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MULTI-AGENCY GROUP FOR NEOTECTONICS IN EASTERN CANADA

L'ASSOCIATION MULTIPARTITE POUR LA NÉOTECTONIQUE DANS L'EST CANADIEN

INVESTIGATION AND DOCUMENTATION OF THE NEOTECTONIC RECORD OF PRINCE EDWARD COUNTY, ONTARIO

GEOLOGICAL SURVEY OF CANADA

OPEN FILE 2062

by

George A. Gorrell
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Oxford Mills, Ontario
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Final Report

March 1988

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DISCLAIMER

The following report was prepared under contract to the Geological Survey of Canada. The views and interpretations expressed in this report are the responsibility of the contractor. In making this report available to the public, the Geological Survey of Canada neither endorses or rejects the report or the conclusions therein.

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J.A. Heginbottom
Terrain Sciences Division
Scientific Authority

ABSTRACT

This study of the neo-tectonic record of Prince Edward County is part of a series of integrated geologic, seismologic and seismotectonic studies being undertaken in Southern Ontario by the Multi-Agency Group for Neotectonics in Eastern Canada (MAGNEC). The project was funded by the Atomic Energy Control Board and controlled by the Geological Survey of Canada and the Ontario Geological Survey. The area studied is approximately 110 km^2 and is located in the southern portion of Prince Edward County south of latitude 43° 56′ N and east of longitude 77° 10′ W.

The origins of the features in the study area can be attributed to a number of different processes. The field investigation showed that ancient tectonic activity, preglacial process, karst activity, glacial processes, post-glacial modification and possibly neo-tectonics all contributed to the formation of the present morphology.

It is possible that neo-tectonic activity has occurred. However, there are also other explanations, not involving neo-tectonics, which could be used to explain many of the features, lineaments and deformations.

ACKNOWLEDGEMENTS

I would like to extend my thanks to P. J. Barnett and Gail McFail of the Ontario Geological survey for their many helpful comments and suggestions concerning the features in the study area. Gail, who worked in the area at the same time for the Survey, was doing an analysis of the bedrock lithology and structure.

Finally I would like to thank my field assistant, Cory. He entertained people who came to visit me and made sure I never got lost.

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INTRODUCTION

This study of the neo-tectonic record of Prince Edward County is part of a series of integrated geologic, seismologic and seismotectonic studies being undertaken in Southern Ontario by the Multi-Agency Group for Neotectonics in Eastern Canada (MAGNEC). The project was funded by the Atomic Energy Control Board and controlled by the Geological Survey of Canada and the Ontario Geological Survey. Its purpose is to examine, classify and then determine the origin of a complex arrangement of lineaments in the southern portion of the area. Many of lineaments were previously observed from an aerial photograph lineament study by Creasy (1976) and a preliminary lineament analysis of colour infra-red photography by Bowlby et al. (1987). The area studied is approximately 110 km^2 and is located in the southern portion of Prince Edward County south of latitude 43° 56' N and east of longitude 77° 10' W.

METHOD OF INVESTIGATION

Preliminary Work

The preliminary work involved a review of the geological work which had been done on the area. Studies by Coleman (1922), Karrow et al. (1961), Liberty (1961), Terasmae and Mirynech (1964), Chapman and Putnam (1966), Mirynech (1962, 1978), St. Jacques and Rukavina (1972), Ministry of the Environment (1972), White et al. (1974), Creasy (1976), Carson (1981), Leyland (1982), Williams and Trotter (1984) and Water and Earth Science Ltd (1985) were studied and pertinent data were transferred to a 1:25,000 scale topographic maps (30N/14a, b, g and h). This was followed by an examination and interpretation of aerial photographs with approximate scales of 1:50,000, 1:35,000, 1:16,000 and 1:10,000 and an uncontrolled colour infrared mosaic.

Detailed Work

Airborne colour infra-red photography acquired by the Ontario Centre for Remote Sensing and black and white photography at scales 1:10,000 and 1:15,840 were used to identify additional lineaments and tonal and textural patterns within the study area. Older sets of aerial photographs (1927, 1954) at various scales were used to aid in separating anthropogenic patterns from those which are natural. These natural features were then examined in the field. The field work was detailed and site specific. It was carried out between August 17 and October 16, 1987.

This field work involved:

1) labeling the station on the map and defining its UTM location;
2) describing the type of sediment and feature and if significant, taking a sediment sample;
3) logging the sediment under the headings shown in Figure 1 where applicable;
4) recording the direction of ice movement (striations, and morphological form);
5) determining the probable depth of the sediment;
6) ascertaining whether any events which affected the underlying bedrock had also affected the sediment;
7) sketching and photographing the features and sediments and
8) generally examining the bedrock surface where it was exposed.

The available data was classified, categorized and catalogued on data sheets designed for the study. This information was collected in order to determine the process(es) which may have led to formation, age and any possible relationships between the bedrock structure and the overlying Quaternary unconsolidated sediments, and to provide a basis for future geological studies.

REGIONAL GEOLOGY

The purpose of this investigation was to do a detailed local study of the southern portion of Prince Edward County. The background geology cited below is based on the work of other researches.

Bedrock Geology

Two bedrock units of Ordovician age which outcrop within the study are: the Verulam and the Lindsay Formations (Liberty, 1961; Carson, 1981; Williams and Trotter, 1984 and Water and Earth Science Assoc. Ltd, 1985). The Lindsay is by far the most predominant.

Verulam Formation

The published reports (Liberty, 1961; Carson, 1981; Williams and Trotter, 1984 and Water and Earth Science Assoc. Ltd, 1985) indicate that the Verulam Formation is found in the study area only at the mouth of the Black River. It is a very fine grained or coarse crystalline limestone, it is thin to medium bedded and brownish gray in its natural state. It weathers to a light or reddish brown. Shale interbeds up to 0.10 m have been noted (Water and Earth Science Assoc. Ltd, 1985).

Lindsay Formation

The Lindsay Formation is the predominant bedrock unit in the study area and has been identified as the uppermost bedrock unit in Prince Edward County (Liberty, 1961; Carson, 1981). It consists mainly of dark grey fine grained crystalline limestone which weathers to a bluish to brownish grey. Shale interbeds up to 0.10 m thick have been observed (Water and Earth Science Assoc. Ltd, 1985).

Three normal faults have been identified by Liberty (1961) between Point Petrie and Salmon Point. These faults converge between the towns of Picton and Cherry Valley and result in vertical displacements of at least 15 m (Water and Earth Science Assoc. Ltd, 1985).

Quaternary Geology

Chapman and Putnam (1973), Mirynech (1978) and Leyland (1982) indicate that the glacial sediments in the study area are of Late Wisconsinan age. These sediments are associated with two directions of ice movement which trended, according to Leyland's (1982) marginal map notes, 240° to 245°. In the study area Leyland (1982) mapped; 1) till, 2) shoreline deposits, 3) glacio-lacustrine deep water deposits, 4) aeolian deposits and 5) organic deposits.

unit	thickness	basal contact	sedimentary structure	height of set	angle of climb	lateral continuity	disturbance	grain size

Figure 1: Headings for the observations which were recorded when a section was logged.

OBSERVATIONS AND INTERPRETATION

The observations made during the study are presented in Appendix A and are summarized below. The sediments and features observed have been broadly subdivided into tow groups; rock features and soil features.

Rock Features

Several of the patterns and lineations studied on the black and white and on the colour infra-red photographs may be attributed to features and variations in the bedrock. The bedrock features of the area have been grouped into three main categories; joints lineaments and configured ground.

Joints

The two most prevalent joint or fracture directions within the study area are approximately 060° and 125° azimuth. It must be stressed that these orientations are the most prevalent and are not exclusive, for it was noticed that joints were also oriented approximately 020°, 090°, 110° and 148° azimuth.

The bedrock surfaces on either side of these joints are not always touching or 'tight'. This spacing, was observed to range from nothing to a maximum width of 0.45 m. Small amounts of calcite were observed along the margins of the fractures and on the underside of the limestone beds within the joints.

To simplify the description of the spacing, the following definitions have been used. If the spacing between adjacent bedrock surfaces is 50 mm or less it has been called a gap. If the spacing is greater than 50 mm the spacing has been called a crevasse. Areas where gaps and crevasses are found are shown on the accompanying maps.

Gaps between adjoining bedrock surfaces are observed throughout the study area. Although many of the fractures have these gaps, the gap was more often observed on the joints oriented approximately 125°.

Crevasses are commonly oriented 060°, 125°, or 148° azimuth. In a few areas the crevasses consist of a series of elliptical holes (Stations 163 and 188). These holes are located where joint sets intersect.

Rarely are the crevasses open to the surface. When filled with sediment they are identified only by their negative relief or by the healthy vegetation which grows upon them. In many areas large Precambrian clasts, unsorted sediment and sorted sediment were found filling the crevasses. These areas are shown on the accompanying maps.

Large clasts are virtually absent other than within and surrounding crevasses (for example; Stations 42, 66, 74 and 134). This, and the observation that unsorted and sorted sediment are found within the crevasses (Stations 66, 173, 175, 205 and 223), suggests that the crevasses were open when the glacier covered the area. The large Precambrian clasts were too large to fit into the crevasses, while the finer sorted and unsorted sediment would readily fill the open crevasses.

At several locations, for example Stations 66 and 73, the sediments of ancient shorelines which cross crevasses are collapsing into the crevasses. On either side of the crevasses the bedrock surface is extremely irregular. The shoreline sediments have either sunk entirely or are currently settling into the crevasses. This settling occurs preferentially on the northwest side of the ancient shoreline. The sinking appears to be recent, but may have been caused by one or more of several processes. The settling may be due to:

1) Neo-tectonic movement which has formed, or at least opened the crevasses farther, shaking the material and causing it settle farther into them;

2) Solution of the limestone at depth in recent periods which has caused the fractures to open farther allowing the overlying sediment to settle into them and

3) Erosion and transportation by meteoric water and groundwate of sediment deposited upon a crevasse which was already present

The position of these features suggests that meteoric processes play an important role. The north side has the steepest grade. It is quite probable that the steep grade caused the water to flow overland, eroding material and carrying it into the crevasses.

Another explanation is that the crevasses opened due to glacial unloading then filled with sediment either deposited subglacially or as the shoreline developed. The sediment was flushed down the crevasses by meteoric water, by neotectonic movement, or by settlement due to gravity. The material was replaced by the overlying sediment as it settled farther into the crevasses. The irregular bedrock surface may be due to frost heaving of the sediment within the limestone. However, this hypothesis does not explain why all beaches in the study area are not sinking into crevasses.

It was observed that the ancient shoreline sediments are collapsing into crevasses where major lineaments cross. For example, at Station 66 the shoreline has developed upon an east/west rise (fold, see below). This rise is at the junction where a 125° and three 148° lineaments cross. Lattman and Parizek (1964) indicated that groundwater yields at the intersection of multiple fracture traces are ten to one hundred times as great as yields from single fracture traces. It is likely then, that the settling of the sediment into the fractures is caused by erosion and transportation by groundwater of the sediment deposited upon already present crevasse.

Calcite was observed along the margins of many of the crevasses and on the underside of the limestone beds within the crevasses. This calcite is probably deposited by the solution and recrystallization of the limestone. This suggests that solution of the limestone by groundwater over the last 12,000 years is an important factor in the formation of the modern terrain.

Related to the solution of the limestone is the role of meltwater flowing subterraneously through the crevasses. The significance of meltwater flow through karst features has been suggested by Smart (1986). In contrast to the current amounts of groundwater present, the volume of water available when the glaciers melted would be considerable. Research into the development of karstic features by meltwater has not been explored greatly and this meltwater hypothesis can only, until further work is completed, be considered as one of a number of explanations. The source of meltwater, subglacial or proglacial, will be discussed in a subsequent section (Abrasion).

Another possible explanation is that minor seismic activity has occurred, causing the sediment in the crevasses to consolidate because of shaking. As the material sank into the crevasses, it would be replaced by the overlying sediment. However, as described above, a seismic shock is not required for the sediment to have settled into the crevasses. At best, this explanation can be regarded as only conjecture and as circumstantial evidence that neo-tectonic movement opened, or at least widened the crevasses in the areas described above. Further work is required to determine which process has occurred.

There is some evidence that a few of the crevasses opened due to tectonic movement. This evidence is the sharp breaks and asymmetric sides of the crevasses walls at Station 138. The examination of the crevasse wall at that station indicates that a few of the crevasses were caused by "pull apart" rather than to solution.

Lineaments

Lineaments which were identified on the colour infra-red mosaic and the black and white aerial photographs and attributed to a bedrock origin have been subdivided into; linear depressions, positive linear features, scarps and east/west rises based on those forms.

a) Linear Depressions

Linear depressions are closely associated with the fracture traces measured on the bedrock surface. What distinguishes a linear depression from a crevasse is that:

1) linear depressions may be traced laterally along the same azimuth to positive linear features;

2) the joint orientation, although similar to the orientation of the linear depressions, is usually slightly different (ie. 125^{o} versus 148^{o}) and

3) the length (ie. distance it can be traced) and width (ie. spacing between adjacent surfaces) are larger than crevasses.

These depressions can be traced laterally for hundreds of metres. Like some of the crevasses, linear depressions are filled with sediment and are only identified on the ground by their negative relief. These depressions could also be classified as 'vegetation alignments' because the vegetation which grows upon them appears to be healthier. The location and extent of the linear depressions are shown on the accompanying maps.

At four locations, (Stations 57, 58, 68 and 71) abandoned shorelines cross linear depressions. The portions of the shoreline which were deposited upon these linear depressions are no longer present. This suggests that:

1) The shoreline has settled into the depression by either, beach sediment being flushed through the linear depression by meteoric and groundwater water, or by settlement of the sediment due to gravity or neo-tectonic movement;

2) The shoreline has been pulled apart and

3) The shoreline was not present in the first place.

The first suggestion that the shoreline has settled into the depression because it was flushed by meteoric water is the least intricate explanation. The other reasons require more evidence to prove.

The third suggestion, that the shoreline was never present does have some merit. If the linear depression existed when the storm beach was developing, it would behave as a channel. As the waves broke on the shore it is possible that the channel would act as a sluice, transporting the sediment away from shore. No sediment would be deposited where the depression crosses the shore because it would be transported away continuously.

b) Positive linear features

These positive relief linear features are oriented approximately 125° and 148° and relief ranges from 0.40 to 2.0 m. In a few locations the overburden has been removed and it was found that the 'core' of these features consists of bedrock which appears to have buckled. The positive linear features are similar in appearance to 'pop-ups' and buckles on quarry floors described by White et al. (1974). They suggested that they formed either because of overburden removal, abrupt temperature changes, earth tremors, or normal weathering. In many cases (Stations 23, 77, 82, 116, 184 and 224) there is a relief change from one side of the feature to another, where one side is higher. Sweet clover grows in abundance upon these features. The location of these positive linear features are shown on the accompanying maps.

The drift, which covers the positive linear features is always thicker on the sides than on top. In a few locations (Stations 23, 77 and 83) the drift found adjacent to these features is a very well preserved sandy-silt till. This type and thickness of till is not found in adjacent areas.

The sediment deposited on either side of these positive linear features appeared to be the same. By studying the characteristics of the surficial sediments on either side of the features a relative age of formation could be determined. For example, if a lodgement till was found on the stoss side of the bedrock ridge, and a subglacial meltout till on the lee side, then the bedroc feature probably formed before the last glaciation.

