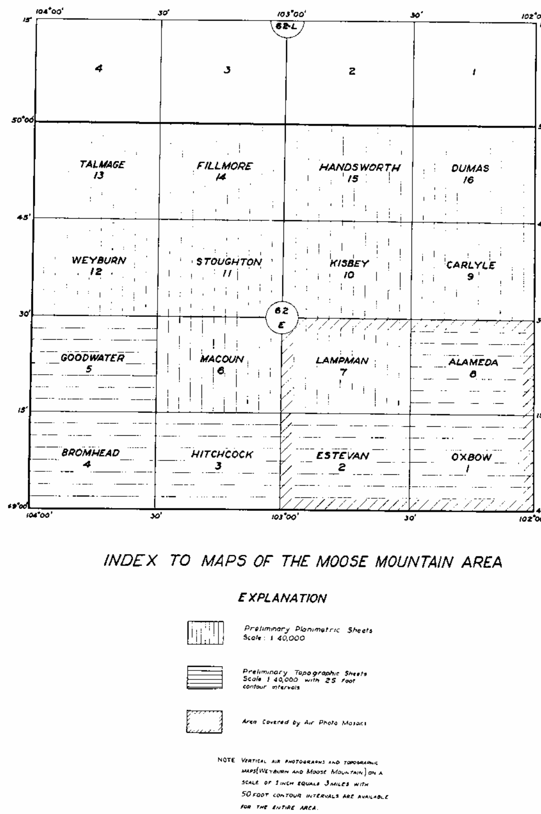


**FIGURE 2. — INDEX TO MAPS OF THE MOOSE MOUNTAIN AREA**

### Drainage

The Moose Mountain area drains southeasterly through the Souris River into Lake Winnipeg. The two major tributaries of the Souris River in this area are Moose Mountain Creek and Pipestone Creek.

The broad Souris River valley is deeply entrenched in the Weyburn Plain. It is occupied by the underfit Souris River that meanders on a broad alluvial flood plain, and heads near Weyburn (township 8, range 14) at which point it receives drainage from the constructed Yellow Grass ditch. Long Creek, which is a tributary to the Souris River, drains the Coteau. Moose Mountain Creek, another tributary to the Souris River, follows the northeastern boundary of the Weyburn Plain. Flowing in a southeasterly direction, Moose Mountain Creek drains the central and eastern portion of the area.

Pipestone Creek, which flows in a broad glacial valley, drains the northeastern sector of the region. Like the Souris, Pipestone Creek is an underfit stream that could not have been responsible for the cutting of the deep and broad valley in which it flows.

## GLACIAL LAND FORMS

### Ground Moraine

The ground moraine comprises an area of low relief consisting predominantly of till* modified locally by such features as drumlins, fluting, minor recessional ridges, crevasse fillings, eskers, and kames. This land form is often referred to as a till plain, which is a suitable term because it calls attention to the topography as well as to the predominant composition.

The topography of the ground moraine in the Moose Mountain area is undulating to gently rolling, and has a local relief that generally does not exceed 15 feet. The landscape is characterized by numerous, small, undrained depressions, commonly referred to as "sloughs." These "sloughs" and intervening low till ridges are commonly orientated in definite lobate patterns. Near Goodwater (township 5, range 13) and Cedoux (township 11, range 14), the ground moraine is traversed by numerous, small, shallow, meltwater channels that exhibit a conspicuous lobate pattern.

Ground moraine is composed essentially of till, although locally there are small amounts of silt and sand owing to meltwater action. In several localities the upper five to ten feet of till are lighter in colour and less compact than the till beneath it. It is believed that this upper more friable till may be ablation till and that the more compact till beneath it may be lodgement till (Flint, 1947, p. 111).

### Dead Ice Moraine

The hummocky knob and kettle landscape of Moose Mountain and the Missouri Coteau, as well as the rimmed kettle area south of Moose

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* The terms used for glacial deposits can be defined as follows:

1. Glacial drift: all rock material which has been deposited by the glacier, either directly from the ice or from accompanying meltwater.
2. Till: a nonstratified, unsorted sediment deposited directly by the ice.
3. Stratified drift: deposits made by meltwater beyond the glacier or in contact with wasting ice (ice-contact stratified drift).

Mountain, are interpreted as being deposits that resulted from the melting of "dead ice" (Figure 3 and Figure 4). The term "dead ice" is used for masses of ice that have become detached from the receding glacier and are therefore stagnant. The term is also used for ice that is still part of the glacier, but has thinned to such an extent that it is no longer actively flowing.

The designation "dead ice moraine", called "ablation moraine" by Flint (1947, p. 131), was used by Schou (1949, pp. 33-34) to describe the hummocky, irregular moraines in Denmark. Such dead ice moraines are devoid of any definite pattern and consist of irregular accumulations of morainic material with numerous, randomly spaced knobs and kettles.

Woldstedt (1954, p. 95) points out that hummocky moraines are marginal deposits of the ice and may locally take the place of true end moraines, which are linear, wall-like structures. Moraines with knobs and kettles which do not show any pronounced lineations and which are here interpreted as dead ice moraines, are therefore often referred to simply as "end moraines," particularly in North American literature. In most German literature, on the other hand, the "Kuppige Grundmoränen-landschaft" (hummocky ground moraine landscape) is distinguished from the wall-like end moraine.

Fuller (1914, p. 38-44) recognized the importance of dead ice blocks in forming kettles and rimmed kettles. He also recognized the inversion of topography that follows the melting of such dead ice blocks.

The Moose Mountain and Missouri Coteau moraines are composed essentially of till and minor amounts of stratified drift in the form of kames. Several kames were observed, but no attempt was made to show them on the map because of the difficulty in differentiating them from till knobs in air photographs, and time did not permit a detailed field investigation. The

**FIGURE 3. — DEAD ICE MORAINE**
**Knob and kettle topography on Moose Mountain in Sec. 24, T. 10, R. 7, W2nd Mer.**

dead ice moraines contain some flat areas representing former glacial lakes and ponds. Although several of these lake and pond plains were observed, only one, north of Kisbey, is large enough to be plotted on the map.

The dead ice moraine south of Moose Mountain is characterized by numerous, shallow, rimmed kettles (Figure 4) that exhibit a conspicuous

**FIGURE 4. — RIMMED KETTLES**
**Rimmed kettles south of Moose Mountain in Sec. 29, T. 3, R. 5, W2nd Mer.**
**Air photo. A11939-163, courtesy R.C.A.F.**

circular pattern in air photographs. The kettle rims are low features composed of either till or stratified drift. They range in height from two to four feet above the level of the interkettle area. In width, the kettle rims range from 20 to 400 feet. Rimmed kettles occur in till plains as well as in areas of stratified drift.

Schou (1949, p. 34) makes the following remarks with regards to the formation of dead ice moraine:

> "This remarkable moraine landscape was formed in conjunction with melted masses of dead ice, and the hummocky surface is a direct consequence to the irregular accumulation of the moraine in the ice. When the ice melted it sank and was deposited on the spot and there was no subsequent planing off. Lumps of dead ice may have caused the hollows."

Gravenor (1955) has described and illustrated the probable origin of such dead ice features as knobs, kettles, and rimmed kettles. He suggests that the ablation till will be unevenly distributed on the ice surface and that a depression will be formed owing to accelerated melting where the debris is thinnest. As debris moves off from the higher areas into the depressions, melting in the higher areas will become more rapid. Continued melting will lead to inversion of topography, that is to say, the topography of the moraine is the reverse of the topography on the ice. He also suggests that, if there is a considerable thickness of ice below the depressions, continued melting will result in knob and kettle topography. If, however, the ice is thin or absent beneath the depressions, but present in adjacent knobs, rimmed kettled or "doughnuts" will result.

