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NOMENCLATURE OF MORAINES AND ICE-FLOW FEATURES AS APPLIED TO THE GLACIAL MAP OF CANADA

(Report and 15 figures)

V. K. Prest

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CONTENTS

Illustrations

ABSTRACT

This report describes and characterizes the various types of glacial features to be shown on the new Glacial Map of Canada and illustrates some of them by means of stereoscopic photographs; a threefold classification of moraine is given in tabular form under features transverse to ice-flow, parallel to ice-flow and non-orientated.

NOMENCLATURE OF MORAINES AND ICE-FLOW FEATURES AS APPLIED TO THE GLACIAL MAP OF CANADA[1]

INTRODUCTION

While engaged in preparation of the forthcoming Glacial (Pleistocene) Map of Canada, the writer found the prevailing nomenclature of drift forms to be somewhat chaotic. Various investigators had used either different terms for similar drift forms, or the same terms for different features. Terms widely used in one part of the country were applied in other parts to somewhat similar features but which have an entirely different genesis. For instance a descriptive name, such as 'washboard moraine', was widely used both for drift ridges of diverse form and for similar forms of diverse origins, until the original meaning and usefulness of the term was lost. As a result it became necessary, in preparation of the glacial map and legend, to choose terms previously used only where the original meaning could be strictly adhered to, and otherwise to employ new descriptive terms. Most difficulty was encountered with terminology of moraines and lineated features.

The following account does not propose to give a standard terminology for glacial mapping, for this must vary according to the scale of the work and the area under study; nor is it intended to be a standard or comprehensive description of all the features enumerated. It is, rather, an attempt to characterize the types of glacial feature shown on the new Glacial Map of Canada, so that the country-wide analysis may be better appreciated.

The materials deposited as a result of glaciation are collectively known as glacial drift. The drift deposited directly from the ice, without the direct aid of meltwater, is referred to as till. In former years this material was often termed 'boulder clay' - a term that is now seldom employed. Till is the most characteristic surficial material, or parent soil-type, in Canada. It consists of a heterogeneous mixture of materials from clay-size to boulder-size. The proportions of the various sizes in the mixture vary greatly according to the character of the local bedrock or unconsolidated material over which the glacier has moved, and with distance of transport. Till may be found intimately associated with stratified and substratified materials indicative of limited meltwater action.

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[1] To be published by the Geological Survey as one of a group of maps of Canada at a scale of 1:5 million.

Manuscript received: 10 October, 1967.

CLASSIFICATION OF MORAINE

Moraine

(Till and other drift – generally displaying a constructional topography – deposited directly from, or in association with, glacier ice.)

Transverse to Ice-flow (Controlled deposition)	Parallel to Ice-flow (Controlled deposition)	Non-oriented (Uncontrolled deposition)
Ground moraine – corrugated.	Ground moraine – fluted and drumlinized; includes drumlin, drumlinoid ridge, crag-and-tail hill.	Ground moraine – hummocky (low relief), includes some ablation moraine.
End moraine; includes terminal, recessional and push moraine.	Marginal and Medial moraine.	Disintegration moraine – hummocky and/or pitted (mainly high relief); includes dead-ice, stagnation, collapse, and ablation moraine.
Ice-thrust moraine.	Interlobate and Kame moraine.	Interlobate and Kame moraine.
Ribbed moraine.	Linear ice-block ridge (includes ice-pressed and ice-slump ridge, and crevasse-filling).	Irregular ice-block ridge and rim ridge (includes ice-pressed and ice-slump ridge, and ablation slide moraine).
De Geer moraine; includes cross-valley moraine.		
Interlobate and Kame moraine.		
Linear ice-block ridge (includes ice-pressed and ice-slump ridge, and crevasse-filling).		

Glaciated areas are generally characterized by a constructional drift mantle. Where it is thin and dominantly till it may be referred to as a till sheet. However, where the drift is thick enough to display an uneven surface, commonly with closed depressions, it should more strictly speaking be termed moraine. Moraine may be deposited from active ice or from dead-ice and it displays a variety of forms that permit variation in classification. The most widespread morainal deposit is termed ground moraine; where it occurs over broad areas and displays very low relief it may be referred to as a till plain. For purposes of this account and the forthcoming Glacial Map of Canada, moraine is subdivided according to the presence or absence of longitudinal and transverse lineaments. It should be understood, however, that there are gradations or transitions from any one type of moraine to another type. It is these very transitions, in fact, that have led to the use of different terms for similar features.

MORAINE FORMED TRANSVERSE TO ICE-FLOW DIRECTION

(Moraine with Transverse Lineaments)

Some moraine occurs as a ridge or series of ridges that lie at right angles, or less commonly at oblique angles, to the direction of ice-movement that formed them. Such moraine may display lineaments, including both ridges and depressions, that may be widely or closely spaced. The depressions may be simple troughs between ridges, or may display a beaded pattern due to side and bottom irregularities; the pattern is commonly accentuated by ponding of water. The ridges are extremely varied. Some serve to delineate the end of a glacier lobe, others a narrow marginal zone near such a terminus, whereas still others formed well back from the ice-front and may be associated with moraine displaying longitudinal lineaments. The specific character of the ridges and depressions and their inferred position relative to the ice-front, provide a means of classifying these moraines.

Ground moraine – corrugated

(Corrugated ground moraine, corrugation ridges)

In the Interior Plains, low-relief ground moraine commonly displays short to elongate, irregular-branching transverse ridges that on the ground and on air photos impart a corrugated or washboard-like form and pattern to broad areas (Fig. 1). The composite pattern of the ridges, generally accentuated by the presence of innumerable ponds and sloughs, forms a broad arcuate system that serves to outline the position of former glacier lobes. The term corrugated ground moraine is proposed for these areas of repetitive transverse ridges; the individual ridges may be termed corrugation ridges. The term washboard moraine has been employed for such areas on the Interior Plains, but as this term has been used for other features, and was also earlier applied to morainal ridges of a different type and origin in the Chibougamau region of Quebec, it should not be so employed.

Corrugation ridges in Alberta range from 1 to 10 feet in height and from a few hundred feet to about a mile in length (Gravenor, Green, and Godfrey, 1960). Ridges up to 30 feet high and one and a half miles in length are reported from Manitoba (Halstead, 1959). Corrugation ridges have an irregular, wavy, outline and occupy about half the spacing between ridge 'crests' or centre-lines; the spacing varies from about 250 feet to 900 feet.

The ridges are typically composed of till, but sorted materials or bedrock slabs may be included locally. The ridges probably owe their emplacement to subglacial pushing, thrusting, or squeezing in association with a fracture system or zone of weakness, in an ice-marginal zone, and were preserved because of subsequent stagnation of the local ice. In places the transverse ridges merge with longitudinal ridges as if both were formed by a common process of either moulding during ice-flow, or squeezing into fractures as the ice stagnated (Fig. 2). Where the longitudinal elements are numerous a reticulate pattern of ridges, ponds and sloughs results.

End moraine

End moraine is a comprehensive and useful term used to designate a transverse morainal ridge, or group of ridges, that delimits a former ice-frontal position (Fig. 3). It includes the recessional and push moraines of some authors. It is typically a markedly elongate and relatively narrow form with a highly irregular surface. The term applies to some of the most continuous moraines shown on the new Glacial Map of Canada, and to some small, albeit fairly continuous, poorly developed ridges. Some of the end moraines rise 500 or more feet above the surrounding terrain whereas others are as low as 10 feet. Some large end moraines include various glaciofluvial features such as eskers, kames, and outwash. The term terminal moraine should be applied only to that end moraine marking the maximum or near maximum position of the ice-front reached by a glacier advance. The term recessional moraine as used by some authors is a variety of end moraine; it appears to imply construction of a transverse ridge during a halt in glacier retreat. The term push moraine perhaps should be restricted to those cases where there is conclusive evidence of pushing, ploughing or overriding action in the unconsolidated materials forming the end moraine. End moraine is here regarded as the most appropriate general term.

End moraines are not as evident on air photos as might be expected. Local features on large end moraines are in places common to adjoining areas. Small end moraines in places resemble other features of either morainal or non-morainal origin.

Ice-thrust moraine

Mackay (1959) drew attention to the large-scale ice-thrust features of the Yukon coast. Slices of stratified sediments, that must have been frozen when emplaced, are known to be a mile or more in length and up to 200 feet thick, and to occur in belts over ten miles long and a mile or more wide. Mackay considers these due to the overriding action of glacier ice in an area of permafrost. The overriding glacier is believed to have provided "...the confining pressure to shear off thick slices of frozen sediments along the basal portion of the frozen ground".

The term ice-thrust ridges was employed by Kupsch (1962) for features on the Interior Plains that appeared to "represent deformed bedrock, with only occasional basal till but in places covered by ablation till...". The term ice-thrust moraine is now in use on the Interior Plains for the composite ice-thrust bedrock structures, with their intimately associated drift deposits (Fig. 4). These morainal areas comprise a broad succession of ridges with a superimposed weakly to strongly developed hummocky surface of high local relief (Fig. 5). They comprise broad, arcuate to gently curving or nearly straight composite structures tens of miles in length and in places several miles wide. Repetitive ice-thrust ridges cannot readily be distinguished from bedding within such units due to the prevalent drift cover and hence the size limits of individual ice-thrust units cannot be estimated with any degree of certainty. A detailed description of the Lancer ice-thrust moraine, in west-central Saskatchewan is given by David (1964).