In a few areas (Stations 86, 109, 110, 128 and 224) shoreline deposits were found to have developed upon and conform to the linear features (see accompanying maps). This suggests some of the linear features were present when the Belleville Stage of Lake Iroquois covered the area. This does not necessarily indicate that the features formed before the glacier retreated from the area, for the Belleville Stage of Lake Iroquois occurred approximate 3,000 years after the ice retreat.

A few of the positive linear features (Stations 82, 99, 184 and 229) do not have shorelines developed on them or have a well developed till abutting them (see unsorted sediment; till). This may indicate that they buckled following the retreat of the glacier and after the Belleville stage of Lake Iroquois. Alternatively the buckles may have been below, or well above wave base and there was no opportunity for a beach to develop.

positive linear features. At two locations, Stations 42 and 117, an ancient shoreline crosses a linear depression which is oriented tangentially from the positive linear feature. The portion of the shoreline which was deposited upon these linear depression is no longer present. Three reasons for the absence of the ancient shoreline were given above (Linear depression).

c) Scarp

For the purpose of this paper a scarp is classified as either:

1) A steep slope separating two different bedrock units or

2) A vertical displacement of the bedrock surface, not necessarily the same rock unit, which has formed a steep slope.

Three scarps were identified in the study area. County Road 24 is located parallel with the first one. Relief along this scarp is commonly 10 to 15 m. Liberty (1961), Carson (1981) and Water and Earth Science Assoc. Ltd. (1985) have indicated that this scarp formed due to faulting and results in the vertical displacement of the upper and lower Lindsay.

The second scarp is located in the eastern portion of the study area near South Bay. Relief along this scarp is commonly 12 to 18 m. Liberty (1961), Carson (1981) and Water and Earth Science Assoc. Ltd (1985) have identified this scarp as the contact between the Verulum (the lower unit) and the Lindsay. The third is aligned with the Black River southeast of the Village of Milford. Relief along this scarp is commonly 12 to 20 m. Carson (1981) and Water and Earth Science Assoc. Ltd. (1985) indicate that this scarp marks the contact between the Lindsay and the Verulum. It should be noted that many of the bedrock exposures at the base of the Valley west of the contact indicated by Carson (1981) have weathered red and may possibly be the Verulum Formation.

d) East/West Rises

On a regional scale these rises in the bedrock surface are oriented approximately in an east to west direction (for example, Stations 14, 59, 66, 84, 115, 223 and 224; Map 1). They range in relief from 0.50 m to a maximum of 6.0 m. One side of these features is steeply dipping and another is dipping gently (Fig. 2). Overall, the side which is dipping gently is at a higher elevation than the surface on the side of the steep rise. Although covered with sediment the bedrock bedding surfaces appear to conform with the surface rather than being stepped (Fig. 2). Many of the shorelines shown on the accompanying maps abut or rest upon these rises.

In many locations there is a change in aspect of the linear depressions and positive linear features where they cross the rises. For example, Station 86, a positive linear feature, is described as a bedrock buckle covered by winnowed sediment. It remains a positive linear feature until it crosses an east to west rise where its aspect changes to a linear depression (Station 71). This change in aspect can be found at other localities (Stations 83, 116 and 184).

The bedrock unit does not appear to be different on either side of the rise. These features appear 'buckled' and not stepped. In addition, the aspect of other features change when they cross the rises (Stations 71, 83, 86, 116 and 184). This suggests that the east/west rises are folds.

Configured Ground

In addition to the lineaments there are small and large scale features which form irregular and irregular patterns on the airborne photography. These patterns can be divided into two groups.

a) Circular Features

Circular features have either positive and negative relief. The depressions can be subdivided according to scale. The small depressions which are commonly less than 6.0 m in diameter and appear to be 0.20 to 0.30 m deep, are found throughout the study area although they are found frequently on the west side of linear depressions and positive linear features. These depressions may be karst wells or solution pits which formed due to solution of the limestone by either meteoric water and groundwater or by subterranean-flowing meltwater. Examples of these features are found at Stations 94, 137 and 146 (see accompanying maps).

Larger depressional features are also found throughout the study area. These features are up to one kilometre in diameter and are greater than 2.0 m deep. Swamps are commonly found upon these areas. These depressions may be sinkholes or shallow basins which formed due to normal groundwater flow or due to subterranean flowing meltwater. The importance of solution of limestone by meltwater is discussed by Vivian (1970) and Smart (1986). The significance of meltwater within the study area will be discussed in a later section (Abrasion).

The positive features, similar to the negative features, are found often in close proximity to the linear depressions and positive linear features. They are 2.0 to 4.0 m in diameter and are filled commonly with limestone and Precambrian boulders.

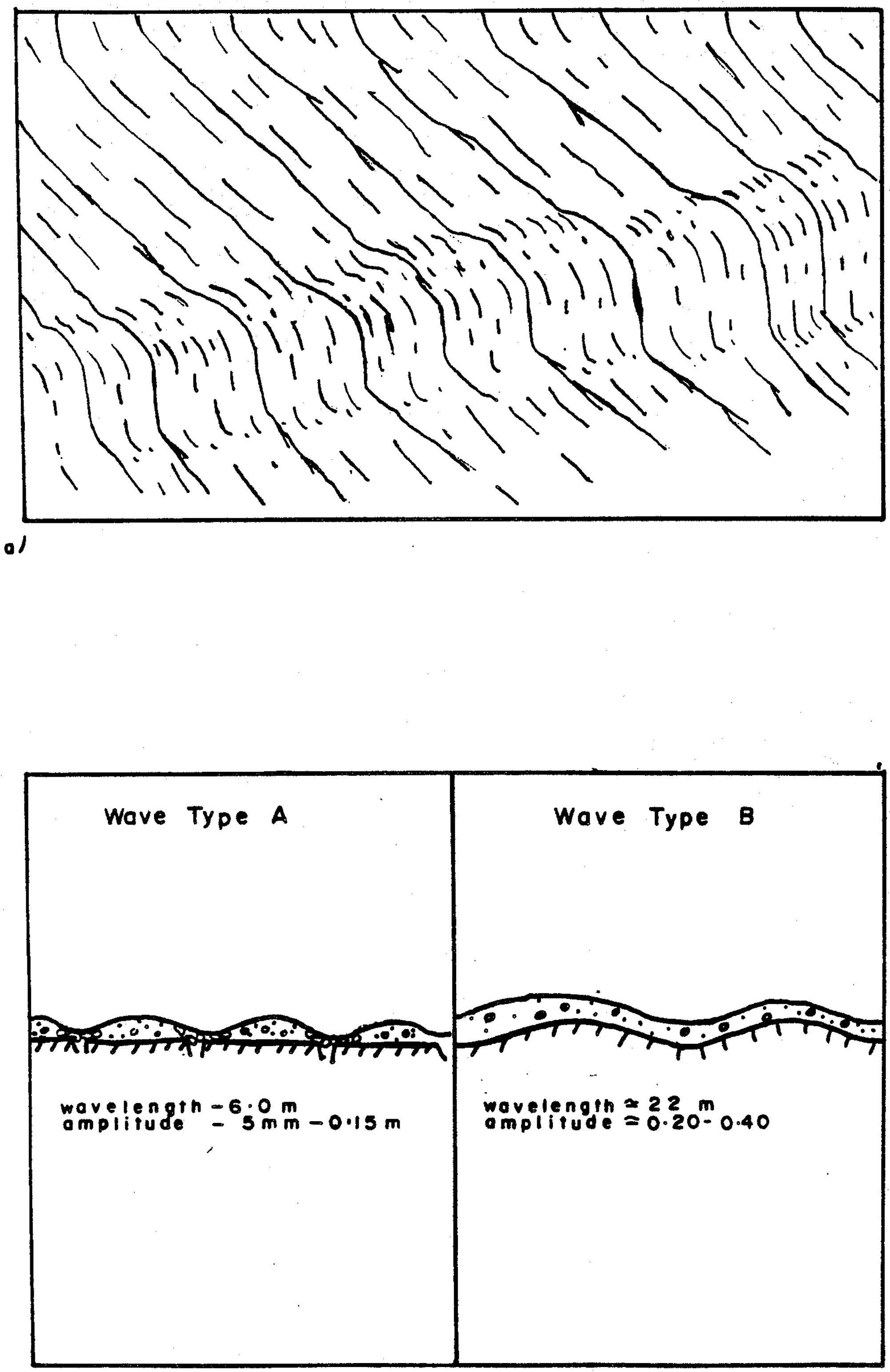


Figure 2: a) Diagram of a typical east/west rise.
b) Diagram of wave type topography.

b) Wave Topography

Waves are the undulating topography consisting of parallel linear alignment of ridges consisting at least in part of sediment are oriented approximately 060°, 125° and 148°. Relief is commonly 0.06 to 0.13 m and the spacing between ridge crests was found to be approximately 6.0 and 12.0 m. In many cases there is a higher proportion of matrix within the sediment at the crest of the mounds than in the sediment within the wave troughs.

At first it was believed that the waves represented an old plowing pattern. However, this pattern is identical on opposite sides of roads, east to west rises, swamps and wooded areas. This wave-like pattern is also present in a few areas where bedrock exposures were examined, but the amplitude or relief is usually smaller.

This pattern was found throughout the area where the drift thickness is less than 2.0 m. Near the positive linear features these wave-like patterns change in the following way.

1) The orientation of the waves change abruptly. An example of this is at Station 135 where the waves change from orientation 125° to 080°, then change to 100° and then back to 125°.

2) The waves are displaced laterally as they cross the positive linear features. Examples of this are found at Stations 82 and 134.

The wavy topography has a similar orientation to the orientation of many of the joints. This similarity may have been caused by preferential erosion along the joints which is supported by the observation that there is less matrix in the troughs of the waves than there is on the crest. It is also possible that meteoric water may have eroded and transported the sediment down through the fractures leaving the clasts behind. This again suggesting that movement of water through the fractures in the last 12,000 years had been significant. This type of waved topography has been classed as Type A Waves (Fig. 2b).

The wave-like topography within the study area may not all have been formed by the transportation of sediment down joints. At Stations 22, 25, 35, 38 and 41 (see accompanying maps) the sediment overlying the bedrock was excavated and a waved bedrock surface was observed. The approximate wavelength and amplitude of these features are 22 m and 0.10 to 0.20 m. respectively. This type of waved topography has been classified as Type B waves.

Waved topography was divided into two types because there appears to be a distinct difference between the two types. These types are shown in Figure 2. Type A waves probably formed due to transportation of sediment down joints. Although this is definitely a recent activity, it does not necessarily involve tectonic activity. Type B waves though, were not formed in this manner. The bedrock ground surfaces actually undulate where these waves are found. In addition, the sediment which was deposited on them conforms to the wave shape and does not noticeably change texture between the crest and trough. It is possible that these waves formed due to neo-tectonic events. More evidence is required to prove that these waves were caused by neotectonic activity.

Discussion

In the area studied three main processes appear to have affected the bedrock geology. These processes are 1) tectonic, 2) karst and 3) glacial. The glacial or Quaternary influence will be discussed in the next section.

The positive relief linear features, wave-like topography, east/west rises, scarps and the consistent pattern of the fracture traces are probably tectonic in origin, the age of which appear to be ancient.

Solution weathering is widespread as evident by the calcite precipitate within the gaps and crevasses and the circular depressior interpreted as sink holes, karst wells and solution pipes. Therefore, it appears that the solution and other karst activity had a substantial impact on the terrain.

Image on the Mosaic

1) Joints - regular cross-hatched pattern of alternating light and dark tones.

2) Lineaments

   a) linear depressions - broad, longitudinally extensive and dark-toned;

   b) positive linear features - longitudinally extensive, narrow, straight and light toned;

   c) scarp - light toned cross-cut all features and

   d) east/west rises - broad light toned areas, the lightest tone is generally on the south side.

3) Configured ground

   a) circular - broad, irregular-shaped and dark toned (swamps) and

b) waved - regular cross-hatched pattern of alternating light and dark tones.

Soil Features

Quaternary sediments overlie the bedrock features. If any neo-tectonic activity has occurred, post-depositional deformation of many of the primary sedimentary structures and bodies should have also occurred. However, there are depositional processes which can deform primary structures and therefore the deformation may not necessarily be caused by tectonic events. The Quaternary sediments have been divided into four categories; abrasion, unsorted sediment, sorted sediment and sorted sediment of glacio-lacustrine origin.

1) <u>Abrasion</u>

Bedrock is exposed at the base of many of the ditches and along the walls of the scarps in the study area. Forms produced by sub-glacial abrasion were observed at these exposures. Three types of abrasion forms were identified:

a) striations
b) p-forms, cavettos and sichelwannen
c) possible large scale features

Many of these features were observed cross-cutting the bedrock rock joints with no obvious displacement. However, in a few locations displacements in the order of 2 to 3 mm were found.

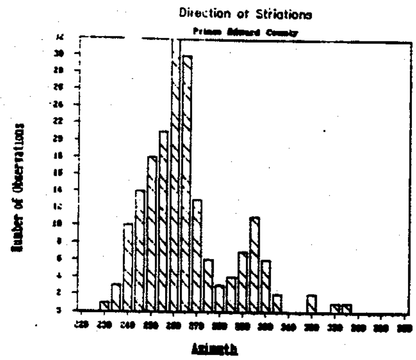
Striations

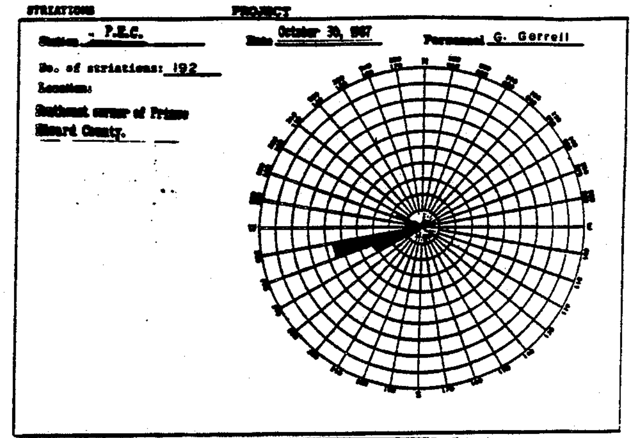
As shown below (Fig. 3), the striations which were measured in the study area are grouped around two different directions, 255° and 293°. These orientations are different to those reported by Leyland (1981), who may not have accounted for the magnetic declination.

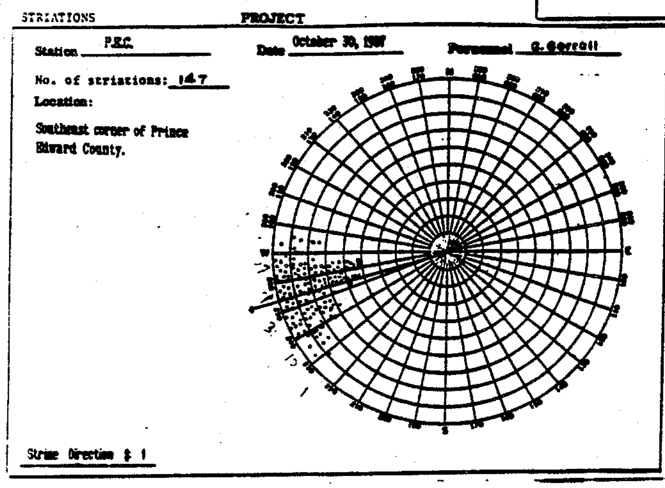
In a few areas the striations oriented approximately 255° are cross-cutting the striations oriented 293°. The ice flow towards 293° was the older flow. The ratio of the number of striations oriented 255° with respect to the ones oriented 293°, is approximately 4 to 1 and supports this contention. The youngest glacier (255°) probably eroded the striations abraded by the older (293°) one (Flint, 1971).