The theories proposed by Schou (1949, pp. 33-34) and Gravenor (1955) explain the origin of the knob and kettle moraine in the Moose Mountain area. Furthermore, the presence of a lacustrine plain on Moose Mountain north of Kisbey, which is now a topographic high, can be explained only by inversion of topography. Collapse structures in lake silts, in an exposure north of the entrance to the Kenosee Lake resort, also support the theory of dead ice deposition.

## End Moraines

### *Major end moraines*

The term end moraine has been used for a ridge-like accumulation of drift built chiefly along the margin of an ice sheet (Flint, 1947, p. 127). End moraines may be deposited along the lateral part of ice lobes as well as in front of them.

Three major end moraines were deposited in the Moose Mountain area: the Kisbey Moraine, the Oxbow Moraine, and the Stoughton Moraine.

The Kisbey Moraine, about one mile north of the village of Kisbey (township 8, range 5), trends in a northwesterly direction. The most prominent part of it is a ridge that rises about 80 feet above the surrounding moraine. This ridge is approximately 1,000 feet wide at the base and is composed of stratified sand of ice contact origin. The ridge is interpreted as being a kame moraine, formed by meltwater which deposited the sand along the ice front. The term "kame moraine" is used for a linear, wall-like end moraine composed of ice-contact, stratified drift. Although there is no evidence of lake deposition on the kame moraine, there appear to be some lacustrine sediments on other parts of the Kisbey Moraine.

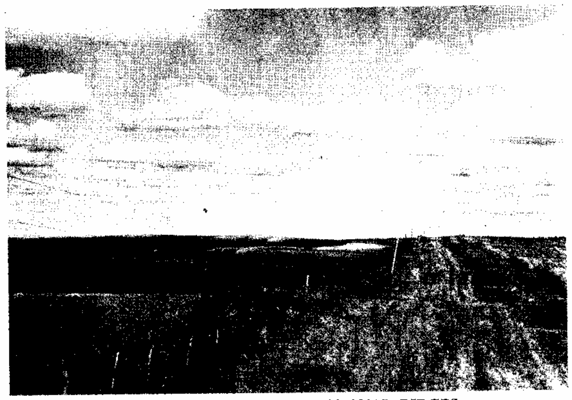

**FIGURE 5. — MINOR RECESSIONAL RIDGES**
**East-west trending white topped till ridges south of Moose Mountain in Sec. 29, T. 13, R. 2, W2nd Mer.**

The north trending Oxbow Moraine lies south of the town of Oxbow (township 3, range 2). It is about 11 miles long and has an average width of approximately one mile. The Oxbow Moraine is a large ridge composed of stratified drift and intercalated till lenses.

The Stoughton Moraine, which is part of the Moose Mountain morainal system (Johnston and Wickenden, 1931, p. 40), is the most extensive end moraine in the area. It extends northwest and southeast from a point two miles east of Stoughton (township 8, range 8). It is gently to moderately rolling and has a local relief that generally does not exceed 40 feet. Locally the moraine is characterized by low, short, discontinuous, till ridges which parallel the general trend of the moraine. The Stoughton Moraine is composed essentially of till, although stratified drift in the form of kames, kame moraines, and outwash, is not uncommon. Most of these land forms, however, are too small to be plotted on the map.

### *Minor end moraines*

Minor end moraines, often referred to as "wash-board" moraines, are numerous in the ground moraine (Figure 5 and Figure 7). Wash-board moraines in Quebec have been described by Mawdsley (1936, p. 9), but because these ridges in Quebec may have a different origin from those in the Moose Mountain area, the term "minor recessional ridges" or "minor end moraines" (Flint, 1947, p. 130) is here applied. Gwynne (1942, p. 206) observed that minor recessional ridges (which he calls "swells and swales") are generally parallel to the position occupied by the margin of the ice lobe. He concluded that the swells and swales outline successive positions of the ice front as it retreated and that they were probably deposited yearly. Gwynne (1942, p. 206) has put forth the following origin for minor recessional ridges (swells and swales):

"The swells are believed to have been initiated through deposition of drift during the summer period of melting. With the ice front oscillating in its retreat, such deposits would be thickened at the margin of the ice as it advanced during the succeeding winter, pushing forward and overriding part of the deposits of the previous summer. The strip not covered by the ice in its readvance would become a line of swales. Neither swells nor swales would be smooth and continuous for any great distance, since the amount of oscillation and deposition along the ice front would not be uniform."

The writer has observed no evidence to contradict this theory, and has therefore accepted it as a plausible origin for the minor recessional ridges.

The minor recessional ridges of the Moose Mountain area are well-defined in most places. In some places, however, the presence of ridges is suggested by lineations in the ground moraine, such as the alignment of undrained depressions which constitute the swales. The ridges range in height from five to 15 feet and average about seven feet. In width, the ridges are most commonly about 100 feet at their base. A pattern is formed by a rhythmic sequence of parallel, generally arcuate, ridges which, in most cases, cannot be traced continuously, but the pattern as a whole may be traceable for many miles in air photographs.

The minor end moraines are composed of till. The composition of the surface, however, has been modified by erosion which has removed some of the fines and which has left a lag concentrate.

The minor recessional ridges (swells) are conspicuous in air photographs not only because of their form and pattern, but also because of the white colour of their tops which contrasts distinctly with the dark coloured swales. This white colour is probably due in part to erosion which removed the finer materials from the ridges and left a coarser, light coloured, lag concentrate on their tops. Moreover, as a result of this erosion, varying amounts of the upper dark soil were removed and deposited in the swales. The removal of the A horizon and the consequent appearance of the calcareous B or C horizon also accounts for the white colour (Edwards, 1955, personal communication).

If the minor recessional ridges are of annual origin, as suggested by Gwynne (1942, p. 206), their spacing should afford evidence of the rate of ice retreat. West of the hamlet of Bender (township 13, range 4), an average of 16 ridges per mile was noted. Along the north boundary of township 13, ranges 10 and 11, an average of 18 ridges per mile was observed. These values indicate an annual retreat of about 310 feet. This estimate compares favourably with Gwynne (1942, p. 206), who determined the rate of retreat in Iowa to be about 330 feet per year by the same method.

The retreat value is also of the same order as the value given by Antevs (1925, p. 2), who determined an average annual retreat of 454 feet in the Timiskaming basin area of Ontario based on a study of varved clays. Flint (1955, p. 254), using radiocarbon dates, found that the ice retreated over land at a rate of 345 feet per year from the Lake Michigan basin, and at a rate of 310 feet per year from the Erie-Ontario basins. The close agreement which thus exists between the retreat values as determined by the spacing of minor recessional ridges with values found by other methods such as radiocarbon dating and varve counts makes it very likely that the recessional ridges are indeed annual in origin.

The arcuate pattern of the minor recessional ridges is in most places concave toward the direction of ice retreat. Re-entrants in the pattern of minor recessional ridges with "V's" pointing toward the direction of ice retreat are common, as in the area west of Forget and in section 36, township 10, range 9. The re-entrants are formed in that place by a more rapid retreat of the ice margin owing to a concentration of meltwater between adjacent lobes (Gwynne, 1942, p. 207). The concavity of the ridges is in the reverse direction on the divide north of Moose Mountain. The mountain apparently obstructed the ice flow and forced the glacier to flow around it. On retreat of the ice, minor recessional ridges were formed whose trend conformed with the topography.

The importance of these minor recessional ridges for the interpretation of the glacial history cannot be too strongly stressed. Because of their wide regional extent and their ease of interpretation they are one of the most important criteria for determining the direction of ice retreat.