Kupsch (1962) states that "...in western Canada ice-thrust ridges apparently developed parallel to the ice-front in the marginal zone of a relatively thin but actively flowing glacier where the ice moved up-slope particularly where it pushed against the valley walls". He believes that a thick layer of ground ice occurred in places and "...that slices of frozen ground which were part of the glacier were deformed and dislocated but left more or less intact during the final melting of glacier and ground ice". Mackay and Mathews (1964) have also concluded that development of permafrost favours ice-thrusting beneath a glacier though it may not be essential; the overlying glacier may provide the stress to promote thrusting of buried clayey sediments, utilizing only their normal water content.

A variation of the ice-thrust moraine, that occur as distinct elongate belts, are the great sheets of nearly flat-lying ice-thrust bedrock that are known from natural exposures, deep road-cuts, and drill records to rest on till. Many of these disturbed rock masses, commonly with a hummock drift mantle, appear to be continuous or nearly so over areas measurable in miles. Very large masses of stratified sediments, that must have been frozen when emplaced, have also been reported from the Interior Plains.

The writer applies the term ice-thrust moraine as a genetic term to both the multiple ridged and flat-lying masses, with their variably hummocky surfaces whether composed of bedrock or stratified sediments that were frozen when emplaced. On the other hand he restricts use of the term push moraine, which also has been widely employed in Canada, to small end moraines that display some evidence of ploughing, pushing or overriding of unconsolidated sediments in a generally unfrozen state.

Where ice-thrust moraines are lobate in plan they suggest the positions of former ice-tongues or lobes, and thus may provide information on the direction of late ice movements where other data are lacking. Some ice-thrustmoraines constitute a type of end moraine, some a form of ground moraine.

Ribbed moraine

Ribbed moraine is a descriptive term used to refer to moraine areas where relatively large scale transverse lineaments give a 'ribbed' pattern to the land surface (Figs. 6 and 7). Ribbed moraine differs from corrugated ground moraine in size, form and origin (cf. Figs. 1, 2). Hughes (1964) used this term in north-central Quebec to emphasize the collective rather than individual character of the ridges. He noted that, "Elongate fields of ribbed moraine occupy shallow depressions in the drift plains or the bottoms of valleys that cut through the hilly uplands" and that individual ridges consist of "...bouldery till up to a mile or more in length, 30 to 90 feet high, with crests 300 to 1,000 feet apart. Typically the depressions between the ridges are occupied by elongate or multifingered lakes which serve to accentuate the pattern of the ridges". The ridges typically are steep-sided and in some areas have lengths of two or three miles. They are gently arcuate to undulating in ground plan, are in places connected by irregular cross-ribs, and at their ends merge into ill-defined ridges that meet them at various angles. In some areas poorly developed ribbed moraine is discernible on relatively high ground adjacent to low areas where it is better developed. A variation of the well-developed ribbed pattern is an irregular wavy transverse ridging. This type of ridging is particularly common on the island of Newfoundland. There are transitions between the irregular wavy and the discrete ribbed moraine.

Ribbed moraine may show a close association with longitudinal ice-flow features. The 'ribs' commonly occur on the flanks of drumlinoid ridges and eskers or on low ground between them, but, again, poorly developed ribbing may occur with these same features on higher terrain. It thus appears that these transverse and longitudinal lineaments have a common origin, possibly reflecting a balance between drift load and rate of flow. Furthermore, ribbed moraine may have a fluted or drumlinized surface that appears to be intimately related to the ribbing process rather than to a later, overriding process (Fig. 7).

Ribbed moraine is common in Shield areas and on the island of Newfoundland. In the Shield the ribbed moraine is commonly ornamented by a strong glacial fluting. In Newfoundland there may be a younger glacial fluting over large areas of ribbed moraine, but rarely the intimate association of ribs and furrows. On Avalon Peninsula the ribbing rarely shows any glacial fluting, and the individual rib ridges have rough, irregular outlines. The different forms of ribbing may reflect different origins, but for the present it appears best to refer to all such features by the descriptive terms rib ridges and ribbed moraine.

De Geer moraine

De Geer moraine is the term applied to a succession of discrete, narrow ridges ranging from short and straight to long and undulating, which are found in areas of former lake or sea cover. This usage is in keeping with that employed in Europe where they are also referred to as 'winter moraine'. Moraine ridges of this type were first described in Canada as 'washboard moraine' (Mawdsley, 1936) and 'annual moraine' (Norman, 1938) from the Chibougamau area of central Quebec. As these terms have since been applied to a variety of morainal ridges of differing types and origins, they are no longer useful.

De Geer ridges are generally spaced from a few hundred to a thousand feet or more apart, and commonly display a rather uniform spacing over broad areas (Fig. 8). The ridges are as much as 40 feet high and rarely higher. Their basal width is commonly only two to three times their height; their steep sides are due to a protective mantle of subangular and subround boulders. The ridges are generally composed of a stony, sandy to silty till, but some may be gravelly. Some contain large patches or lenses of contorted clay and silt. On some bedrock outcrops the De Geer ridges occur as low belts of bouldery materials with virtually no relief. Branching of the ridges into two or more elements is uncommon. The ridges may cross over hill and dale but they are best developed in, and commonly restricted to, low areas.

The author considers the cross valley moraine of Baffin Island (Andrews and Smithson, 1966) to be a variety of De Geer moraine as both were formed in areas of former lake or sea cover (Fig. 9). The cross valley ridges, probably due to confinement by the valley walls, are more irregular in ground plan and are more closely spaced than normal De Geer ridges formed in open waters. The Baffin Island cross valley ridges range in height from 1 to 10 feet except in the central, deeper parts of some valleys where they may range up to 65 feet. A detailed account of the cross valley ridges, their distribution and probable mode of origin is given by the above authors.

In a few areas, such as southeast of Mistassini Lake, Quebec, there is a transition from De Geer ridges into a form of corrugation or small rib ridges, formed above lake level, but such occurrences are relatively uncommon.

Interlobate and kame moraine

Interlobate moraine depending on its position relative to the ice lobes responsible for its emplacement, may display a gross or major lineation transverse to the general trend of one of the responsible glaciers, or display minor lineaments transverse to the local ice-frontal movements of both glaciers. Interlobate moraine may pass into end moraine per se and is in fact a type of end moraine throughout. The term kame moraine is used to signify an ice-marginal complex including many kames, and a predominance of glaciofluvial deposits as compared to till. The term is applicable to some end moraines and many interlobate moraines. The east-west trending Oak Ridges moraine of southern Ontario was formed between a glacier flowing toward the south-southwest and one flowing westward through the Lake Ontario basin; it has been termed both an interlobate moraine and a kame moraine. Such moraines cover large areas and probably due to infilling of depressions by glaciofluvial deposits may not look like moraine on air photos.

Linear, ice-block ridge

The term ice-block ridge is considered applicable to certain small, elongate drift ridges formed transverse to the ice-flow trend where stagnant ice-conditions probably prevailed during ridge formation. The term was actually used by Deane (1950) for till ridges formed parallel to the ice-flow trend and to irregular ridges forming a reticulate pattern, but similar ridges and ridge systems are also known with a transverse orientation. Deane considered the ridges as formed either by the squeezing of till (mainly sandy but in places silty to clayey) from beneath the ice or by the slumping of debris from the ice surface, into a crevasse-system. The transverse ridges are generally less than 1,000 feet long and 25 feet high, and commonly only a few hundred feet long and about 10 feet high; they have a semi-oval profile. Stalker (1960) described ice-pressed features in Alberta and suggested that certain minor till ridges transverse to ice-flow, may well have formed by the squeezing of basal till into a fracture system. Some similar transverse ridges and ridge systems in eastern Ontario are composed entirely of clay that may have been squeezed from below stagnant ice or slumped from its surface. Transverse ridges, of similar form but composed of well-sorted gravel, sand and silt are more properly termed crevasse-fillings. The term ice-block ridge with a prefix as to the type of material, appears useful for ridges formed under stagnant ice-conditions where the precise process of formation is in doubt.

MORAINE FORMED PARALLEL TO ICE-FLOW DIRECTION

(Moraine with Longitudinal Lineaments)

Actively flowing ice commonly develops lineations parallel to the direction of movement; both the till deposited by such ice, and the older drift over which the ice flowed, may exhibit lineaments that record this direction of movement. Such aligned features are known collectively as ice-flow features and include drumlins, drumlinoid ridges, glacial fluting, and crag-and-tail hills. Such oriented moraine is the ground moraine per se of some authors.

Drumlins are moderately elongate to markedly elongate mounds and ridges of drift ranging from about 20 to over 100 feet, and commonly between 50 and 80 feet in height. Typically they have a steep stoss end and taper off in both profile and plan toward the lee end, but variations in both plan and profile are common, and they may grade into drumlinoid ridges (see Fig. 10). There are drumlins of both constructional and destructional origin, the former believed to be ice-moulded forms – generally composed of till – and the latter ice-scoured remnants of pre-existing drift areas that may be either morainic or non-morainic. Rock drumlins have a bedrock core which presumably induced lodgement of the till. Drumlins may occur singly but more often they occur in groups, that have been referred to as drumlin fields. Drumlins are important directional ice-flow features. In places they have been formed by one glacier movement and partially or entirely reformed by a later glacier.

Drumlinoid ridges are narrow, elongate ridges from about 10 feet to as much as 100 feet high, with tapered ends though the stoss end may be more blunt than the lee end (Fig. 11). Most ridges are composed of till and range from thousands of yards to a few miles in length. They are rarely solitary features but generally occur in groups that cover large areas. With decrease in the height of the ridges above the adjacent ground moraine areas, such ridge fields pass into glacial fluting.