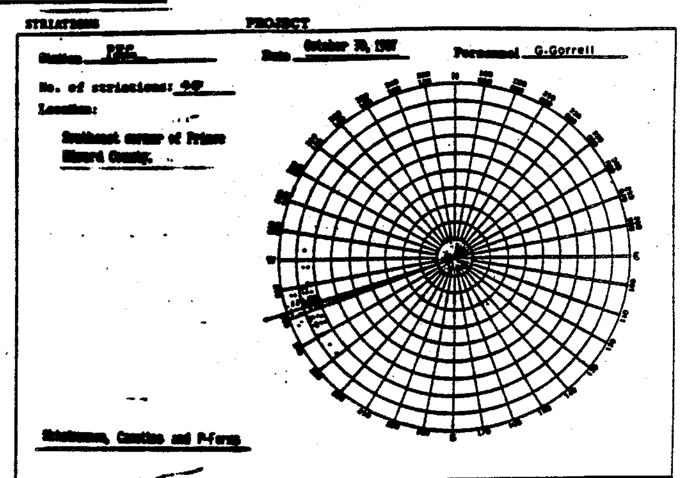
The different striae orientations may indicate two advancements rather than striations caused by a lobating glacier or striations created by divergent flow caused by the glacier flowing over topographic irregularities. It is possible also that the two striae directions may be due to an internal realignment of the glacier and that there were not two advances at all.

Possible evidence for a single advance are that the sichelwannen (sickle shaped features) and plastically sculptured forms









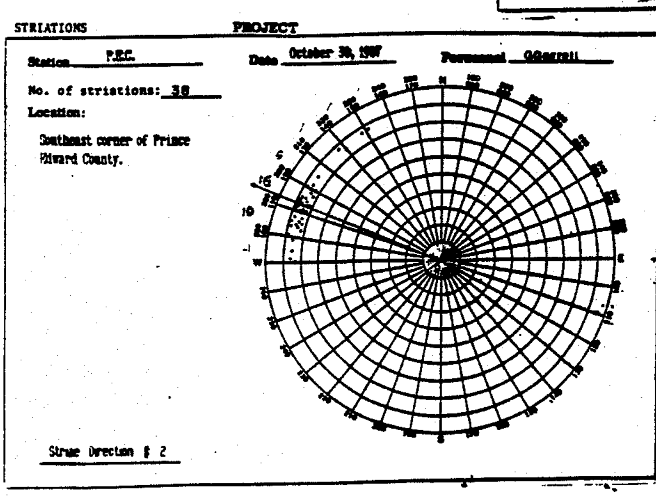


Figure 3: Striae, sichelwannen and cavettos flow directions.

(p-forms; Dahl, 1965) are associated with only the 255° orientation. This suggests that conditions beneath the glacier may have changed after the formation of the older set of striae near the end of the glacial period, and that the sichelwannen and p-forms were produced because of these different conditions (see below, P-forms, Cavettos and Sichelwannen). The glacier may have realigned its flow direction as internal glacier conditions evolved.

In most cases the lateral extent of the exposed striated bedrock surface was not extensive. These small exposures make it difficult to determine whether the striations have been affected by any neo-tectonic movement. However, in two areas the bedrock surface was exposed for tens of metres.

The first (Station 25) is located south of the western pond created by Ducks Unlimited. At this location the bedrock surface is polished and striated. This striated surface extends westward for tens of metres to terminate abruptly along a lineament oriented 125°. The orientation of the striae do not change near the lineament, they just stop. The bedrock on the west side of the lineament is stepped upwards with respect to the polished surface. This suggest that:

1) The bedrock surface has been ruptured subsequent to it being striated or

2) That the type of bedrock on either side of the lineament is different, and that the western side had weathered faster

The second area (Station 228) is located southeast of the first and is found near the modern shoreline. At this location the surface is striated in two directions, 255° and 295°. Many of the striations oriented 295° are cross-cut by ones oriented 255°. These 255° oriented striations are funnelled through sichelwannen (see below) oriented 252°. Portions of the exposure have weathered considerably and are up to 50 mm higher in relief than the rest of the outcrop. The striae described above do not terminate against these weathered rises, but rather flow either around or up their sides. These points suggest that:

1) the last major ice flow in the area was towards 255°;

2) the sichelwannen formed prior to the striations;

3) the raised weathered surface (described in the two examples given above) is probably due, at least in part, to the preferential weathering of a bed in the Lindsay and

4) that the step a Station 25 may caused by postglacial

movement of the bedrock surface because none of the striae, p-forms and sichelwannen flow around it as they do to the step at Station 228. The cause of the movement is unknown but may be due to earth tremors or collapse caused by solution of underlying limestone beds.

P-forms, Cavettos and Sichelwannen

The origin of P-forms (plastically sculptured forms; Dahl, 1965), cavettos (grooves) and sichelwannen (crescent-shaped erosional marks) is presently open to debate. They may form due to:

1) erosion by "tools' embedded at the base of the glacier (Boulton 1974);

2) erosion by saturated till (Gjessing, 1967) or

3) erosion by meltwater moving at high velocities due to large pressure gradients causing cavitation (water hammer; Barnes, 1956), erosion by helical spirals (Shaw, 1983), solution (Vivian, 1970) and corrasion by rapidly flowing sediment-laden water (Allen, 1971; Gray, 1981).

The third process is favoured by this author because, in his opinion, the principles involved are more logical and yield a more comprehensive explanation.

These forms, which are oriented 252° (Fig. 3), represent erosion of the bedrock at an earlier period than the striations oriented 255°. This is supported by the location of the striations which are without exception superimposed upon, and divergent into, these larger forms. This may indicate that the glacier underwent internal realignment after the striations oriented 293° were eroded before the formation of sichelwannen and p-forms. Alternatively, it may indicate that two ice advances occurred.

Possible Large-scale Forms

Large scale forms can be broadly called ice-directed channels and tend to be oriented parallel to sub-parallel with ice movement (Sugden and John, 1982). Similar to p-forms, sichelwannen and cavettos the genesis of these features is presently under debate. The features may form due to:

1) ice streaming or

2) meltwater erosion.

Two such channels were identified in the study area. These valleys are classified as large-scaled erosional forms because of the morphology of the valley. County Road 24 is parallel to the first valley which is oriented approximately northeast to southwest. This feature has been identified as a fault between the upper and lower Lindsay (Liberty, 1961; Carson, 1981). The second, which is oriented approximately east/west, is located on the eastern side of the study area near the Village of Milford. This valley was identified as the contact between the Lindsay and the Verulum (Liberty, 1961; Carson, 1981).

The examination of the margins of the first valley on aerial photographs and in the field indicates that the valley walls have been sculpted and stream-lined by glacial processes. The base of this valley is filled with medium to coarse sand which is at least 2.0 m thick (Stations 138, 139 and 230) and large bodies of unsorted sediment (Stations 1, 138 and 139). This valley can be traced directly into the Village of Cherry Valley where a glaciofluvial sedimentary body had been deposited (Leyland, 1982). Although the valley was formed tectonically (Liberty, 1961; Carson 1981) it is possible that this valley was also sculpted by a southwestern-flowing glacier and possibly later by meltwater which flowed under high pressure gradients. The relative importance of each glacial processes is unknown.

The second valley is not as large as the one described above. However, the amount of alteration which may be attributed to glacial processes appears to be more extensive than for the first. One of the most obvious examples that may be attributed to glacial alteration is the terraces along the sides of the valley. Although these terraces are covered by both sorted and unsorted sediment, the unconsolidated sediment represents only a veneer upon the underlying bedrock. Where the valley is straight (Stations 156 and 159) these terraces are found on both sides. However, where the valley bends (Station 168, Fig. 4) the terraces are found only on, if the meltwater flowed westward, the convex bank of the channel. That the meltwater flowed westward is supported by the direction of the paleocurrent within the glaciofluvial bodies near Milford (see Sorted Sediments-Glaciofluvial Origin). There are no terraces on the near vertical concave bank. In addition, where the bend ends, a 3.0 m deep trough has truncated the bedrock.

Remnants of circular bedrock cuts up to 14 m high and 6 m in diameter (Stations 163 and 164) are found adjacent to this trough, just at the point where the bend, ends. South of the concave bank, and above the channel, are crevasses which consist of a series of elliptical holes (Station 163) whose long axis is oriented parallel with the sides of the valley. Many of these holes have large Precambrian clasts lodged into them. Not all of these holes are located where joint sets intersect.

The large clasts which are lodged into the elliptical holes

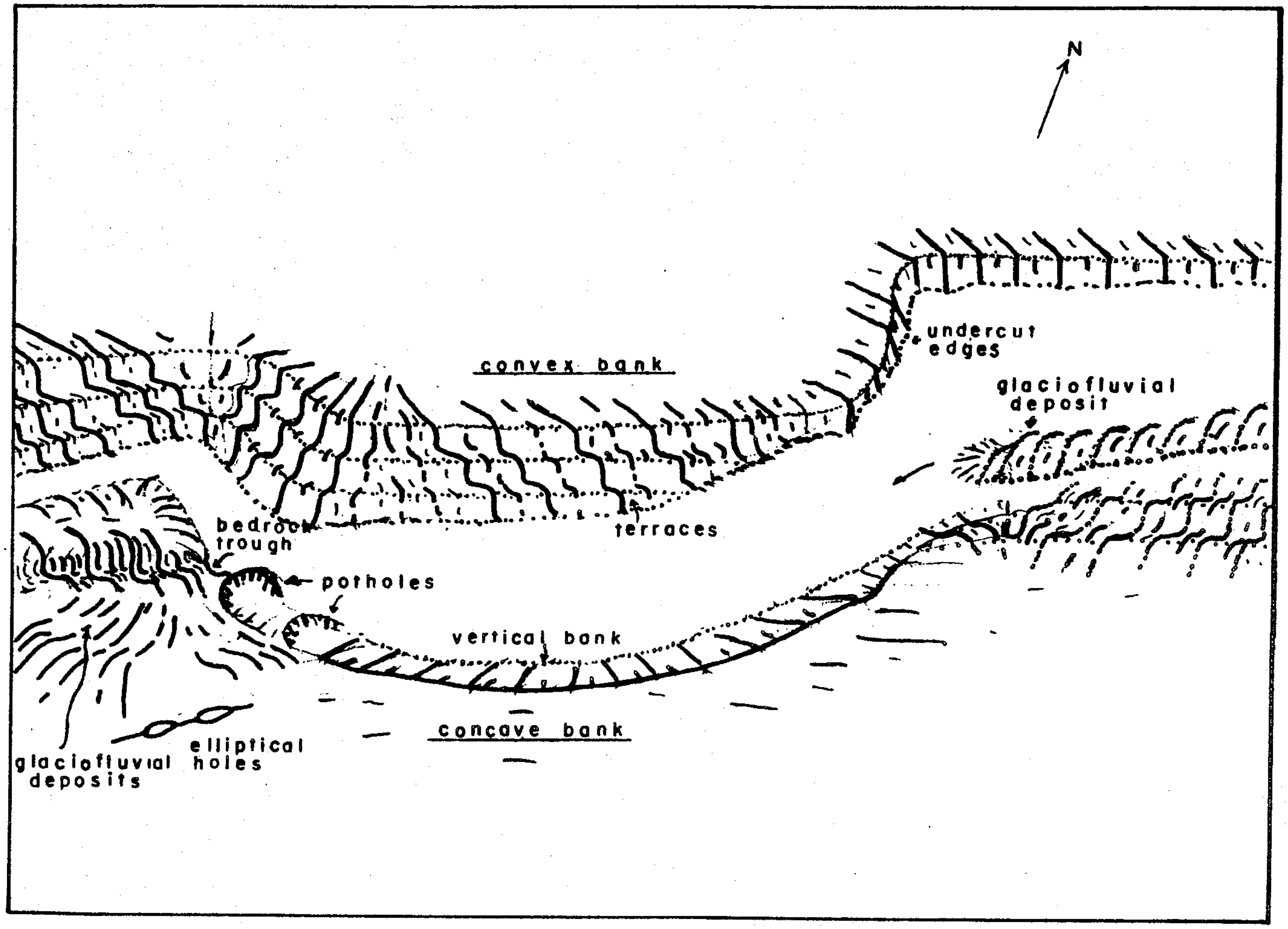


Figure 4: Abrasion forms which are along the valley west of Milford.

may be boulders carried by the glacier or by meltwater. If the crevasses were open during glaciation they would be a zone of low pressure and therefore a preferred area of deposition (Rothlisberger, 1972; Shreve, 1972; Weertman, 1972; Nye, 1973; Boulton, 1974). Because the clasts are so large, they would not be able to fit down the crevasses and would be lodged in the crevasses as the glacier flowed over it or would become wedged as the meltwater flowed down and through the crevasses.

The convex and concave bank configuration and bedrock trough indicates that preferential erosion has occurred similar to that found along bends in modern rivers. This suggests that large volumes of meltwater may have been discharged through the valley. That there had been substantial discharges of water through the valley would explain the large and small-scale circular cuts which are similar to potholes cut by meltwater described by Gjessing (1967). The discharge of large volumes of meltwater through the valley is supported further by the presence of glaciofluvial sediments along the valley walls (Stations 148, 149, 154, 163 and 166) and the sculpted 'rock drumlin' at McMahon Bluff on the eastern end of the valley.

The above discussion indicates that it was quite possible that some of the fractures were open before, or at least during, the last glacial advance. If the fractures were open and meltwater had flowed through them, the large Karst features in the area may be due primarily to solution by meltwater. Vivian (1970) indicated that in Europe many of the Karst features may have been produced in this manner.

Smaller channels which range in depth from one to greater than two metres are found throughout the area (Stations 152, 194, 196, 210, 219, 220). All these channels are filled with sediment which made it impossible to determine whether they are erosional features similar to those described above or a result other process (Configured Ground; waves).

2) <u>Unsorted Sediments</u>

Till

Two types of tills were observed in the study. The most common till in the area thinly covers the bedrock. This till, which is a minimum of 0.15 m thick, consists of angular limestone and Precambrian clasts in a sandy-silt matrix. Since the till cover is generally thin, pedogenesis processes have altered it considerably making it difficult to distinguish from weathered bedrock. The main distinction of the till from weathered bedrock is the inclusion of sub-angular Precambrian clasts with diameters up to 0.85 m. A few of the clasts were observed to be striated.

The second type of till is found abutting a few of the positive linear features (Stations 23, 77 and 178) and along side bedrock rises (Stations 1, 51, 127, 133 and 152). In contrast to the till described above, this till is composed of poorly sorted clayey-silt and very small clasts which are less than 30 mm in diameter. These clasts are striated and are of generally Precambrian origin. Where exposed (Station 1), this till exhibits sub-horizontal joints (fissility) approximately 20 to 40 mm thick which extend laterally for approximately 1.50 m. A till fabric for this till is shown in Figure 5. Since the exposure was limited, only a few clasts could be measured and the fabric should not be considered conclusive.

Since there are few exposures it is difficult, at this time, to classify these two tills. However, on the basis of grain-size, degree of consolidation and internal structure (ie: jointing) the tills described above are tentatively classified as melt-out and lodgement, respectively. The first till was classified as melt-out because the process of melt-out is generally yielding and the deposited sediment generally maintains the grain-size characteristics of the material in transport (Shaw, 1985). In contrast, lodgement tills are abraded during and after deposition. They are therefore finer than melt-out tills derived from the same material (Haldorsen, 1981; Shaw, 1985). In addition, the sub-horizontal jointing observed within the second type of till is typical of till which has undergone slight thrusting during lodgement (Boulton, 1971; Shaw, 1985).