### Crevasse Fillings

Crevasse fillings have been described by several workers (Flint, 1928, p. 415; Sproule, 1939, p. 104; Colton, 1955; Kupsch, 1955, p. 329). Flint (1928, p. 415) proposed the term "crevasse filling" to describe ridges he believed were deposited by meltwater in fissures in stagnant ice at or near its margin.

Sproule (1939, p. 104) noted similar features in the Cree Lake area which he called "ice-crack moraine." He also noted that in most cases the till ridges are parallel to one another, although in a few places separate sets converge at acute angles. The ridges in the Cree Lake area were formed parallel to the ice front.

Although Colton (1955) did not use the term crevasse filling, he attributed the narrow, intersecting, till ridges on the ground moraine near Wolf Point, Montana, to infilling of fractures in stagnant ice. Colton suggested that the fracture pattern roughly indicates the direction of ice movement: the long ridges are parallel to the ice front or normal to the direction of ice movement. These ridges were probably formed by debris which fell into the fractures, and when the supporting ice melted, the material was left as till ridges. Colton (1955, personal communication) also suggested that crevasse fillings may be formed by the squeezing up of material into ice fissures from beneath the ice.

Low, intersecting, till ridges were also observed by Kupsch (1955, p. 329) in the Dollard area of Saskatchewan. Here the longer, better formed ridges are parallel to the direction of ice movement. Kupsch (1955, personal communication) emphasized that the outstanding characteristic of the field pattern of crevasse fillings is the presence of ridges that do not all trend in the same direction. In most cases one set is much better developed than the other which intersects it at acute angles.

The crevasse fillings in the Moose Mountain area are in a belt on the ground moraine near Browning (township 5, range 5), and near Francis (township 13, range 15). In the Browning area the set of ridges, although discontinuous, extends southeasterly about five miles. In most places a poorly-developed second set intersects the primary set at acute angles. The crevasse fillings range in height from ten to 30 feet, averaging about 20 feet. The base is commonly about 200 feet wide. Lack of adequate exposures makes a study of the deeper internal composition impossible, but the surface material indicates that most of the ridges consist of till.

The writer is in agreement with the theory that these ridges are crevasse fillings formed either by material that has fallen into the ice fractures or has been squeezed up from beneath. Crevasse fillings, however, should be used with caution as a criterion for determining the direction of ice movement because, in some fields, these ridges predominate in the direction of ice movement (Kupsch, 1955, p. 329); in others, they are normal to it (Colton, 1955).

### Fluting

A striking glacial feature, plainly visible in air photographs (Figure 6), which consists of a field of narrow, straight, parallel ridges and grooves, has been described by several workers (Hage, 1945, p. 25; Smith, 1948, pp. 503-514; Chapman and Putnam, 1951, pp. 15, 199, 212; Bird, 1953, pp. 218-220; Lemke, 1954, p. 1,380; Colton and Lemke, 1955, p. 1,673). All these writers seem to agree that the parallel, U-shaped grooves are erosional features and that the ridges and grooves are oriented in the direction of ice movement.

Various terms such as "drumlinoids," "drumlinized ridges," and "glacial grooves" have been used to describe this land form. Chapman and Putnam (1951, p. 15) used the term "fluting" to describe all these glacial grooves whether they are in bedrock or in till. The term "fluting" is preferred by Craig (1955, personal communication) because it is a collective term that indicates that these glacial features occur in fields and not as single isolated ridges or grooves.

Fluting was observed in two localities in the Moose Mountain area: southwest of Macoun (township 3, range 10) and west of the village of Corning (township 11 and 12, range 9). The fluting consists of a sequence of straight, parallel ridges and grooves. The ridges are low features ranging in height from two to five feet above the base of the adjacent grooves. The ridges average about 200 feet in width, and reach a maximum length of approximately one mile. The composition of the surface material indicates that the ridges are composed essentially of till topped with a thin veneer of lag concentrate.

Fluting is difficult to discern from the ground. It is therefore necessary to rely largely on air photographs for recognition. The two most outstanding morphological features of fluting are the straightness of the ridges and grooves and the extreme parallelism.

Fluting was examined by the writer in three localities in Saskatchewan: along the Qu'Appelle Valley near Fort Qu'Appelle, along the Souris Valley near Macoun, and along the North Saskatchewan River at North Battleford. In all three areas the fluting is in spillways which suggests that superglacial till has been removed by meltwater in the early development of the spillway and has exposed lodgement till in which the fluting is developed. Erosion of this lodgement till will then emphasize the existing fabric of fluting in it.

**FIGURE 6. — FLUTING.**
**Parallel arrangement of linear ridges and grooves in Sec. 31, T. 3, R. 10, W2nd Mer. Air photo. A11939-163, courtesy R.C.A.F.**

## Kames

Holmes (1947, p. 248) proposed the following definition for the term kame: "A kame is a mound composed chiefly of gravel or sand, whose form has resulted from original deposition modified by any slumping incident to later melting of glacial ice against or upon which the deposit accumulated."

This broad definition of the term kame is useful for describing any sandy or gravelly mound of glacial origin. A small amount of till may be included in the sand or gravel as lenses, or it may form a thin surface layer on the kame, especially on its flanks. Detailed genetic relationships are not implied by the term because it has been demonstrated that a variety of processes may form kames. Any speculation about a more exact origin, however, can be given only after careful study of the sorting, rounding, and other pertinent characteristics of the stratified drift composing the kame.

Holmes (1947) reviews several proposed origins for kames. These include: (*a*) deposition in shafts without outlets which develop on some stagnant ice surfaces; (*b*) deposition by meltwater descending into moulins; (*c*) alluvial cones formed by meltwater dropping material over the edge of the ice.

In the Moose Mountain region most kames are not exposed well enough to permit the study of their internal structure. Their position, also, in regard to the ice front, may be insufficiently known. For these kames the exact origin cannot be stated.

An added difficulty in mapping kames is the total lack of exposures in some conical mounds mapped as kames in air photographs on the basis of form only. As the necessary subsequent field check to determine the material in these mounds cannot be made, it is entirely possible that some land forms mapped as kames are actually conical mounds of till.

Although kames are scattered throughout the Moose Mountain region, they are most conspicuous in the Weyburn, Kisbey, and Lost Horse Hills areas. The kames in the Weyburn area form a long chain of hills that follows the trend of the Souris River. These hills range in height from 50 to 80 feet above the surrounding plain. Some of these kames are composed entirely of sand and gravel which are exposed at the surface. In others, the surface material appears to be ablation till commonly containing some large boulders.

The mounds (mapped as kames on form) in the vicinity of Forget (township 8, range 7) are striking features, which rise to a height of 50 feet above the level sand plain. Lack of suitable exposures made it impossible to determine their internal composition. These mounds may have been formed on stagnant ice, a condition suggested by the esker development near Forget, and may be composed of till in the form of till knobs. The sand plain that surrounds the mounds appears to be younger and not related to them.

The large kame and the kame-esker complex, in the Lost Horse Hills area west of Handsworth (township 10, range 8), is the most striking deposit of ice contact stratified drift in the Moose Mountain area. A kame, two square miles in area known as the "Lost Horse Hills" (township 11, range 8), rises approximately 170 feet above the outwash plain along Moose Mountain Creek. Lack of adequate exposures precludes a study of the internal composition, but some shallow gravel pits indicate that at least the surface material consists of sand and gravel.

#### Eskers

Eskers have been described by many geologists. It suffices to state that eskers are long, narrow, sinuous ridges (Figure 7), discontinuous in places, composed of poorly-sorted, stratified sands and gravels. The building of eskers is attributed by most geologists to deposition by meltwater streams flowing through tunnels or open channels near the ice margin.