Glacial fluting (Figs. 12 and 13) is a narrow and shallow furrowing in drift, with or without adjacent ridging, into markedly elongate forms from about a mile to some tens of miles in length. Where there are ridges, as is usually the case, the ridge tops are more or less at the same level as the surrounding ground moraine or till plain rather than noticeably above it. It is this feature, together with the close spacing of ridges and furrows where developed on till, that serves to distinguish fluted ground moraine from drumlinized ground moraine for the individual ridges within some fluted areas are, in essence, low drumlinoid ridges. The local relief in fluted ground moraine is in the order of 5 to 30 feet. Glacial fluting is developed in a great variety of materials but is most common in till.

There appears to the writer to be an orderly gradation or progression from drumlins through drumlinoid ridges into glacial fluting that is suggestive of an origin dependent on the rate of ice-flow and its consequent capacity to deposit and mould, or to scour and transport, its basal load.

Crag-and-tail hills are common in areas of relatively thin drift with projecting bedrock knobs. They form where drift (generally till) lodged to the lee of a rock knob or crag, and they taper off in the direction of glacier flow. They may be considered as a special type of drumlin. They vary from a few hundred feet to several miles in length and from about 10 feet to 100 feet in height.

Marginal and medial moraine

The terms marginal and medial moraine are generally applied to present-day glaciers and glacier margins but in some mountainous areas are recognizable long after departure of the responsible valley glaciers.

Interlobate and kame moraine

Some interlobate and kame moraines occupy positions more or less parallel to the general flow trend of the glaciers though strictly speaking they are formed at high angles to the local ice-flow trends.

Linear ice-block ridge

Stalker (1960) considered that many elongate straight to serpentine or esker-like ridges in Alberta, composed in part or 'in toto' of basal till and lying parallel to the direction of ice-flow were ice-pressed features. These till and till-cored ridges range from about 5 to 75 feet in height and from 50 to 300 feet in width at the base. He also suggested that certain drumlinoid ridges on the Prairies may have had an ice-pressed origin.

NON-ORIENTED MORAINE

Non-oriented moraine refers to areas of glacial drift with a constructional surface expression that is largely devoid of linear elements and typically has a hummocky, and in places a pitted surface. Such moraine, commonly described as hummocky moraine, may form as a result of both glacier stagnation and glacier ablation, by which means drift materials contained on and in the ice are let-down on the underlying bedrock or drift surface; it may also form as a result of broad-scale basal deposition.

Two main types of non-oriented moraine may be distinguished on air photographs. The first type has low local relief with undulating hummocky surface. The second type has high local relief and displays surfaces that range from irregular-mounded with many pits, to equidimensional mounded with few pits. The first type of non-oriented moraine is generally referred to as ground moraine. The second type has been named disintegration, dead-ice, or stagnation moraine.

Low relief, hummocky, ground moraine

This is believed to originate, in large part, directly from basal ice that became inactive during glacier recession. It probably also originates through ablation and by disintegration of glacier ice. That hummocky ground moraine may be deposited from basal ice is suggested by the frequent gradation into moraine displaying longitudinal lineaments, to which some authors restrict use of the term ground moraine. Where such a gradation is not evident on air photos, it is not possible to make any genetic separation of the hummocky areas into disintegration moraine, ablation moraine, or basal ground moraine; such identification requires detailed field studies. The writer believes that the greater part of the low relief, hummocky ground moraine of Eastern and Northern Canada resulted from basal rather than from surface deposition. In the Interior Plains, however, the ablation process was responsible for much of the low relief hummocky moraine. Generally the local relief ranges from about 5 feet to 30 feet.

Low-relief hummocky moraine in the Interior Plains also includes some elevated areas known as prairie mounds (Gravenor, 1955), earth mounds (Henderson, 1952, 1959), and plains plateaux (Stalker, 1960). These mound features may have a central depression with an attendant outlet or break in the rim. The mounds generally consist of till; in places the central depressions have a thin mantle of silt, but more commonly silt mantles the till in the intermound areas. The mounds average about 300 feet in diameter and are about 10 to 15 feet high. Briefly the origin of the mounds is considered to be (1) ice-depositional with sliding of debris and melting of buried ice; (2) as a periglacial phenomena; and (3) due to squeezing of till into holes at the intersection of crevasse-systems in the ice. Many of the mounds are clearly post-ice and must be regarded as the result of frost-action. It is likely that similar appearing mounds, both with and without rim ridges are formed by more than one process.

High relief, hummocky moraine

Ice-disintegration features in general are discussed by Gravenor and Kupsch (1959). Their descriptions apply to what is here referred to as the high relief, irregularly mounded and deeply pitted type of non-oriented hummocky moraine which is believed to form as a result of glacier disintegration or stagnation (Fig. 14). The local relief is commonly 20 to 60 feet and in extreme cases up to 200 feet. Such moraine, however, is not everywhere markedly hummocky and pitted. As above mentioned, it may have few pits and an equidimensional-mounded surface, and with decreasing local relief, become inseparable, on air photos, from the non-oriented, basally deposited ground moraine.

High relief disintegration moraine is not everywhere hummocky but may include numerous broad, elevated, flat-topped areas known as moraine plateaux (Stalker, 1960). These may be composed entirely of till or be mantled with stratified silt and clay, in places many tens of feet thick. Moraine plateaux may display rim ridges that rise a few feet to about 20 feet (where there are no lake sediments) above the central parts of the elevated areas (Fig. 15). These ridges are irregular in plan. They may have formed by the squeezing of saturated clayey till, from beneath stagnant ice, into spaces between ice-blocks and into cracks or crevasses in the ice, as well as by the sliding of drift from the surface of ice blocks. The importance of the 'squeezing' process in the development of rim ridges, and certain directional features, is discussed and illustrated by Stalker (1960). Pitted outwash, pitted lake deposits and some collapsed alluvium is also an integral part of disintegration moraine.

In view of the lack of accord regarding the origin of many surface features on the Interior Plains, including the occurrence of hummocky surfaces of various morainic and non-morainic origins, and other inherent difficulties in producing a small-scale and much generalized glacial map of Canada, a study of air photos and air photo mosaics of a large part of the Plains was made. This led to the separation of hummocky-surfaced areas, regardless of their relief or possible origin and material, from areas of lineated moraine. The primarily hummocky areas were therefore termed hummocky terrain; in the main, however, these areas are largely areas of hummocky disintegration moraine.

The prevalence of disintegration moraine on the Interior Plain is due to the manner of glacier retreat occasioned by both regional and local topography, and to the thickness and clayey nature of the tills. The clayey tills were derived in large part from soft, argillaceous rocks some of which contained much montmorillonite. The clayey tills are especially susceptible to slumping, sliding, and to being squeezed. In the Shield region, where the tills are commonly sandy or gravelly types, hummocky terrain is less common and has been outlined only in a few areas of relatively high relief hummocky forms. Other hummocky areas are included with the ground moraine.

Interlobate and kame moraine

Because of position relevant to former ice-lobes or to the materials composing them, some unoriented morainal areas may be included in these categories.

GLACIATED BEDROCK

Ice-flow features impressed on bedrock are included on the new Glacial Map of Canada only where other ice-flow features are scarce or lacking, or to indicate an 'older' glacier trend. In some areas striations and grooves are the only direction indicators present, but they may reflect a local glacier flow induced by topography rather than the regional direction of flow. The striations themselves seldom indicate the actual 'sense' of the glacier movement. Associated features such as crescentic gouges, chattermarks, percussion marks, tapering striae etc. may be used to determine the sense of the glacier flow but in general such determinations are unreliable. The meaning of these features must be considered in relation to the type of rock being scoured, the angle of the scoured face relative to possible flow direction, and other factors. The most reliable criterion for indicating sense of ice-flow is the miniature crag-and-tail feature. This occurs where hard bodies such as pebbles, phenocrysts, porphyroblasts, or concretions occur in a softer matrix that has been scoured by a glacier. The harder materials resist abrasion and hence stand out slightly above the general rock surface and protect a tapering tail of the softer rock on their lee side. Not all striae symbols shown on the glacial map have been determined with the same accuracy and hence represent a combination of known and inferred ice-flow directions.

Strong ice-movement may also mould or scour bedrock into large forms indicative of ice-flow direction. Where there has been strong scouring of one side of a rock knob and some plucking on the other the resulting rôches moutonées provides clear evidence of the direction of former ice-flow. They are in places discernible on air photos. They have been used to substantiate the direction of ice-flow indicated by striae trends, and in places to provide an ice-flow symbol where other evidence was lacking.