If the sediment deposited on the stoss side of a positive linear features is lodgement till, this may suggest that the feature were present when the glacier overrode the area. The main difficulty with this argument is why these features, which have positive relief, were not eroded by the glacier.

Boulton's (1974) description of subglacial erosion and deposition may explain why the positive relief linear features could survive overriding. As shown in Figure 6, Boulton indicates that there are relationships between effective normal pressures and abrasion rates for different ice velocities. If the effective normal pressure never reached values sufficient for abrasion (Boulton's Zone C) subsequent to the ridge buckling, the feature would not have been eroded but only have material lodged upon it.

Alternatively, the material on the side of the feature may not be lodgement till but another type of sediment. For example, there may be more infiltration along buckles, hence pedological processes may have altered considerably the original sediment. A third hypothesis is that the sediment abutting the positive linear features may be till that was squeezed from a linear depression when the bedrock buckled.

To determine if the sediment is a lodgement till or a till

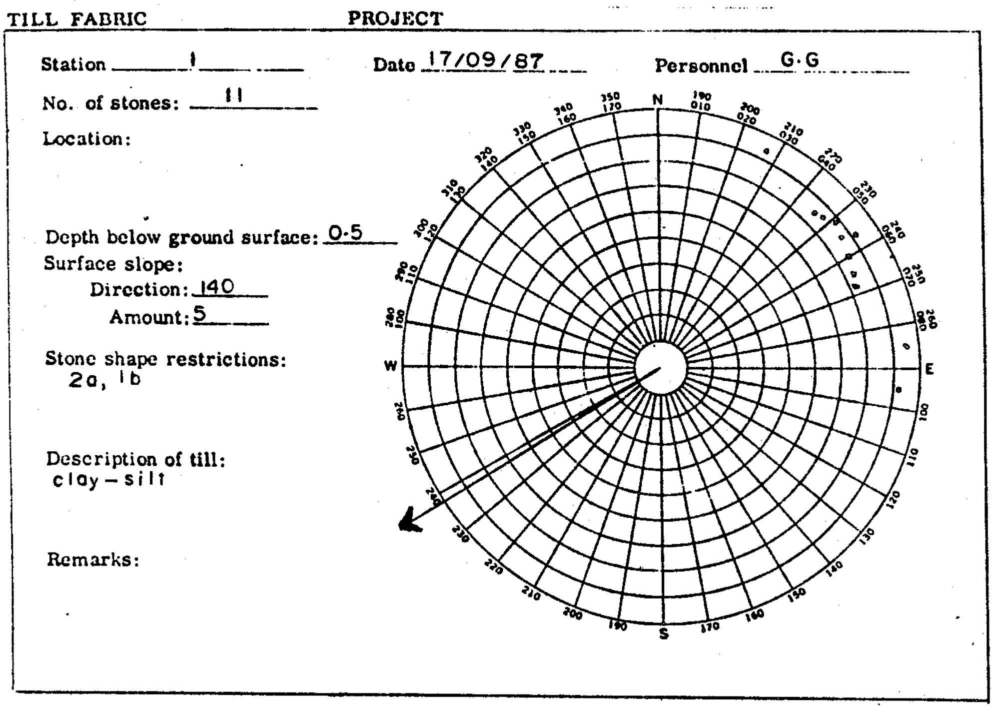


Figure 5: Till fabric for Station 1.

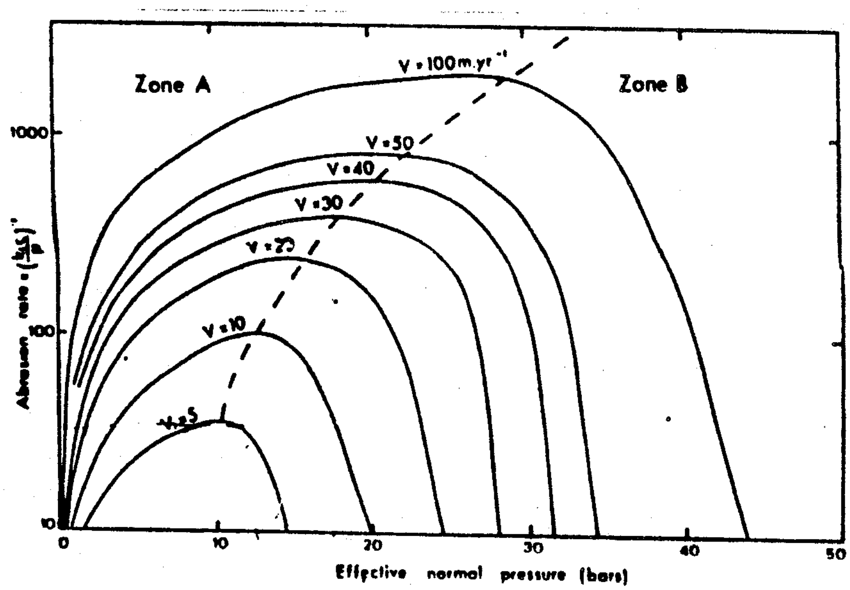


Figure 6: Theoretical abrasion rates plotted against effective normal pressure for different ice velocities. In zone A the abrasion rates increase with increasing pressure. In zone B, the abrasion rates fall with increasing pressure. In zone C (to right of higher x-axis intercept for any one velocity) no abrasion occurs and much of the sediment in transport is deposited as a lodgement till (Boulton, 1974).

which has been squeezed from a linear depression would involve excavating a trench across the feature and examining the structure of the sediment. Trenching may help determine the relative age of the positive linear features as well for if they were present prior to the ice advance, lodgement till would most likely be deposited of the stoss side of the bedrock ridge. On the lee side of the ridge a subglacial cavity would probably have existed. This cavity would be filled with either meltout till of flow varieties of till. However, if the sediment is rhythmically bedded glaciolacustrine sediment which has been deformed, the time of deposition would be considerably different.

Diamicton

The type of sediment found in most of the crevasses and linear depressions is a diamicton. It has been classified as diamicton because it consists of unsorted sediment that cannot definitely be identified as being deposited directly by the glacier. Many of the crevasses and linear depressions have been probed to a depth of 1.10 m and it was observed that pedological processes have altered the sediment to a considerable degree. The sediment in the crevasses and linear depressions may be:

1) melt-out till which has undergone pedological modification;

2) an unsorted mass which had been deposited as a slurry down and through the crevasses and linear depressions;

3) supraglacial sediment which was deposited into the crevasses and linear depressions as the glacier melted or

4) glaciofluvial or glaciolacustrine sediment which has undergone pedological alteration.

Further investigation is needed to correctly classify this sediment.

The presence of this material indicates that these linear depressions and crevasses were open when the glacier covered the study area. As suggested above (Joints) these crevasses may have opened because the joints dilated due to glacial unloading. Possible ramifications of this will be discussed below.

Boulders

The classification of this type of material in the unsorted category is arbitrary for, as will be shown below, the boulders may belong in the sorted category.

The boulders have been grouped into a single category because in many areas (Stations 46, 48, 51, 66, 71, 133, 134, 163 and 188) solitary boulders were found. At all the stations listed above these boulders are beside or lodged within crevasses. This observation was so consistent that when large boulders were seen, the author immediately looked for crevasses.

The boulders which are wedged into the crevasses may have been part of the sediment carried by meltwater or by the glacier. If the crevasses were open during glaciation they would create a zone of low pressure and therefore would be a preferred area of deposition (Rothlisberger, 1972; Weertman, 1972; Nye, 1973; Boulton, 1974). Because the clasts are so large, they would not be able to fit down the crevasses and be lodged in the crevasses as the glacier flowed over it or become wedged as the meltwater flowed down and through the crevasses.

Boulders are virtually absent other than within and surrounding crevasses (for example; Stations 42, 66, 74 and 134). This and the observation that unsorted and sorted sediment are found within the crevasses (Stations 66, 173, 175, 205 and 223) suggests that the crevasses were open when the glacier covered the area. The large Precambrian clasts were too large to fit into the crevasses, while the finer sorted and unsorted sediment would readily fill the already opened crevasses. If this hypothesis is correct the boulders may be the coarse portion of the diamicton found within the linear depressions and crevasses. Alternatively the boulders may be sediment that was carried by meltwater which could not fit through the crevasses.

Irrespective of the origin of the boulders which are wedged into the crevasses, their presence suggests that the fractures were open when the glacier covered the area. It is possible that the karstic-type terrain pervasive in the area was caused by groundwater flow in the fractures for greater than 12,000 years. In interstatial times the karst development may have preceded slowly. During glacial periods this development would accelerate because of the large influx of cold water which would probably not have a high dissolved load.

3) <u>Sorted Sediments- Glaciofluvial Origin</u>

As discussed above the boulders which are lodged into and adjacent to the crevasses may have been carried by subglacial meltwater and may be considered glaciofluvial. This is a possible explanation because a few of the crevasses (Stations 132 and 226) are filled with sorted sediment, which may be of glaciofluvial origin. However, as discussed earlier, some of the crevasses are filled with diamicton which may have been squeezed directly into the crevasses by the glacier. Irrespective of the boulders, sorted sediment of glaciofluvial origin may be broadly divided into two categories; coarse and fine.

Coarse Grained Sediment

Coarse sorted sediment of glaciofluvial origin can be found at two locations in the area studied. The first location is at the base of the scarp west of County Road 24 (Stations 140, 142, 143 and 230). Here the sand is composed of many Precambrian fragments and is least 2.0 m thick. This sediment may be a continuation of the glaciofluvial sediment identified (Leyland, 1982) in the Village of Cherry Valley. However, because there were no exposures it was impossible to tell if this sediment has been deformed.

The second location is in the valley east and west of the Village of Milford. East of Milford, the sediment consists of a broad flat topped sedimentary body consisting of trough cross-bedded and planar cross-bedded coarse to medium sand with a paleocurrent oriented approximately 260°. A few normal and reverse faults are found on the southern side of this sedimentary body.

This system can be traced laterally west along the valley (Stations 154-157, 161, 166 and 199) where it grades into fining upward cycles consisting of, in ascending order:

1) planar cross-bedded medium to fine sand, cross-laminated (Type B) fine sand and rhythmically bedded silt and clay,

2) normally graded sand with very thin silt caps.

Small scours are interspaced throughout the sediment. These scours are filled with, in ascending order, rhythmites of silt and clay, and massive fine to silty sand. These scours suggest that sedimentation was rapid and probably due to high concentration quasi-continuous turbidity flows (Gorrell, 1986; Gorrell and Shaw, in prep.).

Small fluidized channels are found throughout both of the cycles. In many cases these channels are truncated at the contact with the bed overlying it. These channels are bent in the downstream direction suggesting that the loading which caused dewatering was due to rapid sedimentation. The presence of normally graded fine sand supports this. Lowe (1975, 1976) suggests that grading of this type may be due to progressive liquefaction of the sediment as a load is rapidly applied because of burial.

Small normal and reverse faults are found throughout the cycles. In many cases the sediment has folded prior to faulting.

This indicates that the sediment was wet when it faulted. Therefore the sediment faulted either just after it was subaqueously deposited or during the period when Lake Iroquois covered the area. It is unknown whether the faulting is due to ice block melt (McDonald and Shilts, 1975) or to neo-tectonic movement.

The author believes that ice-block melt is the most probable explanation. This is because, many of the sedimentary bodies have steep sides. These steep sides are probably caused by lateral ice support. The faulting which occurred then, is probably due mainly to the removal of lateral and underlying support when the ice melted.

Fine Grained Sediments

In the valley just south of Milford there is also a steeped sided ridge (Stations 151 and 165) consisting of normally and reversed faulted sequences of:

1) massive fine sand with clayey-silt to silty-clay caps and

2) rhythmically bedded silt and clay.

This ridge is adjacent to the sedimentary body which consists of trough cross-bedded and planar cross-bedded coarse sand described above. However, the top of the ridge is as much as five metres higher than the surrounding coarse sediment.

Even though the sedimentary body consisting of trough cross-bedded and planar cross-bedded coarse sand abuts the ridge consisting of fining upward sequences, it is apparent that the two bodies could not have been deposited in the same environment. The flow conditions are not nearly in the same range (Harms _et. al_, 1982). In addition, the sedimentary body consisting of coarse sand is not as faulted as the central ridge, suggesting different environmental conditions.

Explanations of drainage conditions within glaciers with stagnant marginal zones by Price (1973), Gustavson and Boothroyd (1982) and Haldorsen and Shaw (1982) provide a possible explanation for the ridge. They indicate that englacial tunnels form in stagnant marginal zones below the piezometric surface. These tunnels are filled with fluvial and debris-flow sediment. Because the sediment was deposited over ice, substantial amounts of reworking in the form of faulting and folding occurs as the ice melts and the tunnel was let down (Shaw, 1985).

The evidence fits this explanation. The ridge is located in a valley and it seem reasonable to assume that the last vestiges of the glacier will be controlled by the topography (Gadd, 1980;

Barnett 1978 and 1985). Although there are a few reverse faults, the majority of the faults are normal, suggesting that the sediment had collapse as the ice melted (Mcdonald and Shilts, 1975). The folds that were observed indicate that the sediment was wet when it collapsed; it was wet because it was probably below the piezometric surface.

The collapse of the sediment would account for some but not all of the fluidized channels, ball and pillow structures and dish structures that are found throughout the sequences. This is because the structures are found regularly spaced throughout the sequence suggesting that cyclical events were responsible for the deformation.

The englacial tunnels are filled with sediment derived from meltwater and debris-flows. Due to freezing at night and other internal glacial conditions these flows wan. This results in cyclical fining upward sequences where the upper layer is generally highly impermeable. High pore water pressures are produced because of rapid burial and the impermeable layers which hinder water seepage. Therefore, the features described above are probably pencontemporaneous deformation structures brought about by dewatering due to rapid deposition and burial (Kuenen, 1958; Sanders, 1965; Lowe, 1975 and 1976).

Alternatively, these features may also have formed due to seismic shocks (Peacock and Seed, 1968; Chagnon and Locat, 1987). However, in the environment described above, a shock is not required to form them (Lowe, 1975 and 1976).

4) <u>Sorted Sediments- Glaciolacustrine Origin</u>

This group can be broadly segmented into three units; 1) off-shore sediment 2) near-shore sediment and 3) shoreline sediments.

Off-shore Sediments

Sediments in this zone consist principally of silt and clay. They are deposited by underflows, debris-flows and suspension fallout and could also be grouped under fine glaciofluvial sediment. Since these processes are controlled partially by gravity, (density of ambient water, current, slope etc. also control underflows) they are found in topographically low areas. Sediments of this nature are found at Stations 127, 152-154, 174, 182, 186, 195, 196, 205, 209, 215 and 231.

The best exposure of these sediments was found at Station 154. The examination of the exposure indicates that it consists of numerous cycles of sediment which grade from very fine sand to silt interbedded with thick clay layers. The graded units are interpreted to be the distal portion of the graded fine sand units found at Stations 151 and 165. Turbidity currents or underflows were probably responsible for their deposition. The thick clay layers were probably deposited by suspension fallout during the winter months.

The fine sand portion of the rhythmites do not have any current bedding this suggesting that the source of the underflows were not in close proximity. This is supported by the thinnest of the individual fine sand beds which are no greater than 25 mm. If the source of the underflows was in close proximity there should be some variability in thickness between the very fine sand units. This variability was not observed.

The examination of the exposure also revealed that this fine sediment has been folded and faulted. These faults are oriented approximately 060° and 152°. It is possible that the faulting is due to removal of the underlying support as an ice clock melted. There is no way to prove conclusively whether the faults were cause by removal of support, for it is not a prerequisite that glaciolacustrine sediment be faulted. There are many examples of rhythmites in ice-contact lakes which are not faulted (Ashley, 1972; 1975).