Although eskers occur in a large number of localities in the Moose Mountain region, the largest number are south of Forget (township 8, range 7). The eskers in the Forget area are discontinuous ridges of poorly-sorted sands and gravel, have a maximum length of about two miles, and range in height from six to 15 feet. In width, the eskers range from 150 to 250 feet, averaging approximately 200 feet. Most of them are covered with a thin layer of ablation till. The overall trend of the eskers, in most places, is parallel to the direction of ice movement.

Long, relatively straight ridges of ice contact, stratified sands and gravel were observed on the east slope of the Moose Mountain. Although these ridges resemble eskers in form and composition, the trend of the ridges is approximately parallel to the recessional moraines, rather than being normal to them. Hence, they may be minor end moraines composed of ice contact, stratified drift. One ridge, however, trends diagonally across the minor recessional ridges. This ridge, therefore, is probably an esker.

## PROGLACIAL LAND FORMS

#### Outwash Plains

The outwash plains in the Moose Mountain region, except the one in the vicinity of Tyvan (township 12, range 13) and Osage (township 11, range 12), are restricted to areas within major meltwater channels. Outwash

**FIGURE 7. — ESKERS AND MINOR RECESSIONAL RIDGES**
**Eskers and minor recessional ridges in Sec. 22 and 23, T. 7, R. 7, W2nd Mer. Note the perpendicular relationship between the eskers in Sec. 23 and the minor recessional ridges in Sec. 22. Air photo. A11991-42, courtesy R.C.A.F.**

plains are characterized by flat to gently undulating topography and are composed of stratified sand and gravel.

The outwash plain in the vicinity of Wordsworth (township 7, range 3) covers an area of about 80 square miles, and is the most extensive in the Moose Mountain area. A thin veneer of sand, absent in places, overlies the till. The water forming this outwash plain was later restricted, and two channels with numerous tributaries were cut in the underlying till.

The outwash plain in the vicinity of Tyvan and Osage covers approximately 25 square miles. It has the form of a broad, alluvial fan at the mouth of Manybone Creek. Although there is some gravel on this flat to undulating plain, the deposit is largely sand and silt.

The outwash plain in the vicinity of Handsworth (township 10, range 8) is also very extensive, but it is restricted to a broad valley between the Stoughton Moraine to the west and the Moose Mountain to the east. This type of outwash plain is referred to as a "valley train" (Flint, 1947, p. 135). The fact that this outwash plain slopes to the southeast, and the fact that the sediment grades from gravel in the northwest to sand farther down stream indicate that the sediments were deposited largely by meltwater streams coming off the ice to the northwest.

### Glacial Lake Basins

Glacial lake basins in the Moose Mountain area are flat to gently undulating. They consist of stratified sand, silt, and clay which have been deposited in lakes along the ice margin or in ponds on dead ice.

Lake Regina and Lake Arcola are the two major glacial lake basins in the Moose Mountain area. The greater part of the Lake Regina Basin lies outside the Moose Mountain region, but about 200 square miles lie within it along its western boundary. The lake basin is characterized by a smooth, level topography, and is composed essentially of lacustrine clay which is silty near shore. It is difficult to determine the shoreline of Lake Regina, because well-formed beaches or other shoreline features are rare. If the approximate shoreline, as represented by the contact between lake clay and till, is traced northward from Weyburn (township 8, range 14) to Francis (township 13, range 14), it is evident from the topographic map that this boundary rises in elevation approximately two feet per mile. Johnston and Wickenden (1930, p. 47) observed this relation over a much larger area. They concluded that the Regina Lake Basin has been uplifted after it was formed. The northern part was uplifted more than the southern part, resulting in a gradient of about one foot per mile.

The Lake Arcola Basin lies south of Moose Mountain and follows Moose Mountain Creek in trend. It surrounds numerous kames as well as the Kisbey Moraine. Because no shoreline features have been observed, it is difficult to determine the extent of the lake basin, or to what height Lake Arcola encroached on the Kisbey Moraine. Furthermore, the former shoreline on the south slope of Moose Mountain is now obliterated by large alluvial deposits that fan out from the mouths of mountain creeks onto the lake basin.

Lake Arcola sediments range in composition from stratified sands in the northwest to stratified silts and clays (varved in places) in the eastern part of the lake basin. The fact that the smooth, sandy portion of the Lake Arcola Basin northeast of Stoughton (township 8, range 8) slopes three feet per mile to the southeast and the fact that it is level in the east-west direction indicate that the sediments were largely derived from the northwest and, to a less extent, as outwash from the Stoughton Moraine to the west. A few small lakes, believed to be in kettles, occur on the sandy lake plain north of Forget. In the Kisbey area, the sand has been reworked in places by wind into low dunes. The lake sediments in the eastern part of the Lake Arcola Basin are composed essentially of silt and clay. In a small stream cut on the south side of highway No. 13, two miles west of Carlyle (township 8, range 2), four feet of silt and clay overlie till. Varved clays were observed in a road cut on the north side of highway No. 13 about four and a half miles east of Arcola (township 8, range 4). Stratified lacustrine silts and clays are also well exposed on the south side of the same highway, two and a half miles west of Arcola.

### Spillways

Large, deeply entrenched valleys which were formed as drainage outlets of glacial lakes are generally termed spillways. There are two conspicuous spillways in the Moose Mountain area: one occupied by the Souris River (Figure 8) and the other by the lower part of Moose Mountain Creek between Arcola and the Souris River near the town of Oxbow.

The Souris River spillway includes the deeply eroded Souris River valley and the eroded till plains that flank the valley on both sides. These eroded till plains range in width from two miles in the vicinity of Bienfait (township 2, range 6) to eight miles near Midale (township 5, range 11). The till plains are characterized by numerous boulders and some finer gravel which was left as residual material forming a lag concentrate. Locally, this eroded till is covered by a thin veneer of sand and gravel deposited by the stream. The Souris River valley floor, however, is covered by alluvial silt and clay.

The Moose Mountain Creek spillway differs from the Souris in that no eroded till plains flank the Moose Mountain Creek valley and that no fine-textured alluvial deposits occupy the valley floor. It ranges in depth from 30 feet near the town of Arcola to 175 feet in the vicinity of Oxbow. Because Moose Mountain Creek has not reached grade, its water rushes over an excessively stony bottom before joining the slowly flowing Souris River near Oxbow.

**FIGURE 8. — SOURIS SPILLWAY**
**Broad level flood plain on valley floor occupied by underfit Souris River. Note large residual boulders on upper terrace (foreground). Sec. 36, T. 3, R. 11, W2nd Mer.**

### Meltwater Channels

The term meltwater channel is here used to describe any channel that carried meltwater from a glacier either under the ice, or parallel to, or away from the ice margin.

Broad, shallow meltwater channels, which are now commonly occupied by intermittent streams, are incised in the ground moraine. Although a few meltwater channels (Pipestone Creek, Upper Moose Mountain Creek, and Manybone Creek) attain a depth of 150 feet and a width of 3,000 feet, most channels are about 1,000 feet wide and range in depth from five to ten feet. A large number of meltwater channel bottoms are cut by post-glacial gullies and the old glacial stream bottoms appear as poorly developed paired terraces along the channel walls. This type of rejuvenation or longitudinal gullying is common where meltwater channels empty into spillways or larger meltwater channels. Erosion by transverse gullying of the walls of the meltwater channels is also a common feature in places.

Outwash material in meltwater channels is restricted to areas where conditions of deposition were favourable. Slip-off slopes on meanders are commonly covered with a thin deposit of sand and gravel.

Most of the meltwater channels in the Moose Mountain area are parallel to the minor recessional ridges, and like these ridges, the channels outline successive positions of retreat of the ice front (Lemke and Colton, 1955, personal communication). The term ice marginal channel is used to describe meltwater channels that were incised along the margin of the ice.