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ILLUSTRATIONS

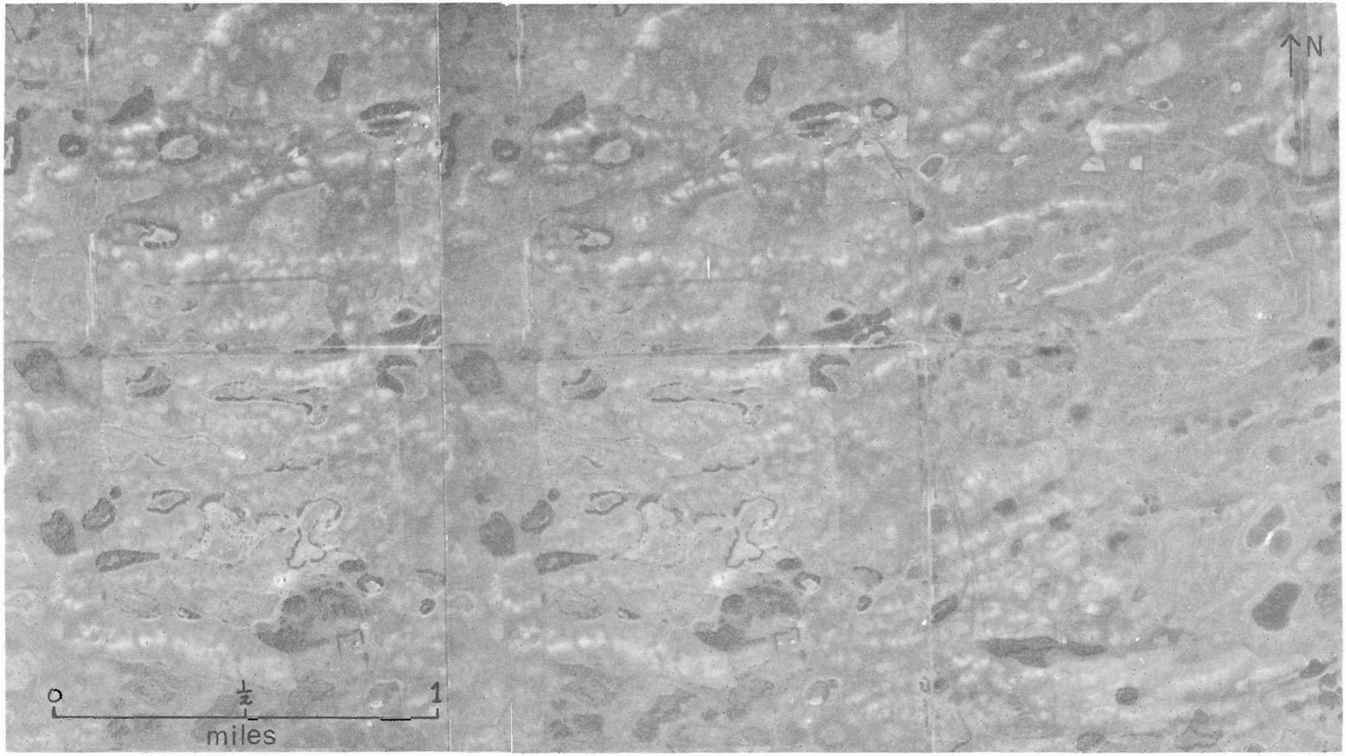

Figure 1. Corrugated ground moraine; southeast of Quill Lakes, Saskatchewan (stereoscopic pair). Local relief about 40 feet. EMR-A 11853/41, 42.

Figure 2. Corrugated ground moraine with longitudinal lineaments contributing to a reticulate ridge pattern; southwest Manitoba (stereoscopic pair). Local relief about 30 feet. EMR-A 15528/50, 51.

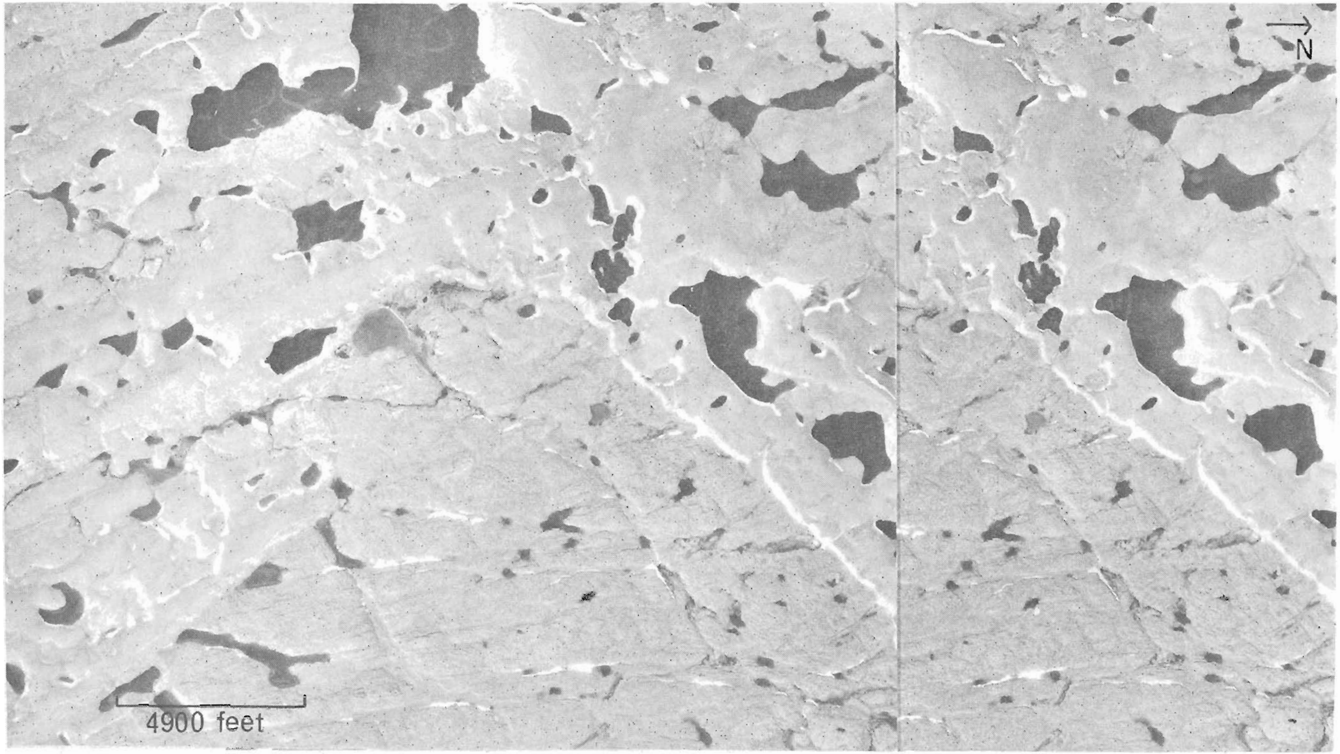

Figure 3. End moraines; southern Baffin Island, Northwest Territories (stereoscopic pair). Moraine ridges, formed by glacier from the northwest, rise over 100 feet above bare bedrock area. EMR-A 16166/82, 83.

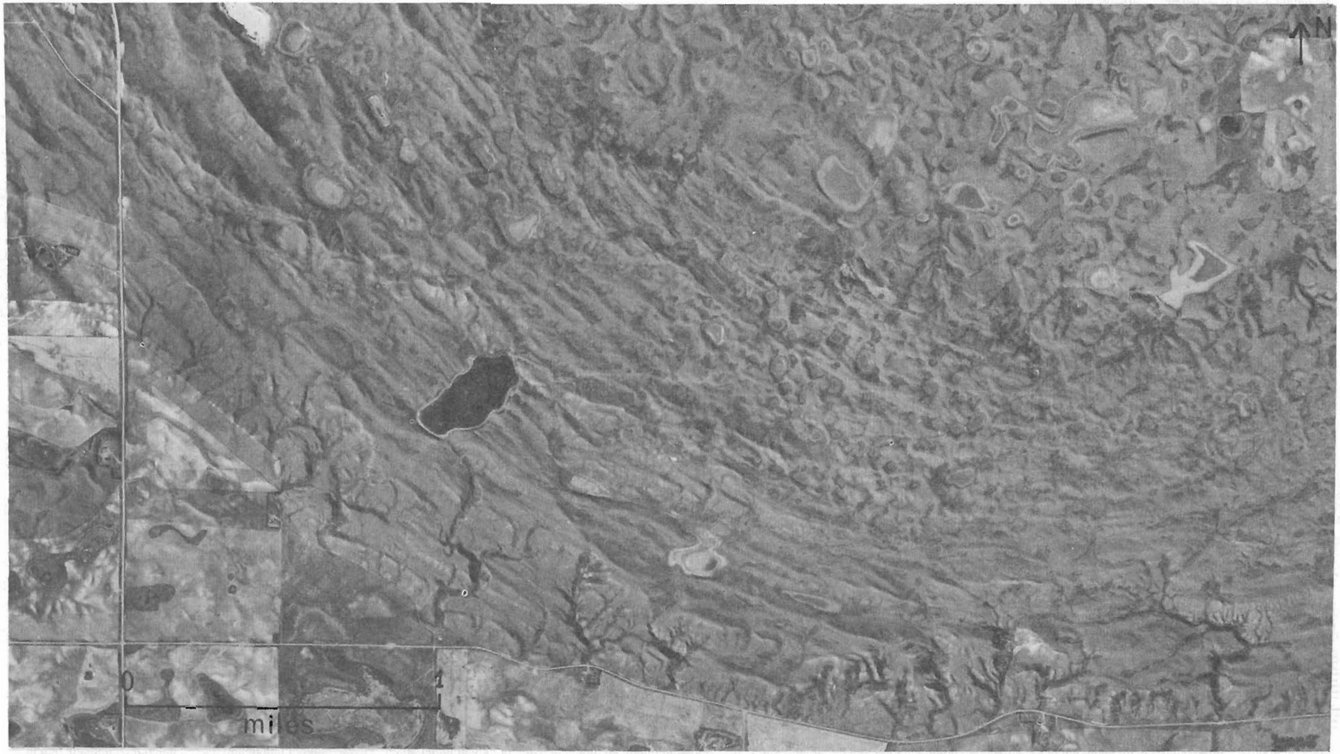

Figure 4. Ice-thrust moraine; The Dirt Hills in The Coteau moraine complex south of Moosejaw and southwest of Spring Valley, Saskatchewan. Hummocky drift-covered area in central right side of photograph is 300 feet above road intersection in lower left corner. Note the bare bedrock ridges along southern side of moraine. EMR-A 17844/108.