It is also possible that rapid sedimentation was responsible for the folding and faulting. Sediment gravity flows and slump failures may have loaded the sediment, due to rapid sedimentation, causing the sediment to dewater. It is possible then, that some of the faulting was due to removal of underlying support as the sediment dewatered. The folding may be due to shearing action of the slump or flow.

The folding may be due also to dewatering and consolidation. As the sediment dewatered due to rapid loading it would retain sufficient strength to resist liquefaction and as a result it is folded (Lowe, 1975). The small faults which were observed may have been caused by this consolidation. Further study is required to determine whether this had occurred.

Alternatively, these features may also have formed due to seismic shocks. However, in the environment described above, a shock is not required to form them.

Linear mounds (Stations 153 and 214) are found south of the area described above. These mounds are approximately 500 m long and have a wavelength of approximately 55 m and are oriented approximately 250°. They are composed of up to 1.5 m of rhythmically bedded silts and clays. The underlying bedrock surface does not conform to these mounds. It is possible that these forms are:

1) glacial flutes caused by an advancing glacier similar to those described by Terasmae (1965),

2) flutes caused by meltwater erosion,

3) mounds caused by iceberg scouring or

4) offshore bars.

The author believes that the mounds are caused by iceberg scouring. The morphology of the mounds is similar to features described by Mollard (1983). Although there are no exposures to support this, the location of the mounds could tentatively be used as a supporting argument.

As shown on the accompanying maps, the mounds can be traced to the edge of the escarpment west of County Road 24, where they stop. It is possible that the depth of water on the eastern side of the escarpment was not sufficient to support the mass of the icebergs. Therefore, the sediment would be scoured because the icebergs were grounded. The water depth on the west side of the escarpment may have been sufficient to totally support the mass of the icebergs. The sediment on the western side would not be scoured because the icebergs were not grounded. Further investigation is required to determine the process responsible for their formation.

Near Shore Sediments

Near shore sediments are deposited just offshore from the shoreline. The extent of this environment ranges from the portion of the shoreline that was frequently, but not always, covered by water due to waves breaking on shore to the part of the shoreline that is always below water and lies between the lowest water line and the depth where sand is not found typically. This last part is the area where sediments derived from the land and the lake are collected. The lower limit of this zone corresponds to the average maximum wave base.

The above description is a subjective break-down and is based on the depth of water which is controlled by the fetch, seiche and other factors which will change the wave base. Spits, longshore bars and sediment with little matrix (winnowed sediment) are commonly found in this portion of the shoreline. Sediment of at least one of these types are found at the base of many of the shorelines shown on the accompanying maps.

However, in a few areas the ancient shorelines cross linear depressions and, without exception the shoreline does not exist at these locations. If this gap was a channel along the glacial-lake shore it may have been a focus for currents flowing offshore.

Shoreline Sediments

The shoreline is the part of the beach that is located above the average high-water level. It is subjected to modification by waves only when water levels are extremely high. Beach ridges are formed by these storms.

Six and possibly seven shorelines were identified in the study area. These shorelines can be traced laterally for up to 5 kilometres, and are customarily no thicker than 1.50 m. They commonly consist of alternating units, up to 60 mm thick, of open-work fine gravel and either cross-bedded or plane bedded fine to coarse sand. Definite shorelines are found approximately at 85, 88, 91, 94, 98 and 101 m ASL (280, 290, 300, 310, 320 and 330 feet). A washed level may be found at 82 m ASL (270 feet). This level is found only in the western portion of the study area. Although segments of this level are definitely shoreline features other portions are probably nearshore (ie. spits, offshore bars) features. These shorelines are shown on the accompanying maps.

The shorelines may all fall within the Belleville Stage of Lake Iroquois (Mirynech, 1962; Fig. 7). However, the upper 94-101 m ASL levels do not correspond to Mirynech's isostatic levels for the shorelines in the area (Fig. 8). In addition, if the study area is divided into east-west zones, with the dividing line starting approximately two kilometres east of Gull Pond and oriented 125°, the same number of shore-levels do not exist on either side of the line. Investigation has found that on the eastern side of this line only the 88, 91, 94, 98 and 101 m ASL shore-levels are found, but the lower 82 and 85 m. ASL levels are not. This suggests that there may have been changes in relief during the later part of the Belleville Stage of Lake Iroquois.

The levels may indicate also that one of the other late stage Iroquois shoreline levels or another stage not previously unrecognized are in the study area. Previous lake reconstructions were not of the detail required for this type of investigation and it is possible that a level was not identified. The shorelines at 94 m, 98 m, and 101 m ASL are, where they are found in the study area, far above the Belleville beaches and well below the Sidney and Frontenac stages of Lake Iroquois. An alternate explanation is that the isobases which have been calculated for the area, are incorrect.

At four locations, Stations 57, 58, 68 and 71 ancient shorelines have crossed linear depressions. The shoreline does not cross these linear depressions. The reasons for the absence was discussed previously (Lineaments, linear depressions).

As discussed previously (Lineaments) the suggestion that the

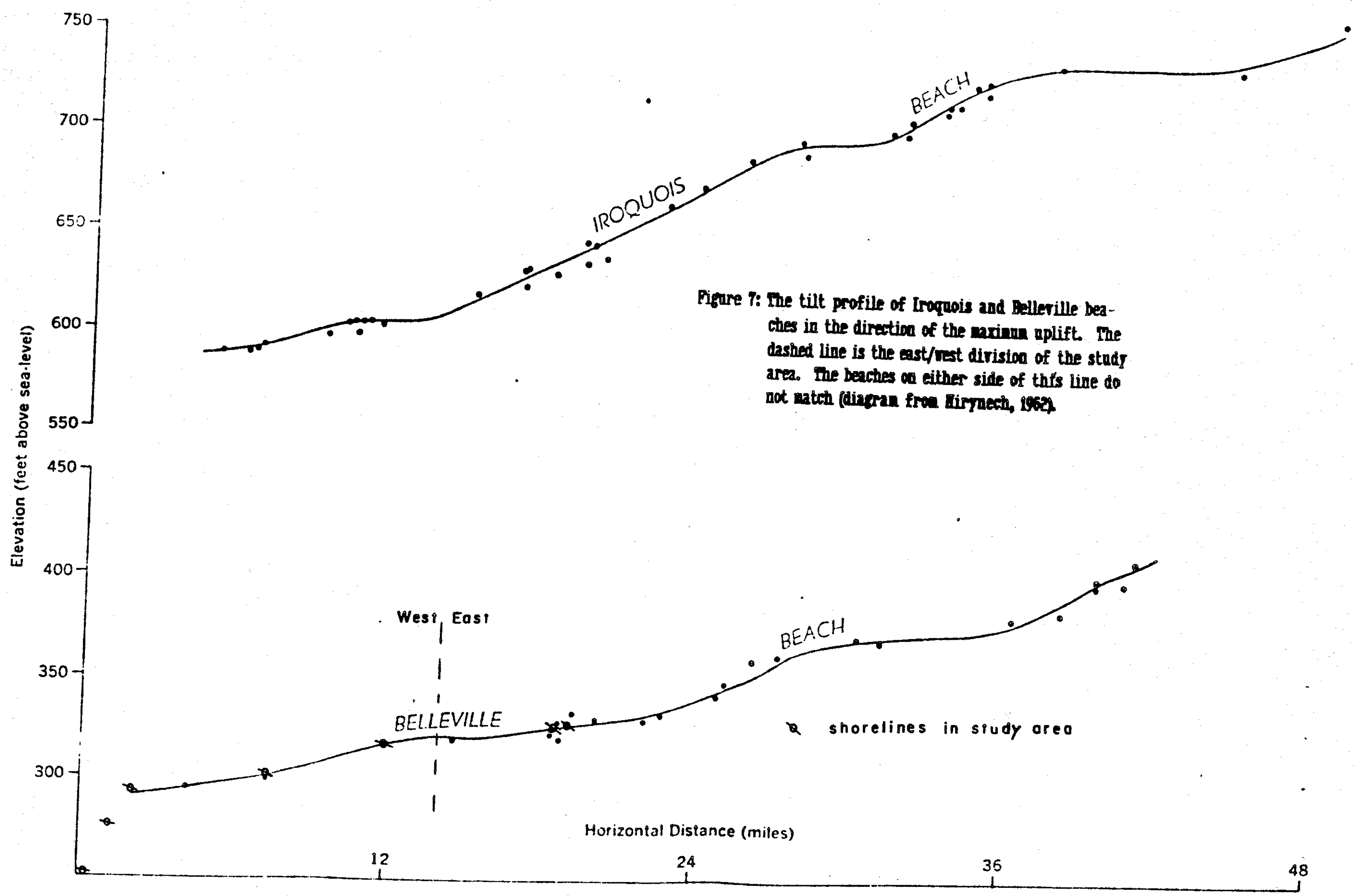


Figure 7: The tilt profile of Iroquois and Belleville beaches in the direction of the maximum uplift. The dashed line is the east/west division of the study area. The beaches on either side of this line do not match (diagram from Kirynech, 1962).

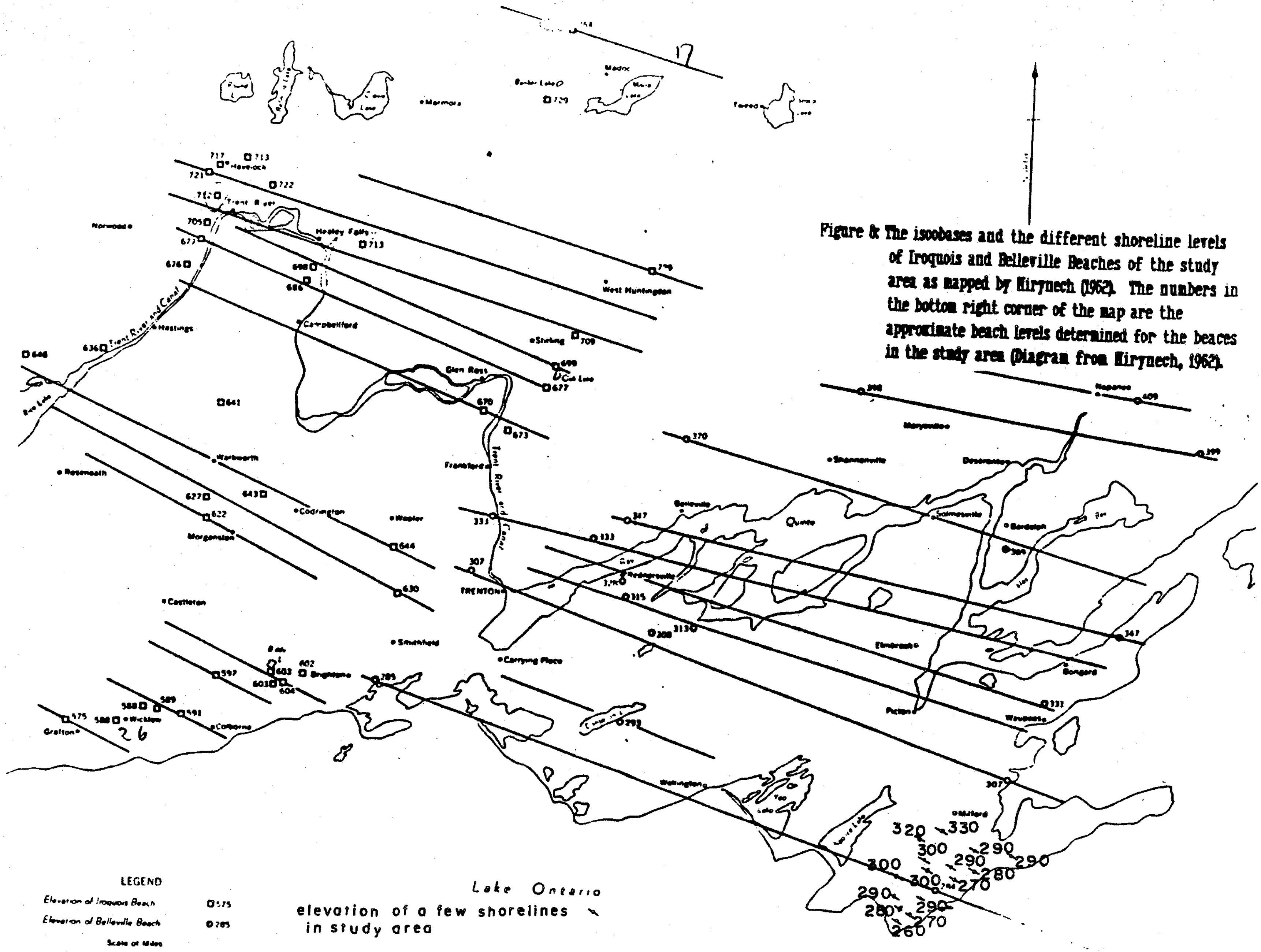


Figure 8 The isobases and the different shoreline levels of Iroquois and Belleville Beaches of the study area as mapped by Kirynech (1962). The numbers in the bottom right corner of the map are the approximate beach levels determined for the beaces in the study area (Diagram from Kirynech, 1962).

In many areas linear depressions have extended from the shoreline was never present is plausible. If the linear depression existed when the storm beach was developing, it would behave as a sluice. Sediment that was deposited on the depression would be carried away and a shoreline would never develop upon the depression.

The suggestion that the shoreline has settled into the depression by either, beach sediment being flushed through the linear depression by meteoric and groundwater water, or by settlement of the sediment due to gravity or neo-tectonic movement also has merit. As suggested previously, the linear depressions were probably open when the glaciers covered the area. Till or glaciofluvial sediment filled these depressions. The difficulty is determining how the sediment consolidated or was removed from the depressions. Further work is required to determine the exact reasons.

<u>Image on Mosaic</u>

Below is a brief description of how the features as seen on the false colour, infra-red mosaic.

1) Abrasion

a) striations - cannot distinguish on mosaic;

b) p-forms, cavettos and sichelwannen - cannot distinguish on mosaic;

c) large scaled forms - hard to distinguish; they are generally

a) light-toned areas which are found along side of the scarps or

b) dark-toned areas which cross areas where the drift cover is thick;

2) Unsorted sediment

- in areas where the sediment cover is thin (< 0.30 m) this material cannot be distinguished;

- in areas where the sediment cover is thick (> 0.30 m) this material is dark-toned (see linear depressions);

3) Sorted Sediment - glaciofluvial

- broad and light toned; found within and along the margins of the scarps;

4) Sorted Sediment - glaciolacustrine

- broad and dark toned; vegetation is generally healthier in these areas than others.

SUMMARY

The work which has been done has classified the different lineaments and tonal and textural patterns which can be seen on the colour infra-red mosaic. On the basis of principle formational processes, the lineaments can be divided into three groups. It has to be stressed that these groups are only simplistic divisions, for many of the features are interdependent. These groups are:

1) Quaternary sediments such as shoreline deposits and concentrations of unsorted and sorted sediment;

2) tectonic structures such as 'pop-ups', joints, scarps, bedrock rises and linear zones of fractured bedrock and

3) karst features such as sinkholes and long linear depressions.

There is still considerable doubt as to importance of each group and the origin of some of the features is still in suspect. For example, the strong and persistent orientation of the fractures is tectonic in origin. However, the reason why the fractures, specifically fractures oriented 125°, are open so frequently is not as definite.