Manybone Creek, which is in the northeast part of the region, is a very good example of an ice marginal channel. This channel parallels the topographic contours and thus its position can be explained only by assuming that ice prevented drainage down slope in a southwestern direction. It is likely that ice marginal channels develop best when ice lobes are retreating down slope. Meltwaters thus flow along the ice margin and trace the lobate pattern of the ice lobe in the ground moraine. These ice marginal channels help, especially in areas where minor recessional ridges are lacking, to determine successive positions of the retreating ice.

Meltwater channels which are not parallel to the minor recessional ridges and which, consequently, are not parallel to the retreating ice front, are also present in the Moose Mountain region. These channels are similar to the ice marginal channels in size and form, but lack the characteristic lobate pattern exhibited by the ice marginal channels. These consequent meltwater channels drained the ice margin, and in some places received meltwater from the ice marginal channels which acted as tributaries to them.

## DRAINAGE HISTORY

### Fieldwork

The Moose Mountain Creek and the Souris River below Oxbow were traversed by the writer at intervals ranging from four to 11 miles. Elevations were recorded with a Wallace altimeter. The average elevation of the terraces, in relation to the elevation of the streams and that of the valley tops, was determined and later plotted as longitudinal profiles (Figure 9).

### Moose Mountain Creek

#### *Upper Moose Mountain Creek*

Moose Mountain Creek may be divided into three parts: Upper Moose Mountain Creek, Lake Arcola, and Lower Moose Mountain Creek. Upper Moose Mountain Creek lies upstream from Lake Arcola. It is interpreted as being a meltwater channel which had its origin in a large re-entrant of the ice front in the Lost Horse Hills west of Handsworth. Meltwater which flowed on the ice between adjacent lobes, poured over the ice front at the re-entrant to form a large alluvial cone now referred to as the Lost Horse Hills. From there the meltwater flowed through the Upper Moose Mountain Creek drainage channel into Lake Arcola. The upper part of Upper Moose Mountain Creek north of township 11 originated later as an ice marginal channel to the Weyburn Lobe. That segment of the valley does not have fluvial deposits, because the stream deposited its load either as outwash in the vicinity of the Lost Horse Hills or into Lake Arcola.

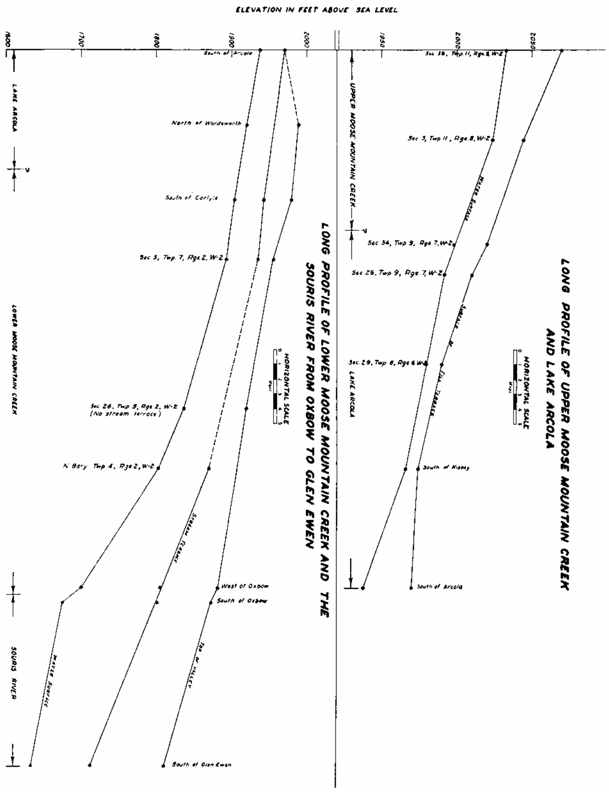


FIGURE 9. — LONG PROFILES*

The sands and gravels along the lower portion of the Upper Moose Mountain Creek may have been derived from three different sources: outwash deposits near the glacier; reworked ice contact stratified drift; and later outwash from Upper Moose Mountain Creek north of township 11. Upper Moose Mountain Creek has subsequently cut into this valley fill and has left the ancient stream bottom as paired terraces along its course.

*Lake Arcola*

Glacial Lake Arcola received its closure from the Weyburn Lobe to the southwest, the Moose Mountain Lobe to the east, and the already deglaciated

*It is realized that the profile of Lower Moose Mountain Creek is anomalous as it is convex upward, but no explanation is presented here.

Moose Mountain to the north (Figure 10). The longitudinal profile of the Lake Arcola Basin in its final development is illustrated in Figure 9. Although Moose Mountain Creek has reached grade on the sandy lake plain in the vicinity of Kisbey and Forget, it is not at grade east of Arcola where it cuts sharply into the lake sediments exposing the underlying till. A further comment on this point is given later in the section on Lake Regina.

### *Lower Moose Mountain Creek*

Lower Moose Mountain Creek connects Lake Arcola and the Souris River in the vicinity of Oxbow. It was the main outlet for glacial Lake Arcola. One set of terraces, which in most places are paired, flank the valley walls. They appear to be covered locally by a thin cover of gravel, which may represent a lag concentrate inasmuch as the boulders and pebbles do not appear to be water-worn. The terrace level along Lower Moose Mountain Creek appears to be the same as the best developed terrace along the Souris River south of Oxbow (township 3, range 2) and Glen Ewen (township 3, range 1) (Figure 9), which suggests that the valley of Lower Moose Mountain Creek at the time of formation of the terrace followed the Souris River valley below Oxbow, as it does today. As there is no comparable terrace in the Souris River valley upstream from its junction with Moose Mountain Creek, it is indicated that the upper part of the Souris River did not join Moose Mountain Creek near Oxbow at the time Moose Mountain Creek flowed on its terrace.

### Riviere des Lacs and Souris River

The deep valley of the Riviere des Lacs ends abruptly about three miles north of the International Boundary, but a broad, rather flat depression continues to the northeast where it connects with a broad terrace in the Souris River valley. The elevation of this flat depression and the Souris River terrace is at approximately 1,850 feet, or about 100 feet above the present flood plain of the Souris River. It is called, therefore, the 1,850 foot terrace. The continuity of this terrace along the course of the Riviere des Lacs indicates that the Souris River in its early phase of development flowed southeast through the Riviere des Lacs (Lemke and Kaye, 1953). The lowland to the northeast of the junction between the Souris River and the Riviere des Lacs was at this time blocked by ice. When this ice melted away, the Souris River took its present course.

The Souris River at the time of the 1,850 foot terrace was probably a meltwater channel from the ice margin, and not a spillway of an early phase of Lake Regina, as Lemke (1953) assumed. The history of deglaciation of the Moose Mountain area shows that Lake Regina did not yet exist at the time of the 1,850 foot terrace.

The extremely low grade of about one foot per mile of the Souris River in its early development, as indicated by the 1,850 foot terrace, probably accounts for the broad valley of the Souris River in its upper course as well as the broad valley of the ancient Riviere des Lacs.

When the ice retreated farther, it exposed the lowland southwest of Oxbow. The Souris River then abandoned the Riviere des Lacs for a lower course to the north where it joined Moose Mountain Creek near Oxbow. The Souris River thus established its present course.

### Lake Regina

The Souris River in its final phase of development became a spillway that drained Lake Regina before the Qu'Appelle River spillway came into existence (Johnston and Wickenden, 1930, p. 46). The Souris River draining Lake Regina flowed down the same course that had been established in the previous phase of its development. The river, however, was restricted, and formed the deeply entrenched Souris Valley, leaving the upper, broad, former stream bottom as the 1,850 foot terrace along the valley.