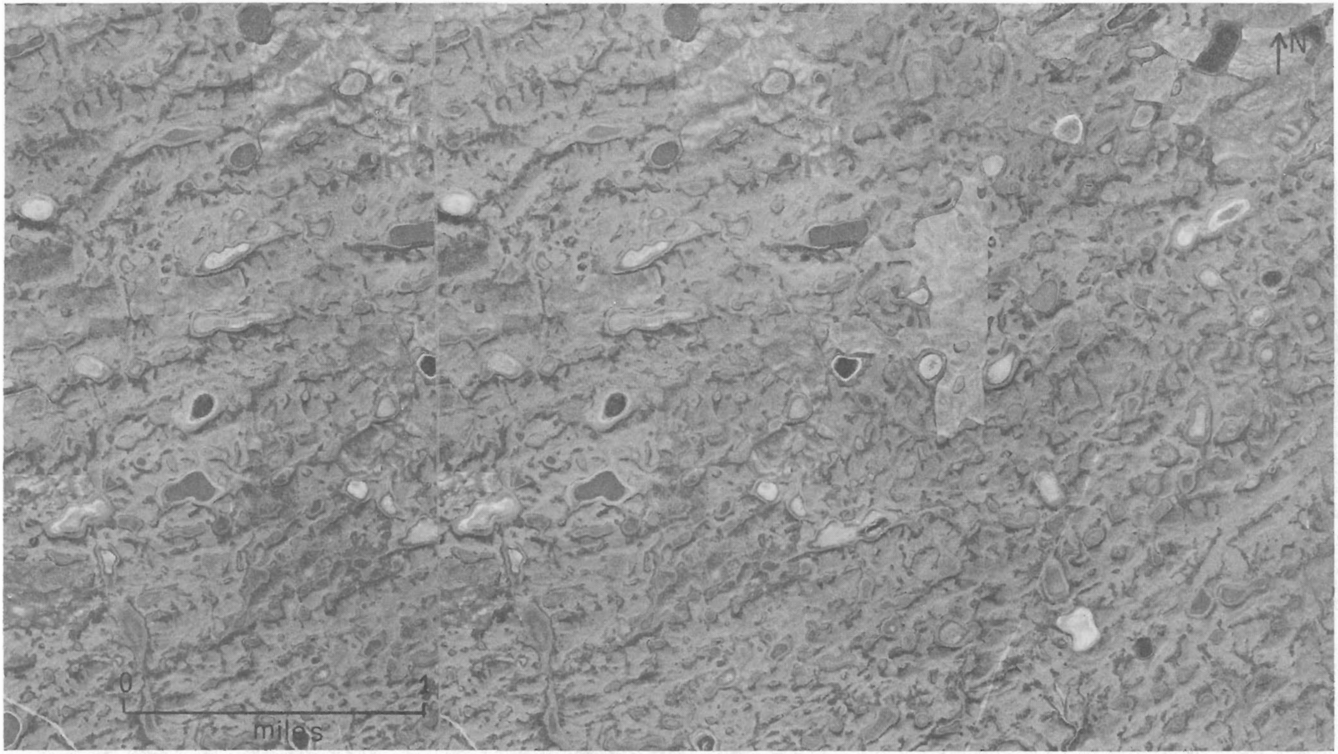

Figure 5. Hummocky ice-thrust moraine; The Dirt Hills, southeast of Spring Valley, Saskatchewan (stereoscopic pair). Local relief up to 80 feet. EMR-A 17497/16, 17.

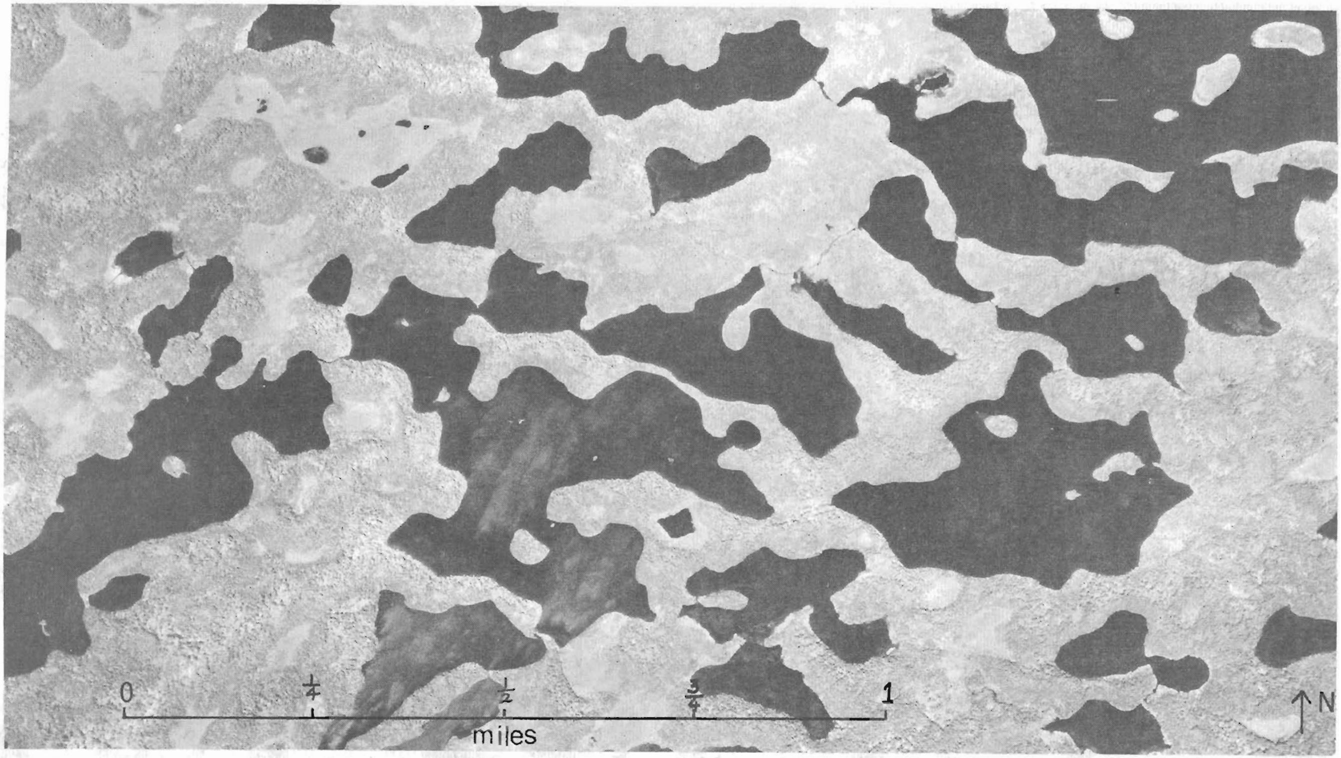

Figure 6. Ribbed moraine; southwest of Middle Gull Pond, central part of Avalon peninsula, Newfoundland. Local relief about 50 feet. EMR-A 19589/100.

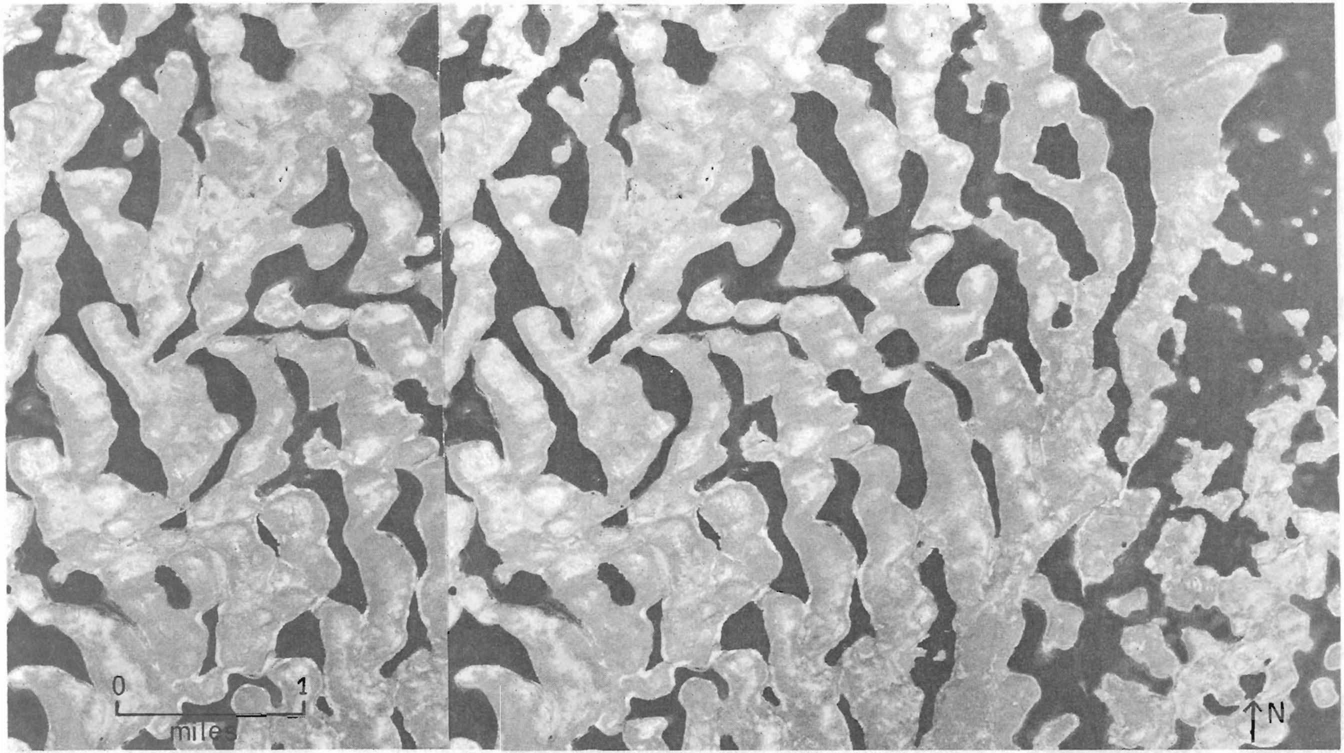

Figure 7. Ribbed moraine, drumlinized; Boyd Lake area, Northwest Territories (stereoscopic pair). Ice flowed from top right to lower left. Relief about 100 feet. EMR-A 14887/105, 106.