The author believes that the fractures were probably open prior to the last glacial period. The opening of the fractures, as discussed above may be due to; repeated loading and unloading of the crust by the advancing and retreating glacier which caused the fractures to dilate and opened father, solution of the fractures by groundwater and meteoric water prior to the last advance, or possibly tectonic processes. That the fractures were open when the ice covered the are is implied by the diamicton, sorted sediment and large clasts found within the fractures.

Since the gaps were open it is possible that cold meltwater which had a small dissolved load, flowed subterraneously through the fractures. The large circular depressions observed throughout the area, linear depressions may have been caused, or at least enlarged by this subterraneous solution. This solution of the limestone probably still continues to this day.

It could be argued that the discussion of the role of meltwater is not relevant to the discussion of neotectonics. However, as discussed above, it needs to be addressed since it may have played a role in the formation of the terrain in the study area. For example, the valley south of Milford exhibits features (potholes, concave and convex banks) whose development can easily be explained by meltwater processes.

That neo-tectonic movement has deformed and altered the terrain has not been shown conclusively. As discussed throughout the report, there has been some deformation of the sediment and the features, but most of these can be accounted for without invoking neotectonics.

The types and possible causes of development of the bedrock and soil features and deformation which have been presented in this report are summarized in Tables 1 and 2 respectively. As shown in the Tables 1 and 2, neo-tectonics could be used as a plausable explanation for the existance of the type B waves and the abrupt termination of the striae. However, the most obvious example of the bedrock buckling, the 'pop-ups' may have existed before the glacier covered the area.

Determining the age and origin of the positive linear features (pop-ups) is the most difficult. As described previously, it appears that a well developed till abuts a few of the features. This till is not found in adjacent areas. This suggests a few of the features were present when the ice covered the area. However, there are also buckles which do not have any material abutting them. These buckles may have occurred after the glaciers retreated from the area.

If the bedrock has buckled after the glaciers left the area the mechanism which caused the buckles remains undetermined. As discussed previously, White et al. (1974) indicated that the features may form either by overburden removal, earth tremors, weathering of the surface and abrupt temperature changes.

The explanation that the buckles were present when the ice covered the area is not unreasonable, for Boulton (1974) indicated that if the effective normal pressure of a moving ice sheet never reached values sufficient for abrasion (Boulton's Zone C) subsequent to the ridge buckling, the feature would not have eroded. In fact, sediment would have been lodged upon it. However, there is some doubt as to the exact origin of the sediment. It could be:

a) glaciolacustrine sediment which has undergone pedological modification or

b) diamicton which has been squeezed from a crevasse as the bedrock buckled.

Further work is required to clarify these points.

RECOMMENDATIONS

1) Trenching across some of the positive linear features will indicate whether the material abutting the feature is indeed a till and whether the sediment has been deformed or moved due to post-depositional buckling. Areas which are recommended for trenching are:

   a) UTM E 32915 N 45765 - Station 23, east of the western pond created by Ducks Unlimited;

   b) UTM E 32877 N 45820 - Station 25, just south of the western pond created by Ducks Unlimited;

   c) UTM E 33135 N 45900 - Station 77, southwest of the eastern pond created by Ducks Unlimited;

   d) UTM E 33227 N 45926 - Station 99, southeast of the eastern pond created by Ducks Unlimited and

   e) UTM E 33241 N 45890 -Station 229, south of the eastern pond created by Ducks Unlimited.

2) A detailed topographic survey, specifically around the ancient shorelines will determine the exact elevation of the features.

3) Photographing the area during another time of year than those already taken may yield additional information. Although the aerial photographs which were taken previously are excellent, more information may be obtained if the photographs were taken at a different time of year, specifically along the southern portion of the area.

4) Excavating two segments of the ancient shoreline where the lineaments cross them may determine whether the shorelines have sunk into depressions and whether the disappearance occurred penecontemporaneously or post-depositional.

   Areas which are recommended for excavation are:

   a) UTM E 32827 N 45927 - Station 42 where the shoreline disappears where a lineament crosses it and

   b) UTM E 33075 N 46025 - Station 66 where the shoreline is presently falling into crevasses and a linear depression.

5) Coring or excavating the deep water sediments in the study area. These sediments have the thickest sedimentary sequences (some greater than 10 m) and may give an indication of

the tectonic record. If seismic events occurred, they may be recorded within the following sedimentary sequences:

a) UTM E 33494 N 46252 - Station 127;

b) UTM E 33155 N 46350 - Station 154;

c) UTM E 33140 N 46180 - Station 205 and

d) UTM E 33288 N 46307 - Station 215.

6) Geophysical (radar) studies along major alignments, specifically the linear depressions will determine the depth of the lineament, and possibly the type of material which abuts and is found within the feature. However, it is not known whether this technique would be effective in the terrain described above. Areas which are recommended for geophysical analysis are:

a) UTM E 32827 N 45927 - Station 42;

b) UTM E 33075 N 46025 - Station 66;

c) UTM E 33494 N 46252 - Station 127 and

d) UTM E 32683 N 45938 - Station 140

CONCLUSION

In the study area the processes which were responsible for the morphology of the modern terrain appear, at first glance, to be straight forward. However, the field investigation showed that the present morphology and sediment arrangement was created by the many interrelationships between ancient and neo-tectonic activity, glacial processes and post-glacial modification. However, a definitive explanation of the origin of many of the features could not be given. Rather, the explanations for these features tend to be discussions of causes which are most probable. These explanations are summarized in Tables 1 and 2.

In summary, the origins of the features in the study area can be attributed to a number of different processes. The field investigation showed that ancient and possibly neo-tectonic activity, glacial processes and post-glacial modification all contributed to the formation of the present morphology.

TABLE 1: BEDROCK FEATURES

FEATURE	POSSIBLE ORIGIN
1) Joint orientation	ancient
a) crevasses	1) solution by meteoric water 2) solution by meltwater 3) neotectonics*
2) Lineaments	
a) linear depressions	1) solution by meteoric water 2) solution by meltwater 3) neotectonics*
b) positive linear features	1) stress release cause by unloading, minor earth tremors, and weathering of rock surface 2) existed preglacially
c) scarp	1) ancient; faults
d) east/west rises	1) ancient; folds
3) Configured Ground	
1) circular features	1) solution by meteoric water 2) solution by meltwater
2) waved; type A	1) solution by meteoric water
type B	1) neotectonics 2) glacial thrusting*

* notes weakest(s) possible explanation

TABLE 2: SOIL FEATURES

FEATURE	POSSIBLE ORIGIN
1) Abrasion	
a) abrupt termination of striae	1) neotectonics 2) solution of bedrock causing collapse
b) small lateral displacement or striae	1) solution of bedrock causing collapse 2) neotectonics
c) sculpted bedrock valleys	1) meltwater erosion 2) erosion by glacier
2) Unsorted sediment	
a) till on sides of buckles	1) deposited when ice covered area 2) not a till
b) diamicton in fractures and depressions	1) deposited when glacier covered the area 2) post-glacial settlement
c) boulders in fractures	1) lodged into crevasses by meltwater or glacier
3) Sorted sediments-Glaciofluvial	
a) deformed sediment in Valley south of Milford	1) englacial tunnel; faults and folds caused by removal of ice support 2) rapid sedimentation
4) Sorted Sediments-Glaciolacustrine	
a) deformed rhythmites	1) rapid sediemntation 2) consolidation 3) removal of underlying ice support 4) neotectonics*
b) linear mounds	1) iceberg scours 2) meltwater erosion* 3) glacial fluting 4) offshore bars*
c) anomalous shorelines	1) unrecognized beach levels 2) isobases incorrect 3) post-glacial movement
d) disappearance of shorelines into lineaments	1) consolidation of sediment 2) sediment has been flushed through crevasses 3) shoreline was never present 4) shoreline has pulled apart

* notes weakest explanation(s)

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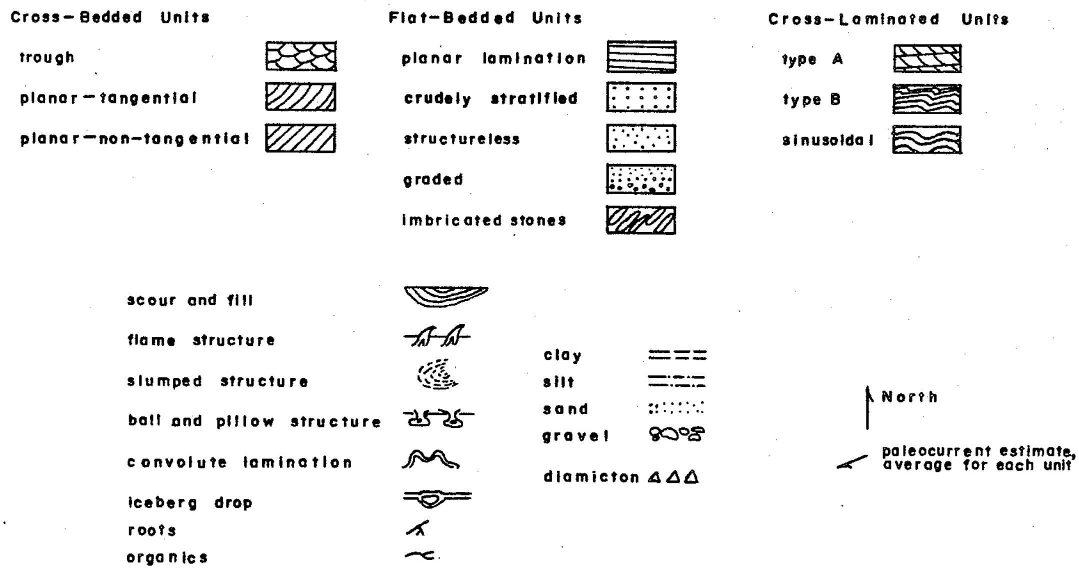
APPENDIX A

Station Descriptions


Cross-Bedded Units
trough
planar-tangential
planar-non-tangential
Flat-Bedded Units
planar lamination
crudely stratified
structureless
graded
imbricated stones
Cross-Laminated Units
type A
type B
sinusoidal
scour and fill
flame structure
slumped structure
ball and pillow structure
convolute lamination
iceberg drop
roots
organics
clay
silt
sand
gravel
diamicton
North
paleocurrent estimate, average for each unit

STATION NUMBER: 1

UTM: E 32625 N 457357
TOWNSHIP: Athol CON. IV Lot: 18
ELEVATION: 81 metres above sealevel

Brief Description of Morphology:

There is a linear depression between two bedrock highs. Within this depression there is a sedimentary body, oriented approximately parallel with the bedrock highs.

Observations:

This station is within the Point Petre Picnic Area; Soup Harbour is located to the northeast of this station. This station is bounded on the west and east by bedrock highs. These highs are oriented approximately 20° to 200°. The western bedrock high is at a lower elevation than the eastern high. Joints within the bedrock appear to be oriented 60° and 125° and the gap between these joints are generally less than 0.05 m.

Between these two bedrock highs is a 1.50 to 1.80 m high sedimentary body composed of unsorted sediment consisting mainly of silty-sand and very small precambrian and limestone clasts. Overlying this body are small sub-angular clasts of limestone. Along the northwestern portion of this station the unsorted sediment was seen to directly overlie the bedrock. The bedrock was not see in the centre of the depression. The till body never reaches a higher elevation than the surrounding bedrock.

The upper 0.40 to 0.70 m of this diamicton is weathered and exhibits a blocky structure. The structure does not appear to have been deformed subsequent to deposition. Although there were few pebbles observed within the exposure, the fabric of the sedimentary body was tentatively taken from eleven pebbles.

Many large precambrian clasts were observed along the shore within Soup Harbour. This is in direct contrast to the lake shore to the south, where the sediment consists predominately of limestone clasts.

Comment:

The information outlined above indicates that a linear depression of undeterminable depth is between two bedrock highs. This depression which is aligned parallel with the fault mapped by Carson (1981) and Water and Earth Science (1985) suggests that the depression is part of the same block.

The texture and the fabric of the unsorted sediment found between the two bedrock highs suggests that the sediment is a till deposited by an ice lobe which came from the northeast, parallel with the fault discussed above. The till does not appear to have been disturbed subsequent to deposition. This suggests that a tectonic event of sufficient intensity to disturb the sediment had not occurred at this station.

There are difficulties concerning the orientation of the till body, and these are:

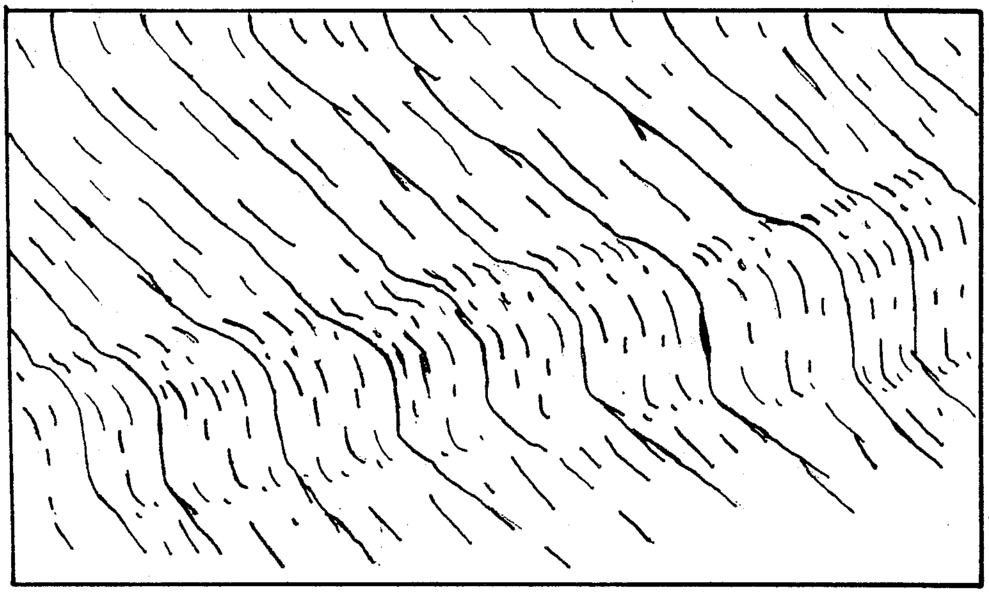
1) The till body was deposited by an earlier ice advance. The striations of that advance were eroded by the later, 250°, advance. It is possible that the bedrock highs protected the till body.

2) The clast fabric shown for Station 1 is inaccurate. The till may represent a lee-side or stoss-side fill as the ice advanced to the northwest.