In partly draining Lake Regina the Souris River entrenched itself to a much greater degree than the Moose Mountain Creek, which by that time, had little or no meltwater flowing down it. Moose Mountain Creek was left hanging with a high gradient at its mouth (Figure 9). As a result, Moose Mountain Creek began to cut into its former stream bottom leaving it as paired terraces along the valley walls. This happened during and since the time of the formation of Lake Regina.

With the exception of terrace remnants south of Oxbow and Glen Ewen, which represent the terrace of the ancient Moose Mountain Creek bottom (Figure 9), all other remnants of this terrace in the Souris River valley between Oxbow and the International Boundary have been destroyed by the Souris River during the time of the formation of Lake Regina and afterwards.

## GLACIAL HISTORY

### General Remarks

Five significant phases of ice retreat dominate the glacial history of the Moose Mountain area. Each of these phases is shown in a map (Figures 10-14) on which the ice front at that particular time is drawn. The ice fronts were reconstructed in such a manner as to explain the origin of the prominent glacial land forms. The trends of the meltwater channels and of the minor recessional ridges are the two most important criteria used for determining the position of the ice front. No attempt has been made to estimate the time occupied by these various phases.

Although other interpretations have been suggested (Lemke, 1956, personal communication), the author believes that the interpretation here presented is most consistent with the limited evidence available at this time.

### Phase No. 1

The Missouri Coteau and the Moose Mountain itself were the first parts of the Moose Mountain area to be deglaciated (Figure 10). The presence of lake deposits high on the south facing slope of Moose Mountain can be explained only by the presence of ice to the south and east which provided the necessary closure for impounding a glacial lake.

Townsend and Jenke (1951, p. 885) and Lemke (1955, personal communication) reported that the Fort Union formation is exposed high on the Max Moraine in North Dakota. The Max Moraine is the continuation of the moraine along the eastern part of the Missouri Coteau in Saskatchewan which is, therefore, also regarded as a glacial deposit on a preglacial topographic high.

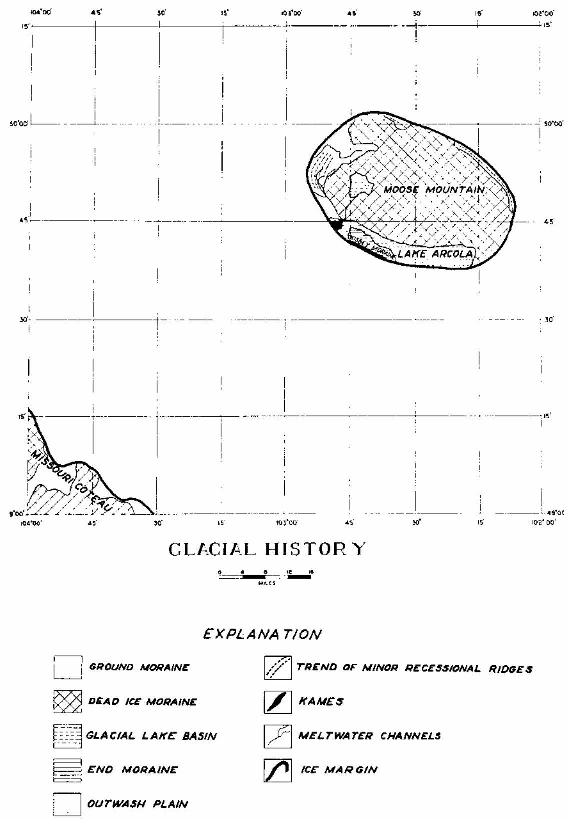


**FIGURE 10. — PHASE No. 1 OF GLACIAL HISTORY**

Seismic velocities, as shown by limited well surveys, do not conform as would be expected were Moose Mountain composed entirely of glacial drift (Perryman, 1956, personal communication). MacKay *et al.* (1936b, p. 10) reported that a Ravenscrag coal seam was penetrated in a well on Moose Mountain (northeast quarter, sec. 18, township 10, range 4, west of the second meridian) at a depth of 300 to 400 feet, or at an elevation of 2,100

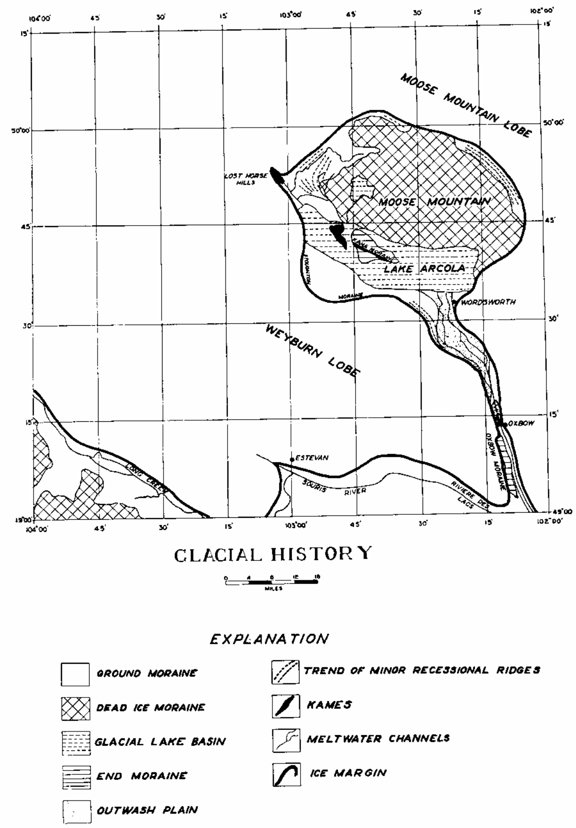


**FIGURE 11. — PHASE No. 2 OF GLACIAL HISTORY**

to 2,200 feet, which is still about 350 feet higher than the bedrock encountered at the foot of the mountain in township 7, range 3, west of the second meridian (MacKay *et al.*, 1936a, p. 10).

The above evidence suggests that Moose Mountain and Missouri Coteau are preglacial topographic highs and consequently it is reasonable to assume that the ice melted from these areas first.

## Phase No. 2

Phase No. 2 (Figure 11) commenced when the ice to the south of Moose Mountain split, forming the Weyburn Lobe to the west and the Moose Mountain Lobe to the east.

Lake Arcola was bounded on the east by the Moose Mountain Lobe. The southern shore of the lake, however, was bordered by a land surface that was high enough to dam the waters.

Two shallow channels on a sand plain near Wordsworth indicate that Lake Arcola overflowed to the south. This overflowing water also accounts for the outwash deposits on a terrace above the east bank of Moose Mountain Creek immediately west of Oxbow. These deposits are too high to have been formed by a stream following the present course of Moose Mountain Creek. Furthermore, the margin of the Weyburn Lobe must have stood immediately west of this terrace (down-slope side) to account for its "side hill" position. The drainage continued south from Oxbow, occupying a fairly well-incised channel east of the Oxbow Moraine, and finally emptied into the Riviere des Lacs.

During Phase No. 2 the ice margin receded steadily away from Moose Mountain and formed a major re-entrant around the Lost Horse Hills. Part of the Stoughton Moraine was built at this time.

The Souris River came into existence as a broad meltwater channel along the southern margin of the Weyburn Lobe. This channel probably had its headwaters in the re-entrant near Estevan. Because the Weyburn Lobe stood at the Oxbow Moraine, blocking the lowland southwest of Oxbow, the Souris River used the Riviere des Lacs drainage way.

The "side hill" position and the lobate pattern of Long Creek indicates that it originated as a channel marginal to the Weyburn Lobe.