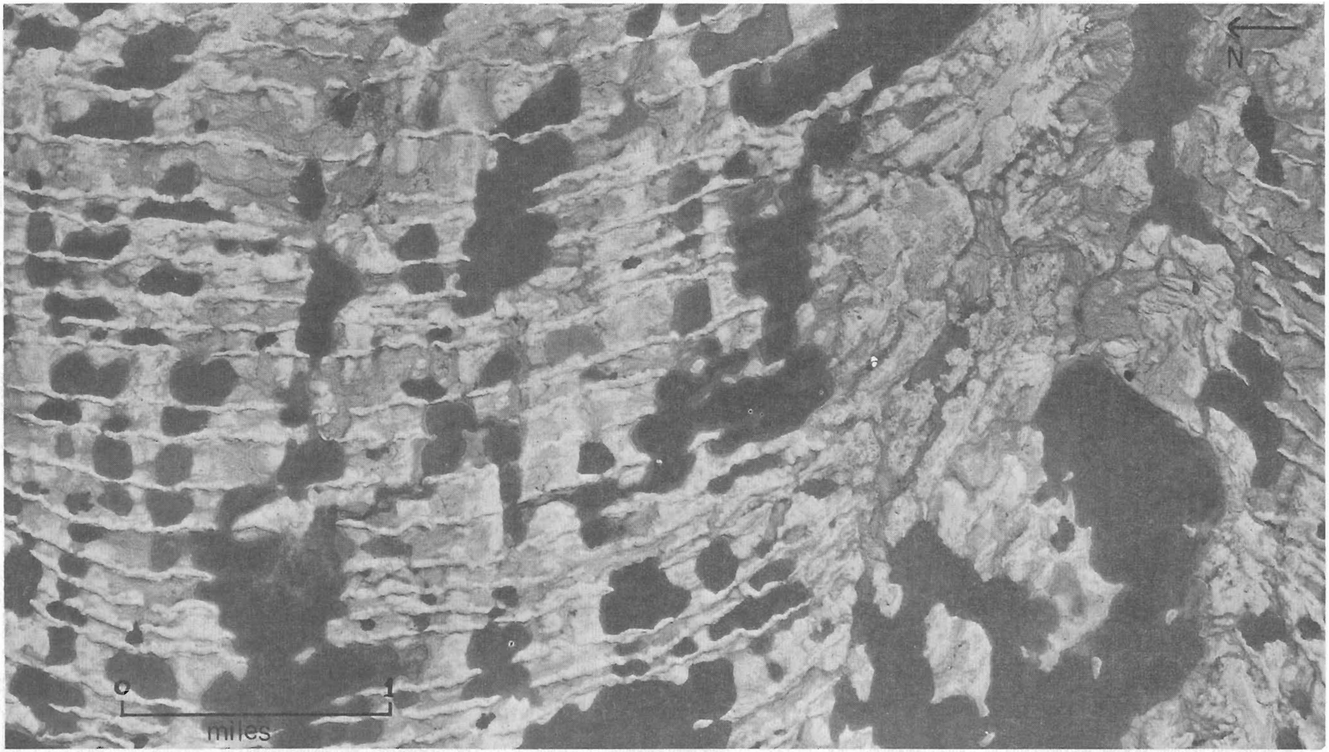

Figure 8. De Geer moraine; east side Hudson Bay near Port Harrison, Quebec. Ridges about 40 feet high. EMR-A 14877/98.

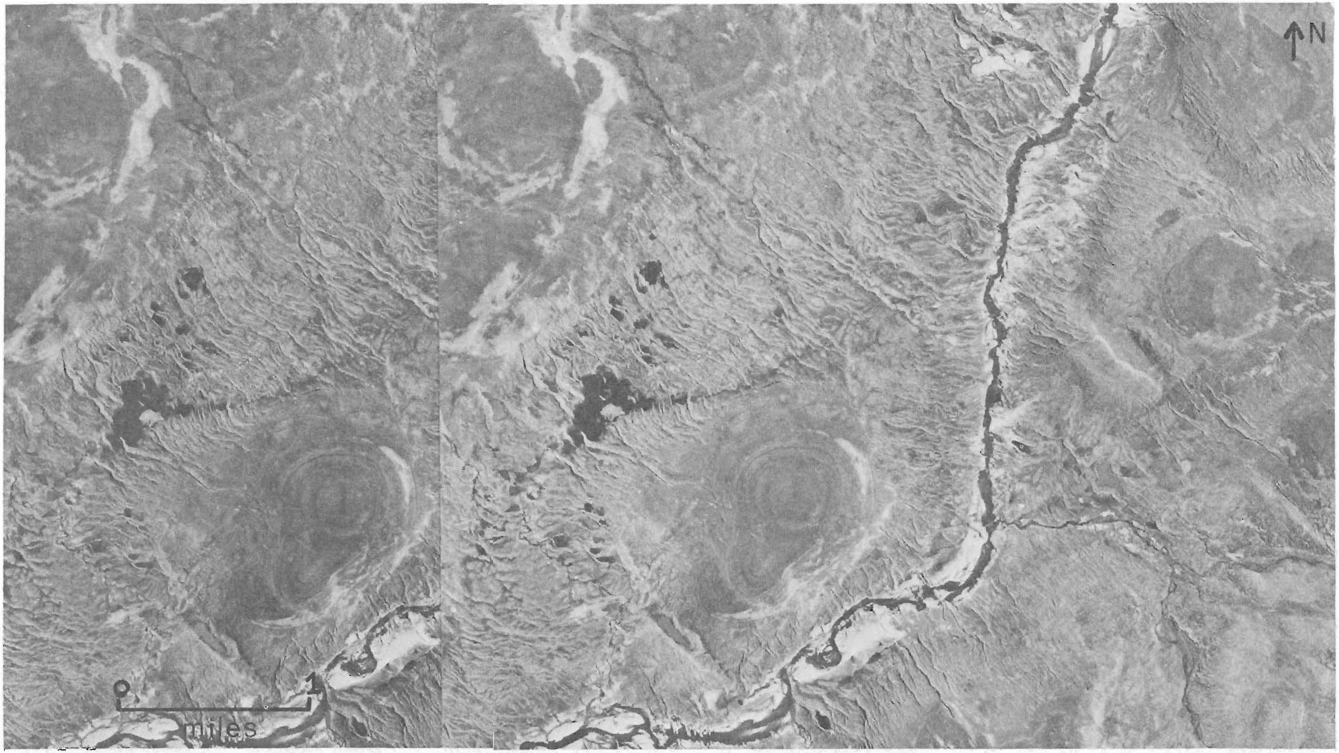

Figure 9. Cross-valley (De Geer) moraine; north of Barnes Ice Cap, Baffin Island, Northwest Territories (stereoscopic pair). Ridges up to 50 feet high. Note the strandlines on hills in valley. EMR-A 17044/33, 34.