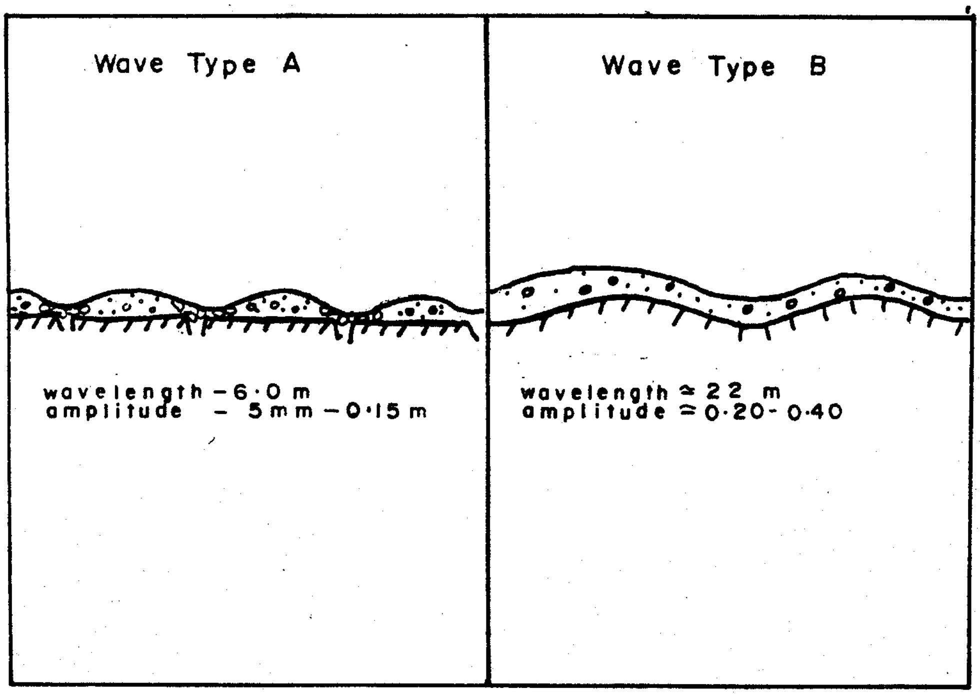
3) The till body represents a meltwater cavity fill similar to those suggested by Shaw (1983). It is possible that the glaciofluvial system within Cherry Valley (Leyland, 1982) extends down the valley. The sculpturing of the material along the side of the valley and the sand within the valley could be a product of this system (see Stations 1, 138, 139 and 230).

4) The whole valley may have originally been filled with till. The till body may be a remnant that was not eroded by either the glacier or by meltwater.

<u>Diagram and/or Picture:</u>



(a)



(b)

Figure 2: a) Diagram of a typical east/west rise.
b) Diagram of wave type topography.

b) Wave Topography

Waves are the undulating topography consisting of parallel linear alignment of ridges consisting at least in part of sediment are oriented approximately 060°, 125° and 148°. Relief is commonly 0.06 to 0.13 m and the spacing between ridge crests was found to be approximately 6.0 and 12.0 m. In many cases there is a higher proportion of matrix within the sediment at the crest of the mounds than in the sediment within the wave troughs.

At first it was believed that the waves represented an old plowing pattern. However, this pattern is identical on opposite sides of roads, east to west rises, swamps and wooded areas. This wave-like pattern is also present in a few areas where bedrock exposures were examined, but the amplitude or relief is usually smaller.

This pattern was found throughout the area where the drift thickness is less than 2.0 m. Near the positive linear features these wave-like patterns change in the following way.

1) The orientation of the waves change abruptly. An example of this is at Station 135 where the waves change from orientation 125° to 080°, then change to 100° and then back to 125°.

2) The waves are displaced laterally as they cross the positive linear features. Examples of this are found at Stations 82 and 134.

The wavy topography has a similar orientation to the orientation of many of the joints. This similarity may have been caused by preferential erosion along the joints which is supported by the observation that there is less matrix in the troughs of the waves than there is on the crest. It is also possible that meteoric water may have eroded and transported the sediment down through the fractures leaving the clasts behind. This again suggesting that movement of water through the fractures in the last 12,000 years had been significant. This type of waved topography has been classed as Type A Waves (Fig. 2b).

The wave-like topography within the study area may not all have been formed by the transportation of sediment down joints. At Stations 22, 25, 35, 38 and 41 (see accompanying maps) the sediment overlying the bedrock was excavated and a waved bedrock surface was observed. The approximate wavelength and amplitude of these features are 22 m and 0.10 to 0.20 m. respectively. This type of waved topography has been classified as Type B waves.

Waved topography was divided into two types because there appears to be a distinct difference between the two types. These

Additional Comments:

Sorted sediment is found within the valley northeast of this station (Stations 138, 139 and 230). In addition, examination of the aerial photographs suggests that valley has been sculptured by either, or both, the glacier or by meltwater.

Unsorted sediment or till which was deposited upon and abutting a bedrock high.

STATION NUMBER: 2 UTM: E 32650 N 45685
TOWNSHIP: Athol CON. V LOT: 18
ELEVATION: 83 metres above sealevel

Brief Description of Morphology:

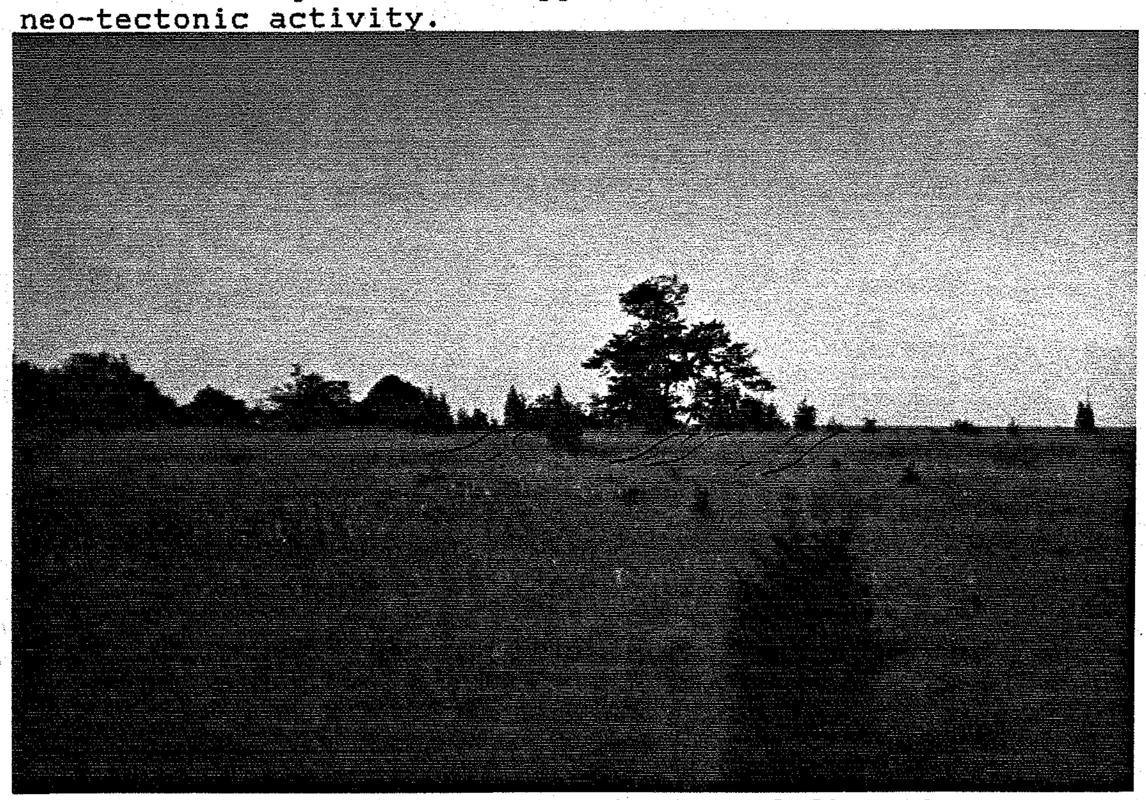
This station is located on a small linear ridge approximately 0.60 to 1.00 m high.

Observations:

This small linear ridge which is oriented approximately 16° to 194° is covered with sweet clover. A small pit was dug in this feature and it indicated that the sediment consists of coarsening downward cycles of medium to fine sand and fine gravel. The maximum clast diameter was 0.10 m and many of them were of precambrian origin. Due to the nature of the excavation, no sedimentary structures were observed. The steepest side was found on the eastern portion of the feature.

Comment:

The coarsening downward cycles and morphology suggest that the feature is a shoreline deposit with the lake side on the west. The ridge does not appear to have been effected by any neo-tectonic activity.



The shoreline deposit can be traced directly northeast into Stations 6 and 12.

STATION NUMBER: 3

UTM: E 32632 N 45665
TOWNSHIP: Athol CON. V LOT: 18
ELEVATION: 76 metres above sealevel

Brief Description of Morphology:

Bedrock exposure along the western shore.

Observations:

There was very little sediment overlying the small bedrock escarpment along the western shore. Bedrock joints oriented 32° and 55° were seen along the shore. In addition, striations, oriented approximately 250° to 252°, were seen on the bedrock surface.

There is approximately 0.10 to 0.20 m of sediment overlying the bedrock. Precambrian clasts were observed within this sediment.

Comment:

The striations that were observed are perpendicular to the till body at station 1. This suggests that:

1) The till body was deposited by an earlier ice advance. The striations of that advance were eroded by the later, 250°, advance. It is possible that the bedrock highs protected the till body.

2) The clast fabric shown for Station 1 is inaccurate. The till may represent a lee-side or stoss-side fill as the ice advanced to the northwest.

3) The till body represents a meltwater cavity fill similar to those suggested by Shaw (1983). It is possible that the glaciofluvial system within Cherry Valley (Leyland, 1982) extends down the valley. The sculpturing of the material along the side of the valley and the sand within the valley could be a product of this system (see Stations 1, 138, 139 and 230).

4) The whole valley may have originally been filled with till. The till body may be a remnant that was not eroded by either the glacier or by meltwater.

There is no evidence of neo-tectonic activity at this station.

STATION NUMBER: 4

UTM: E 32647 N 45670
TOWNSHIP: Athol **CON.** V **LOT:** 18
ELEVATION: 83 **metres above sealevel**

Brief Description of Morphology:

A linear ridge less than 1.00 m high covered with sweet clover.

Observations:

The sediment within the ridge consists of coarsening downward cycles of fine to medium sand and fine gravel. Many of the clasts are of precambrian origin. The diameter of the clasts are between 0.02 and 0.06 m. The sediment west of the ridge has less matrix than the sediment on the eastern side of the ridge. There is approximately 0.10 to 0.15 m of sediment overlying the bedrock on either side of the linear ridge.

Comment:

The ridge is a shoreline deposit. It was noted that the sediment on the western side of the ridge had less matrix than the sediment on the eastern side. This is due to the winnowing of the sediment by waves. This indicates that the western side was the lake side.

Diagram and/or Picture:

STATION NUMBER: 5

UTM: E 32660 N 45675
TOWNSHIP: Athol CON. V LOT: 18
ELEVATION: 83.5 metres above sealevel

Brief Description of Morphology:

A 0.15 m high ridge covered with sweet clover.

Observations:

This small ridge consists of angular to sub-rounded clasts supported by a sorted matrix. This material overlies a weathered bedrock surface.

Comment:

The ridge is a shoreline deposit. Since the material is not too sorted, the feature probably formed in the shoreface environment (ie. an offshore bar) rather than the foreshore.

Diagram and/or Picture:

STATION NUMBER: 6

UTM: E 32652 N 45730
TOWNSHIP: Athol CON. V LOT: 17
ELEVATION: 84 metres above sealevel

Brief Description of Morphology:

A ridge approximately 4.50 m high oriented 346o-168o covered with sweet clover.

Observations:

The ridge consists of coarsening downward cycles of medium to fine sand and fine gravel. The diameter of the clasts are generally less than 14 mm and are of precambrian and paleozoic origin. The western side has the greatest relief. The material at the base of the ridge on the west side has less matrix than the sediment on the eastern side.

West of the ridge, adjacent on the west side to the north-south road, there is a hill less than a metre high. The sediment within this ridge consists of unsorted material.

Comment:

The ridge consisting of unsorted sediment is a shoreline deposit. This ridge, with respect to others in the immediate area, is much more developed. This ridge probably developed in the foreshore-backshore environment. The lake-side of the deposit was on the west because the sediment on that side has less matrix, suggesting winnowing by wave action.

Diagram and/or Picture:

STATION NUMBER: 7

UTM: E 32660 N 45747
TOWNSHIP: Athol CON. V LOT: 16
ELEVATION: 84 metres above sealevel

Brief Description of Morphology:

A linear ridge 100 m north of Station 6.

Observations:

This ridge is very similar to station 6.

Comment:

As discussed in Station 6 the ridge is probably a shoreline feature deposited in the foreshore-backshore environment.

Diagram and/or Picture:

STATION NUMBER: 8

UTM: E 32725 N 45775
TOWNSHIP: Athol CON. V LOT: 15
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

The sediment and bedrock in a ditch cut and at the bottom of a creek.

Observations:

West of the ditch extending into southward the bedrock surface is polished. On this polished surface striations and other sculptured forms were seen. As shown below, the average for the striations is 242° while the average for the other larger sculptured forms is 274°. In addition the surface of the bedrock is waved. The amplitude of these waves is approximately 0.20 m. The crest of the waves is oriented 234°. There is no displacement of the striations and other forms where they cross joints in the bedrock.

The sediment overlying the polished surface is less than 0.20 m thick and consists of angular to sub-angular clasts of paleozoic and precambrian rocks supported by an unsorted matrix. It is possible also that a 50 mm to 0.10 m high ridge, consisting of sorted sediment, crosses the north-south oriented creek.

Comment:

The striations represent the abrasion of the bedrock surface by tools incorporated in the ice at the base of the glacier. However, the origin of the other sculptured forms is open to debate. They could either be by meltwater as thought by Gray (1981) or by glacial abrasion, as thought by Boulton (1975). Whatever the origin, they are oriented consistently in a different direction than the striations. This suggests that a different mechanism of formation (or different time) was involved.

The small ridge consisting of sorted sediment is probably a shoreline feature deposited in the shoreface environment.

Since the striations are not displaced it is believed that no significant neo-tectonic activity had occurred in the immediate area.

Diagram and/or Picture:

STRIATIONS

PROJECT

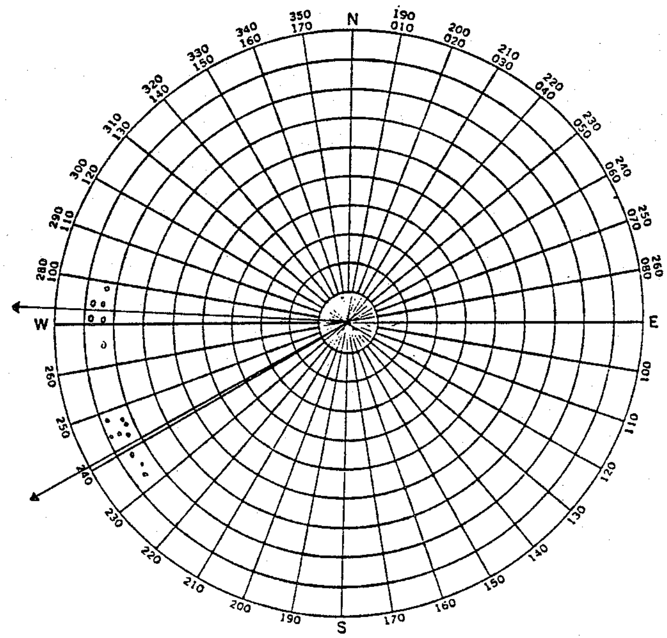
Station 8

Date 30/10/87

Personnel G. Gorrell

No. of striations: 15

Location:



• direction 1
direction 2

STATION NUMBER: 9 UTM: E 32715 N 45748
TOWNSHIP: Athol CON. V LOT: 15
ELEVATION: 86 metres above sealevel

Brief Description of Morphology:

A linear ridge approximately 1.5 to 2.0 m thick.

Observations:

The ridge is composed of coarsening downward cycles of medium to fine sand and fine gravel. The diameter of the clasts ranges from 10 to 30 mm and many of them are of precambrian origin. The ridge is approximately 40 m wide and the southern slope has the highest local relief. The sediment at the base of the ridge on this side has less matrix than the northern side.

Comment:

The feature is a shoreline deposit probably formed in the foreshore environment. The coarsening downward cycles indicate that the feature developed through the waxing and waning of flow typical of wave action upon a shore. The lack of matrix along the southern margin suggests that the southern side faced the lake.

Diagram and/or Picture:

Additional Comments: Station 10 is upon the same feature.