## Phase No. 3

During the third phase (Figure 12), Lake Arcola was drained by Lower Moose Mountain Creek rather than by the higher channel in the vicinity of Wordsworth which was operative during Phase No. 2. The water now flowed from Lake Arcola down Lower Moose Mountain Creek to Oxbow. From there it continued on to the east and south cutting a channel which preceded the later course of the Souris River in this area. The ice front of the Weyburn Lobe still stood at the Oxbow Moraine, and consequently the Souris River was compelled to use the Riviere des Lacs channel. The Weyburn and Moose Mountain Lobes separated from one another northwest of Moose Mountain; the northeast margin of the Weyburn Lobe was along the Stoughton Moraine. Trends of minor recessional ridges suggest that a large re-entrant existed along the southern margin of the Weyburn Lobe in the vicinity of Elswick.

Owing to the relatively steep slope of the land surface toward the ice front north and east of Moose Mountain, the rate of retreat of the ice margin was low in this vicinity.

After Lake Arcola was drained, Moose Mountain Creek began to cut into the Lake Arcola sediments.

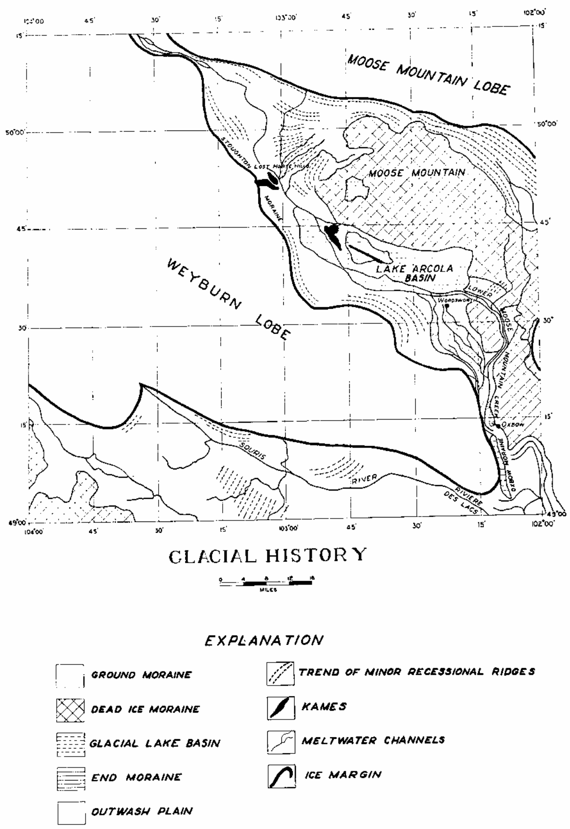


**FIGURE 12. — PHASE No. 3 OF GLACIAL HISTORY**

### PHASE NO. 4

The fourth phase (Figure 13) represents the final development of the Stoughton Moraine. The southeastern part of the Weyburn Lobe withdrew from a position near Alameda (township 4, range 3) to a position near Benson (township 6, range 8). Rimmed kettles suggest that the main type of deposition of the Weyburn Lobe in the Alameda-Benson area was related to

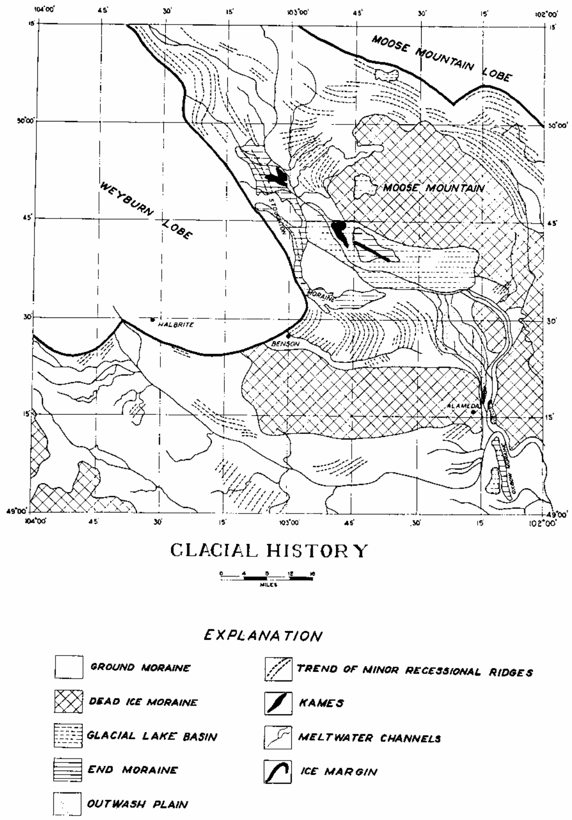


**FIGURE 13. — PHASE No. 4 OF GLACIAL HISTORY**

dead ice conditions. Minor recessional ridges southeast and southwest of Halbrite (township 6, range 12) indicate that a re-entrant existed there.

The Moose Mountain Lobe continued to retreat from Moose Mountain in a northeasterly direction. Minor recessional ridges in this area exhibit southward projecting salients where the ice front encountered valleys along the northeast face of Moose Mountain.

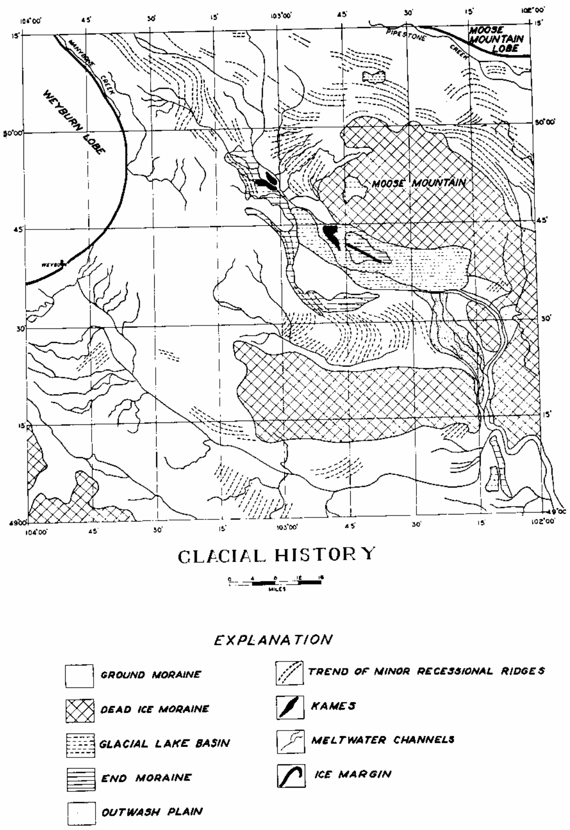


**FIGURE 14. — PHASE No. 5 OF GLACIAL HISTORY**

## Phase No. 5

During phase five, the northeastern margin of the Weyburn Lobe stood immediately southwest and parallel to the Manybone Creek (Figure 14), and thus accounts for the "side-hill" position of the stream. The lobate pattern of the meltwater channels near Weyburn shows several minor positions of northwest retreat of the ice margin in this vicinity.

The Moose Mountain Lobe continued to recede to the northeast and probably exposed Pipestone Creek at this time.

The relationship between the Weyburn and Moose Mountain Lobes during Phases No. 4 and No. 5 is only indefinitely known. More information regarding the glacial history to the north must be obtained before any definite relationship can be established.

## ECONOMIC GEOLOGY

### GRAVEL

#### *General Remarks*

Accumulations of glacial gravel fall into two classes (Flint, 1947, p. 133): deposits made beyond the glacier (proglacial deposits) and deposits built in immediate contact with wasting ice (ice-contact deposits).

Proglacial gravels form outwash plains and valley deposits. These gravels are fairly well sorted, but there are many vertical as well as lateral variations in grain size. This type of deposit is the most important source of gravel for highways and other construction work. Screening, and in some places crushing, are required.