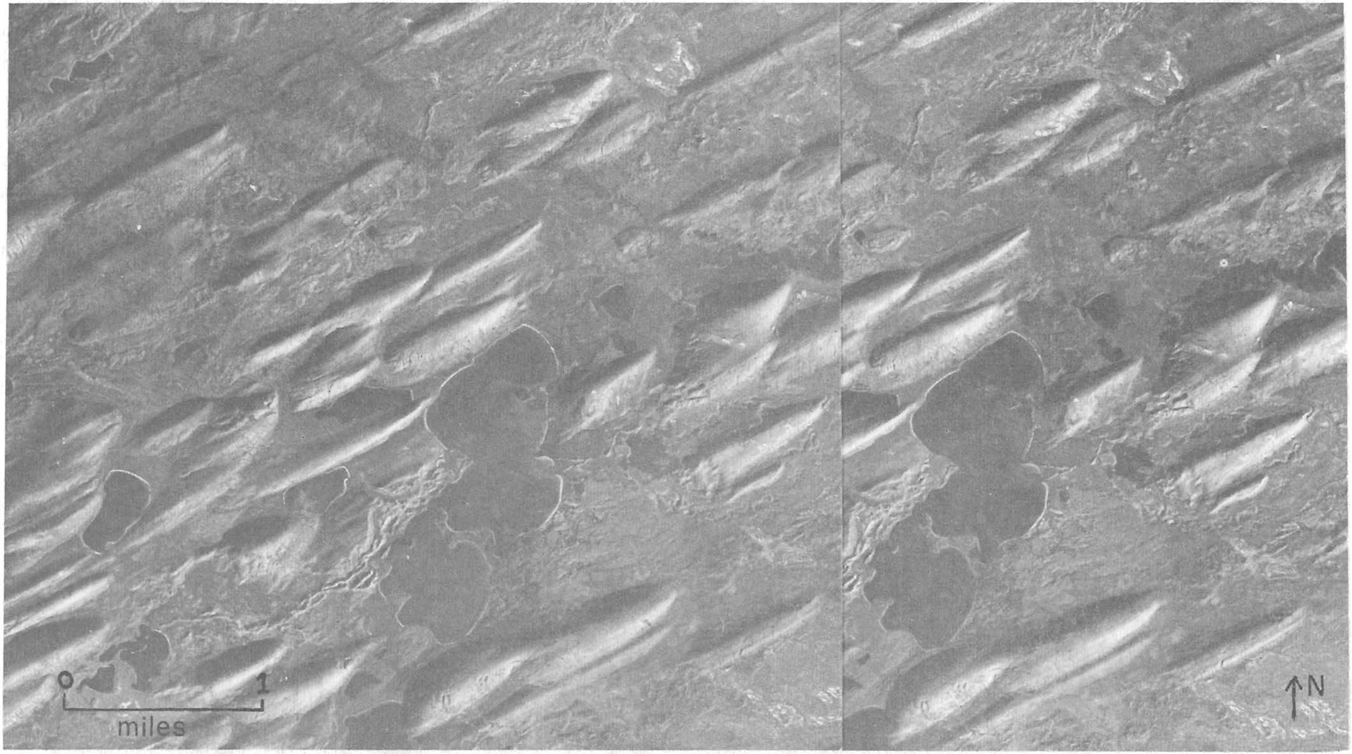

Figure 10. Drumlins and drumlinoid ridges developed on Athabasca Sandstone; southeast of Lake Athabasca, Saskatchewan (stereoscopic pair). Ridges about 100 feet high. EMR-A 14509/4, 5.

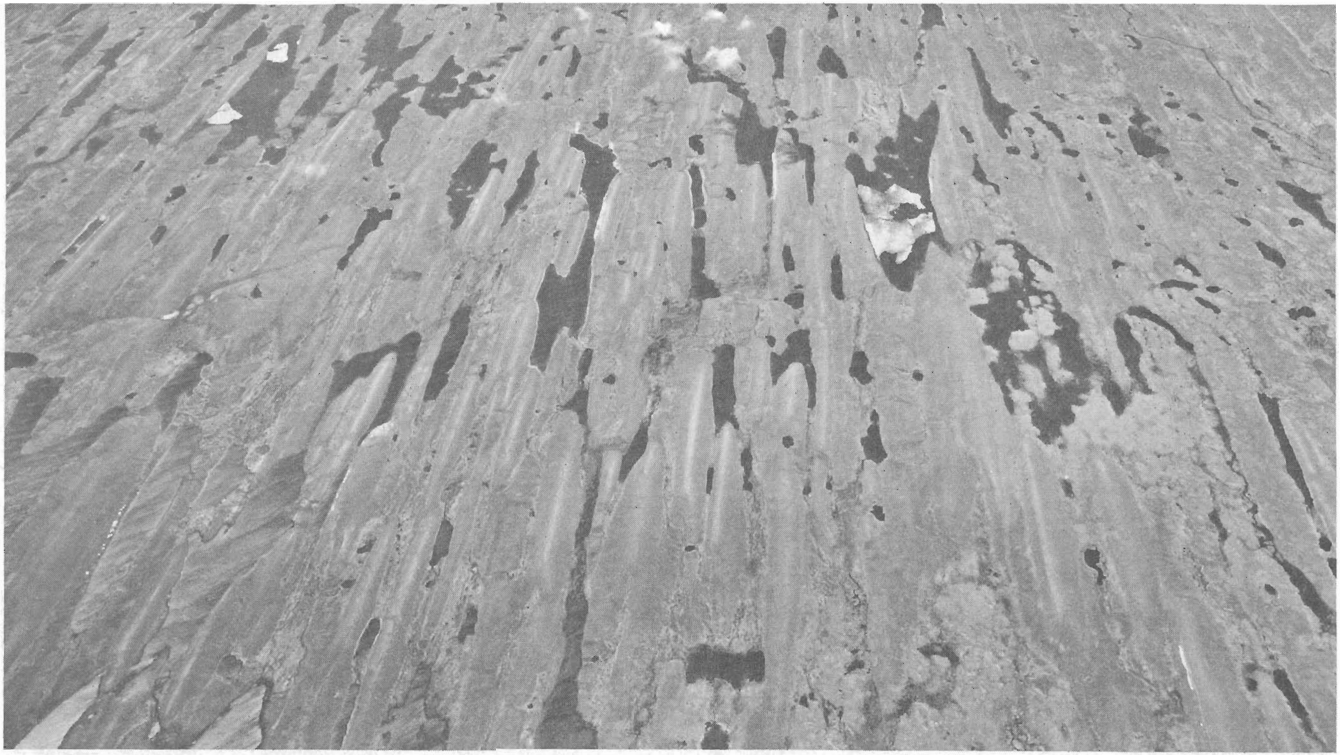

Figure 11. Drumlinoid ridges; view to the west in NTS 65 H, east of South Henick Lake, Northwest Territories. Ice flowed toward observer at N95°E. Distance from top to bottom of photograph is about 10 miles. EMR-T 296L/200.

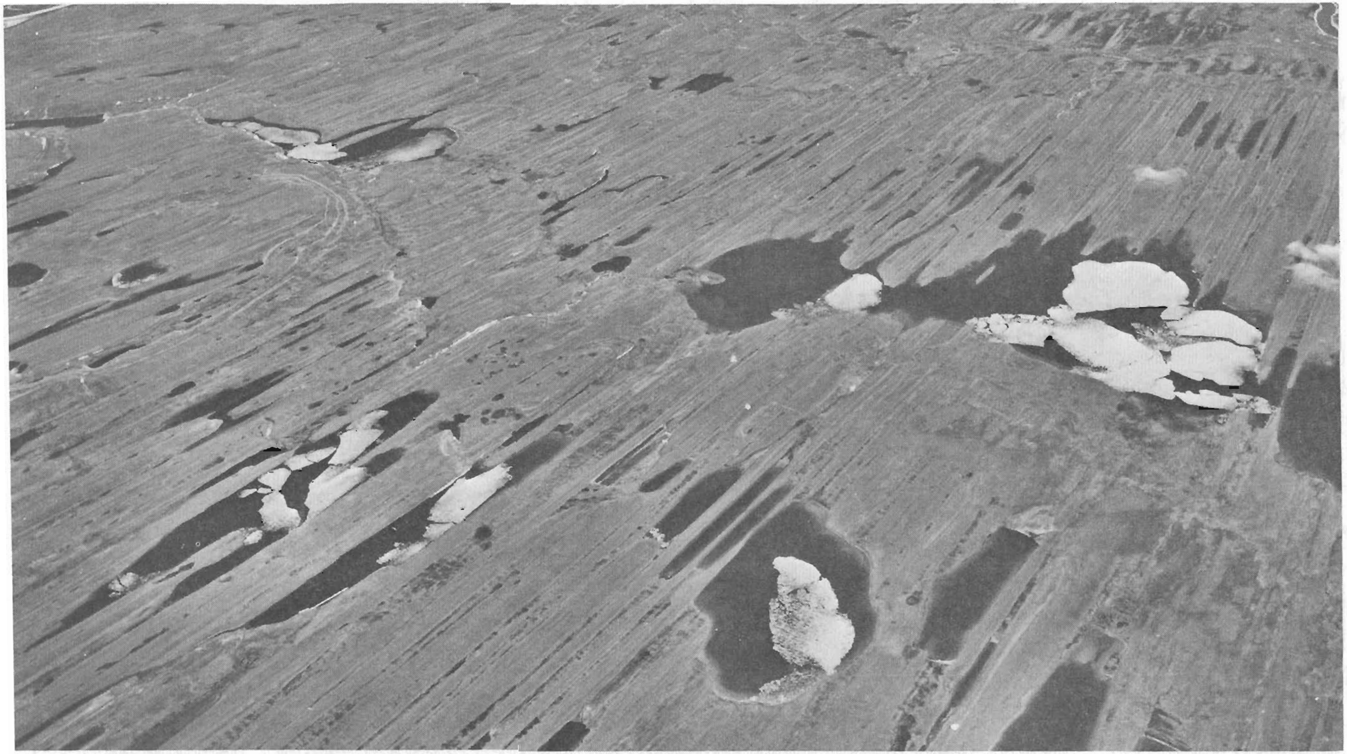

Figure 12. Glacial fluting; view to east about 60 miles northwest of Dubawnt Lake, Northwest Territories. Ice flowed toward observer in direction N60°W. Thelon River in top corners of photo. EMR-T 301L/214.