Ice-contact deposits occur as eskers, kames, and kame moraines. The ice-contact sediments have three general characteristics that distinguish them from proglacial deposits: very poor sorting, the presence of slump features, and the inclusion in places of till lenses (Flint, 1947, p. 143). In a few places this type of deposit forms good sources of gravel. In most places, however, the poor sorting renders ice-contact deposits useless as a source of gravel for most construction jobs.

#### *Occurrence*

Deposits of gravel are rare in ground moraine. Small deposits of local economic importance, however, do exist in places where meltwater caused the necessary sorting.

Dead ice moraine of the knob and kettle variety generally contains several deposits of gravel in the form of kames. These kames, however, are similar in form to till knobs, and therefore cannot be distinguished solely by the use of air photographs. Gravel deposits are generally rare on dead ice moraine of low relief.

Gravel deposits are not numerous in the till end moraines in the Moose Mountain area. Local concentration of gravel in the form of kames has been observed, but there are few deposits of commercial importance. The Kisbey Kame Moraine, on the other hand, is an excellent source of sand, and although gravel has not been observed, it may also be present.

Outwash plains and outwash stream deposits are the most important sources of gravel in the Moose Mountain area. The stream deposits in the vicinity of the Lost Horse Hills are excellent sources of gravel.

Ice-contact deposits, such as eskers, kames, and kame moraines, are important gravel sources for local demand, but only in a few places are they of commercial importance. The kame forming the Lost Horse Hills appears to be a good prospect for gravel.

Meltwater channels and spillways, especially slip-off slopes on stream meanders, are favourable areas for gravel prospecting.

The most extensive deposits of gravel are confined to major re-entrants in the ice front. Because large amounts of meltwater, which are necessary for sorting of the glacial deposits, are restricted to re-entrants, it follows that these areas are very favourable for gravel prospecting.

## Ground Water

### *General Remarks*

Topography has a pronounced influence on ground water supply. In rolling country there is more seepage into the ground to form ground water than in level areas. The texture of the surface deposits also has a great influence on the ground water supply. In areas of gravel and sand the seepage is high and therefore ground water is in good supply. The opposite is true for less permeable sediments, such as till and clay.

### *Occurrence*

Morainic deposits contain local lenses of sand and gravel which commonly bear water where they lie below the water table. Sands, between till sheets, may also form aquifers if they lie below the water table.

Outwash plains, eskers, and kames generally contain a good supply of ground water where they lie below the water table. Glacial lake clays do not contain a water supply because of their condition of near impermeability.

Further information regarding ground water in the Moose Mountain area may be obtained from the Geological Survey of Canada water supply papers (Table 1).

Table 1. Water Supply Papers of the Moose Mountain Area

| *No. of Water Supply Paper* | *Rural Municipality Covered* |
|---|---|
| 1 | Enniskillen No. 3 |
| 3 | Coalfields No. 4 |
| 6 | Estevan No. 5 |
| 8 | Cambria No. 6 |
| 11 | Souris Valley No. 7 |
| 20 | Moose Creek No. 33 |
| 28 | Browning No. 34 |
| 44 | Benson No. 35 |
| 34 | Cymri No. 36 |
| 55 | Lomond No. 37 |
| 15 | Moose Mountain No. 63 |
| 30 | Brock No. 64 |
| 14 | Tecumseh No. 65 |
| 21 | Griffin No. 66 |
| 33 | Weyburn No. 67 |
| 36 | Wawken No. 93 |
| 46 | Hazelwood No. 94 |
| 64 | Golden West No. 95 |
| 51 | Fillmore No. 96 |
| 40 | Wellington No. 97 |
| 66 | Silverwood No. 123 |
| 58 | Kingsley No. 124 |
| 71 | Chester No. 125 |
| 76 | Montmartre No. 126 |
| 83 | Francis No. 127 |

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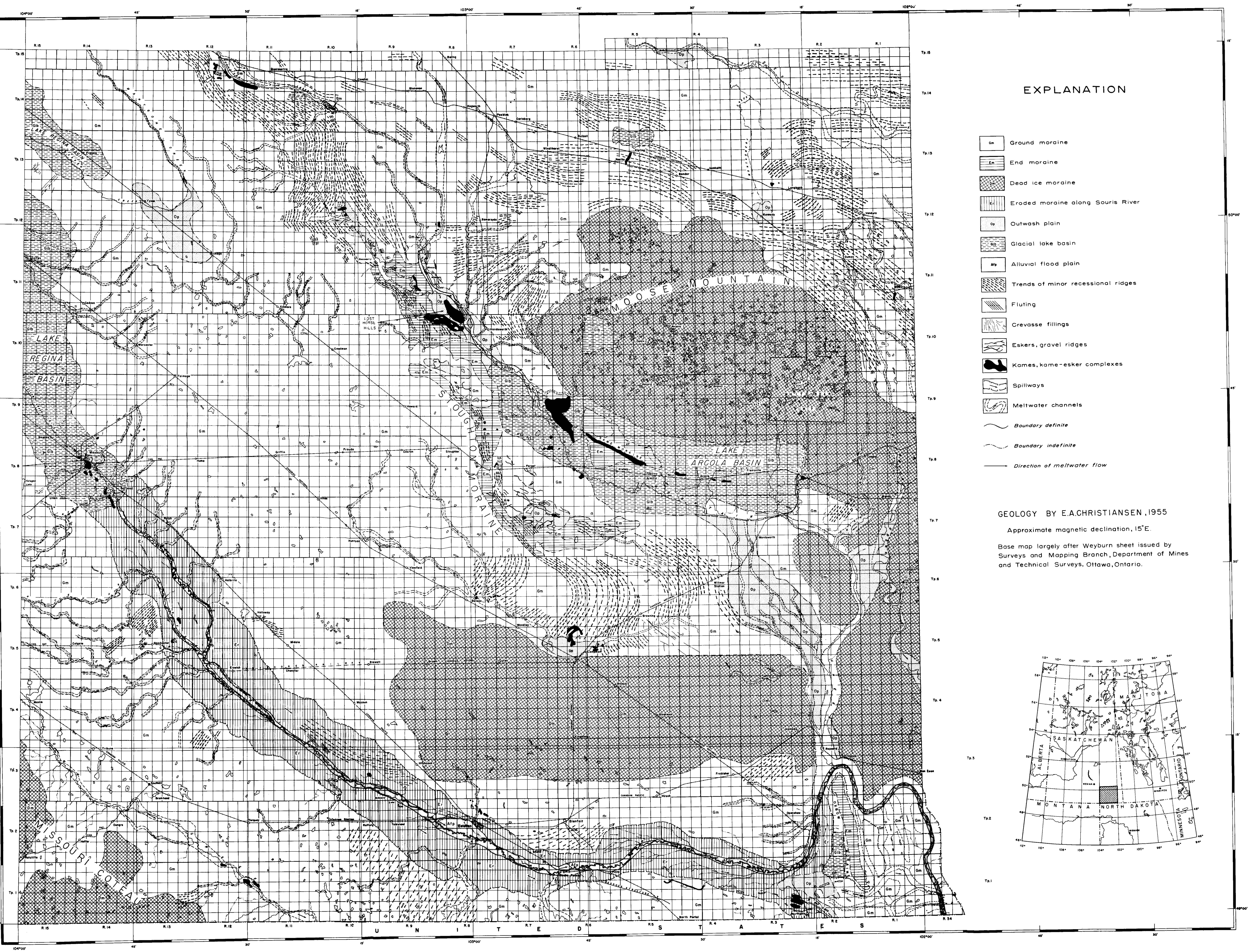


# GLACIAL GEOLOGY OF THE MOOSE MOUNTAIN AREA SASKATCHEWAN

SCALE