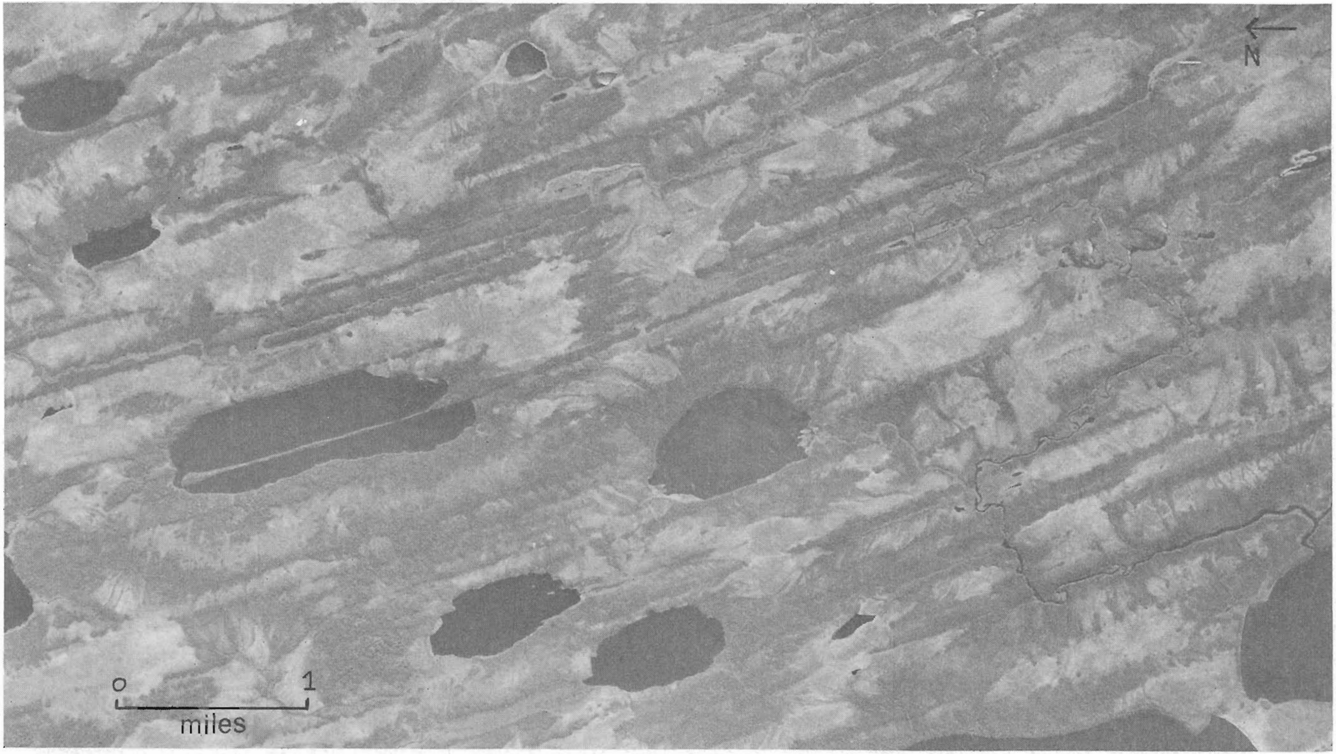

Figure 13. Glacial fluting developed on Cochrane till; 60 miles north-northeast of Cochrane, Ontario. Ice moved from left to right in direction N150°E. EMR-A 13390/75.

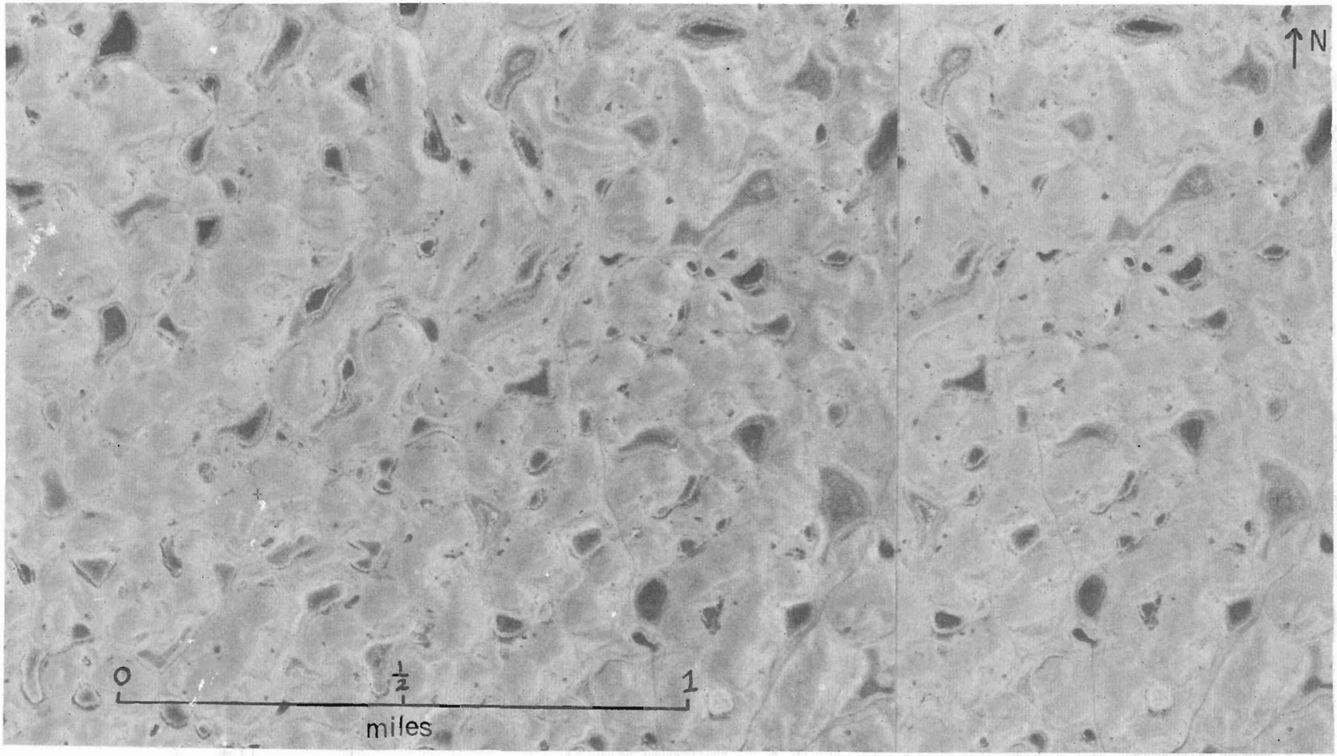

Figure 14. Hummocky disintegration moraine; south of Drumheller, Alberta (stereoscopic pair). Local relief up to 100 feet. EMR-A 7629/73, 74.

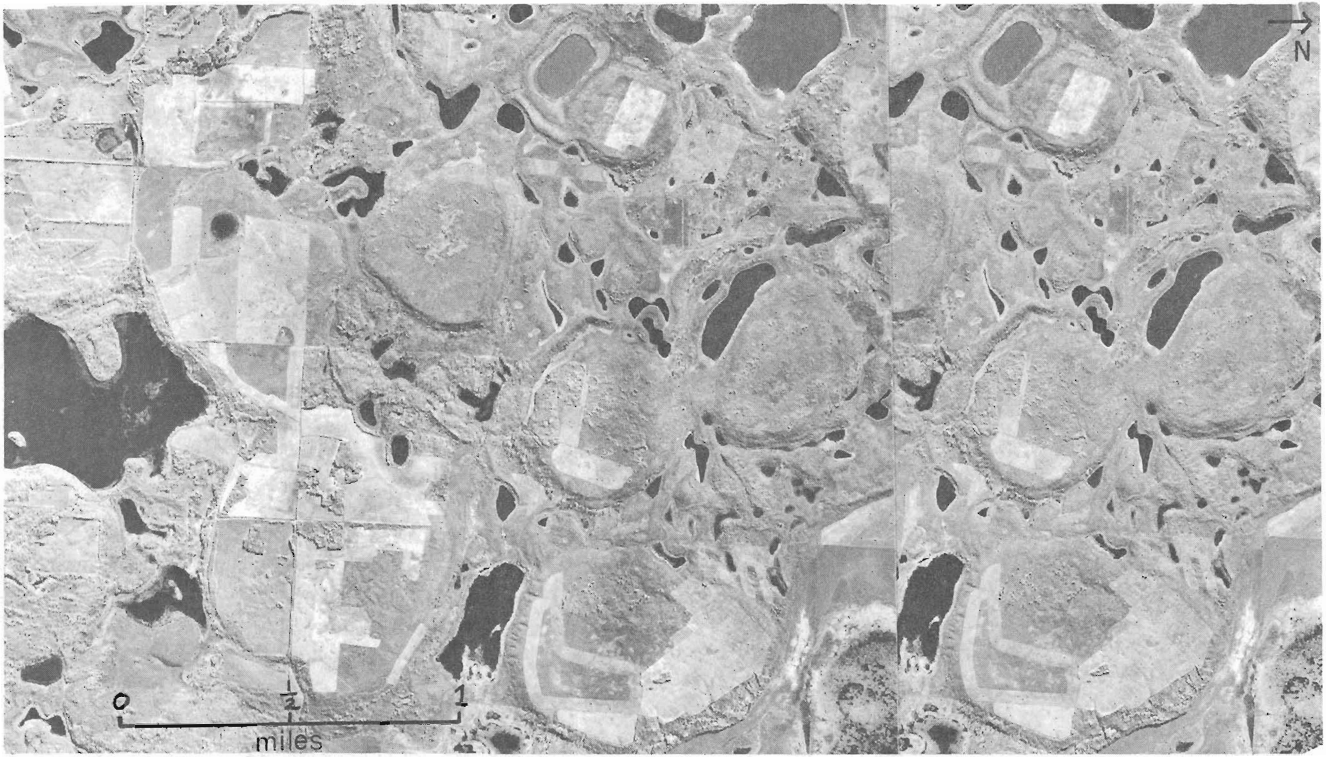

Figure 15. Disintegration moraine with moraine plateau and rim ridges; fifty miles north-northeast of Battleford, Saskatchewan (stereoscopic pair). Local relief about 125 feet. EMR-A 15882/138, 139.