STATION NUMBER: 10

UTM: E 3270 N 45740
TOWNSHIP: Athol CON. V LOT: 16
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

A linear ridge covered with sweet clover, and the sediment and bedrock surrounding it.

Observations:

There are actually three ridges composed of sorted sediment at this location, The largest, which is approximately 0.5 to 1.0 m thick and is found at 85 m ASL, consists of coarsening downward cycles of medium sand and fine gravel. The clast size of the gravel ranges from 5 to 25 mm and many of the clasts are of precambrian origin. The sediment south of this ridge has less matrix than the sediment on adjacent sides.

Two smaller, yet distinct ridges extent west of the one described above. These ridges are less than 0.20 m thick and are composed of medium to fine sand and very fine gravel. The maximum observed clast size was 15 mm and many of the clasts are of precambrian origin.

The thickness of the sediment on the sides of the sorted ridges described above is less than 0.15 m. The sediment on the south side has less matrix than the sediment on the other ones. Clasts of precambrian with diameters up to 0.60 m were observed throughout the are.

Three large conical hills are found in areas where the three ridges described above are absence. These piles are composed of topsoil, fence posts and wire and medium to fine sand.

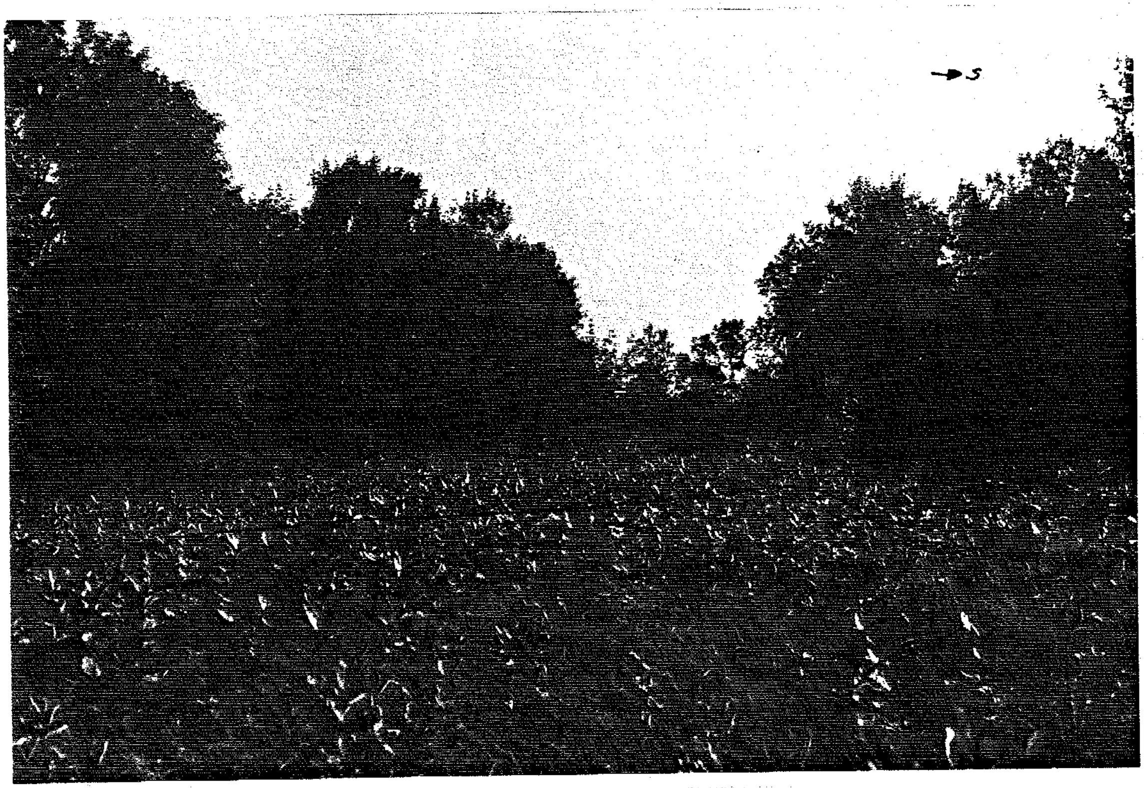
In a few areas where the sediment has been stripped, a polished bedrock surface was could be detected. Chattermarks and striations oriented approximately 272° were found on this surface.

Comment:

The largest ridge is a shoreline deposit formed in the foreshore environment. The other two, which are connected to the first, are probably either offshore bars or spits formed in the shoreface environment. The lake side was probably on the south as suggested by the lack of matrix in the sediment.

The three conical hills are stripping piles placed in that area for some undeterminable reason; probably for a backstop for target practice.

Diagram and/or Picture:



High-lighted ridge is an ancient shoreline composed of sorted sediment consisting of fining upward cycles.

Additional Comments:

To the east, Station 9 is located on the largest ridge.

STATION NUMBER: 11

UTM: E 3270 N 45765
TOWNSHIP: Athol **CON.** V **LOT:** 16
ELEVATION: 87 metres above sealevel

Brief Description of Morphology:

The bedrock surface along the road which separates concessions V and IV, just west of the creek which is oriented north/south.

Observations:

There is 0.30 to 0.40 m of sediment over the bedrock surface. This sediment consists of and silty-sand material with clasts up to 0.0 m in diameter.

The bedrock surface is polished and weakly striated. Two mean directions, 240° and 296°, were viewed. The striations oriented 240° appear to be the youngest because they cross-cut the 296° striations.

South of the ditch is a small ridge less than 0.20 m thick. It is composed of medium to fine sand and very fine gravel. The maximum observed clast diameter was 15 mm and many of the clasts were of precambrian origin.

Comment:

The striations suggest that two ice advances had occurred. The initial advance was 296° followed by the 240° advance.

The ridge composed of sorted sediment is a shoreline deposit probably deposited in the shoreface environment.

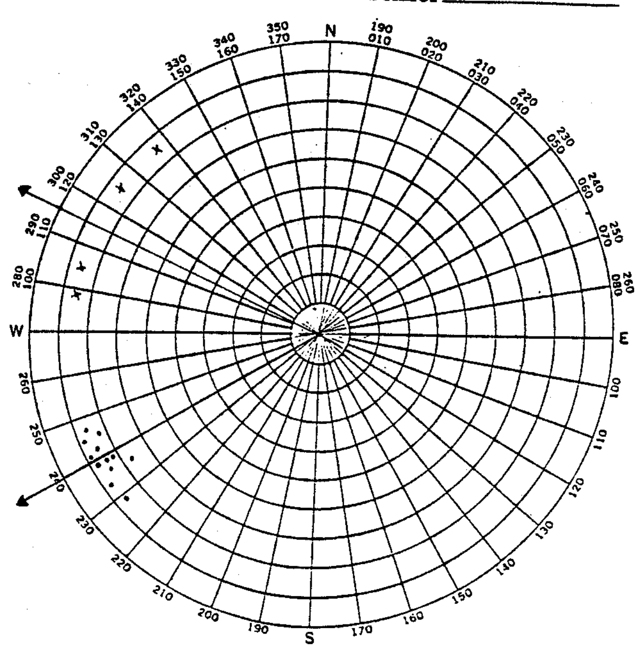
Diagram and/or Picture:

Station 11 Date 30/10/87 Personnel G. Gorrell

No. of striations: 16

Location:

• direction 1
x direction 2



STATION NUMBER: 12 **UTM:** E 32680 N 45785
TOWNSHIP: Athol **CON.** IV **LOT:** 16
ELEVATION: 88 metres above sealevel

Brief Description of Morphology:

A 2.0 to 4.0 m thick linear ridge and the sediment surrounding sediment.

Observations:

The ridge consists of coarsening downward cycles of medium to coarse sand and fine gravel. The basal portion of the cycles is clast supported. The clasts are predominately limestone and are very well rounded. The maximum observed diameter was 40 mm.

A small, less than 0.20 m thick ridge is aligned parallel with the large ridge on the southeastern side. This ridge is composed of medium to fine sand and very fine gravel.

On the northwestern side of the large ridge there is approximately 60 mm of sediment overlying the bedrock. The clasts in this sediment are very angular.

Comment:

The sorted ridge is a shoreline deposited formed in the foreshore environment. The small ridge which is aligned parallel with the large ridge is an offshore bar. This suggests that the lake side was to the southeast. However, the lack of matrix of the sediment on the northwestern portion of the feature indicates that it was also affected by wave altercation.

Diagram and/or Picture:

STATION NUMBER: 13

UTM: E 32735 N 45740
TOWNSHIP: Athol CON. V LOT: 15
ELEVATION: 83 metres above sealevel

Brief Description of Morphology:

The bedrock surface along the creek and ditch bottom.

Observations:

The bedrock surface in this area is striated. There are two directions; 257° and 326°. As shown below the 257° is the stronger and these striations cross-cut the 326° striations.

Comment:

The 257° striations cross-cut the 326° ones suggesting that the 257° are the youngest ones.

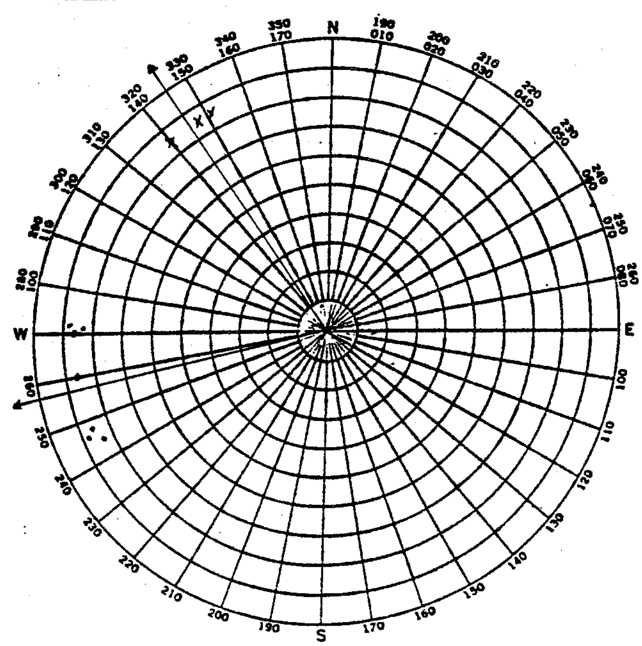
Diagram and/or Picture:

STRIATIONS PROJECT

Station 13 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 9

Location:



• direction 1
× direction 2
• p–forms, sichelwannen or cavettos

Additional Comments:

There are other cross-cutting striations at Stations 11, 194 and 228.

STATION NUMBER: 14 **UTM:** E 32775 N 45680
TOWNSHIP: Athol CON. V LOT: 14
ELEVATION: 76 metres above sealevel

Brief Description of Morphology:

The land just north of the modern shoreline.

Observations:

The bedrock surface rises abruptly 1.0 to 1.5 m and then drops just north of the modern shoreline. This rise is aligned approximately 99°. North of rise there is 40 mm of sandy-silt. Aligned parallel with the rise is a linear depression approximately 0.10 to 0.15 m deep filled with clasts of limestone and a few of precambrian origin.

The bedrock joints that were noticed in the area are oriented approximately 125°, 20°, 356° and 0°.

Comment:

The silty-sand area is probably the backshore of the modern shoreline.

The linear depression may be a crevasse which has been filled with drift.

Diagram and/or Picture:

STATION NUMBER: 15

UTM: E 32750 N 45765
TOWNSHIP: Athol CON. V LOT: 14
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

Small excavation upon a linear ridge and the underlying bedrock surface.

Observations:

Two excavations are upon a linear ridge which is approximately 1.0 to 1.5 m thick. This ridge is composed of fine to medium sand and fine gravel. The clasts are rounded and the maximum observed clast diameter was 25 mm. This feature is covered with sweet clover.

Striations were observed where the ridge has been excavated to bedrock. These striations are oriented approximately 265°. However, there are a few abrasion marks which may be striations and these are oriented approximately 293°.

The joints that were observed in the underlying bedrock are oriented approximately 125°, 80° and 60°.

Comment:

The linear ridge is a shoreline feature developed in the foreshore environment.

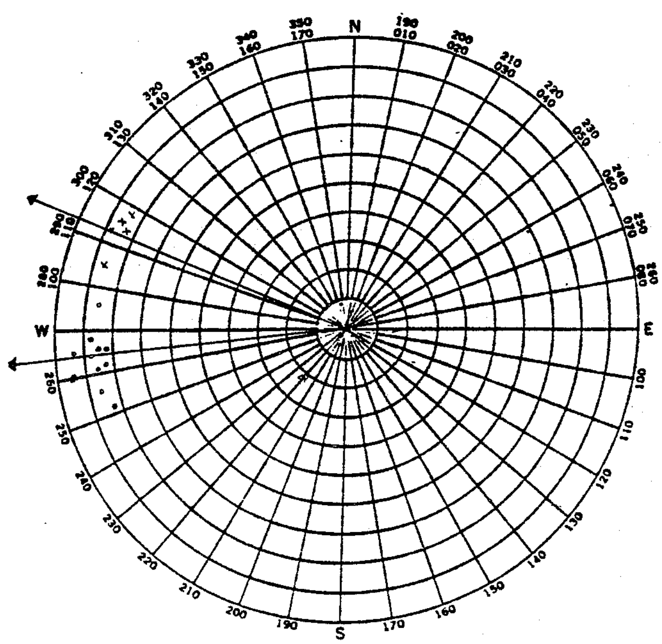
The striations that were observed suggest that the area was affected by two ice advances.

Station 15 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 16

Location:

- • direction 1
- × direction 2
- • p–forms, sichelwannen or cavettos



STATION NUMBER: 16 UTM: E 32737 N 45790
TOWNSHIP: Athol CON. V LOT: 14
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

A linear ridge oriented approximately 250° to 70° and the surrounding sediment.

Observations:

The linear ridge is approximately 0.65 m thick and is composed of medium to fine sand and fine gravel. The clasts are rounded and the maximum observed clast size was 35 mm. These clasts are predominately of paleozoic origin although a few precambrian clasts were observed.

Located approximately 30 m south and aligned approximately parallel with the sorted ridge is a linear ridge composed of unsorted material. With respect to the surrounding drift this ridge has more matrix.

South of the ridge described above the bedrock surface is covered with 0.10 to 0.15 m of unsorted material. The drift is composed of angular limestone and precambrian clasts supported by a sandy-silt matrix.

Comment:

The sorted ridge is a shoreline feature deposited in the upper shoreface or foreshore environments. The unsorted ridge is either an offshore bar or a crevasse fill.

STATION NUMBER: 17

UTM: E 32885 N 45675
TOWNSHIP: Athol CON. V **LOT:** 12
ELEVATION: 76 metres above sealevel

Brief Description of Morphology:

The modern shoreline.

Observations:

There are three distinct levels along this modern shore. These are:

1) The lower level: It is composed generally of clasts ranging in size from 0.05 to 0.20 m. The flat clasts have well rounded edges.

2) The middle level: It is composed of flat clasts with rounded edges with diameters ranging from 10 to 50 mm.

3) The upper level: It is composed of rounded clasts with diameters ranging in diameter from 20 to 100 mm.

Immediately behind the shoreline the bedrock surface is covered with up to 50 mm of silt.

The joints in the bedrock in front of the shoreline are oriented approximately 82°, 91° and 65°.

Comment:

The different levels in the modern shoreline reflect 1) times of different wave intensity, 2) seiches and other limnological processes. The silty area behind the highest level is the backshore.

STATION NUMBER: 18 **UTM:** E 32880 N 45770
TOWNSHIP: Athol CON. V LOT: 12
ELEVATION: 77 metres above sealevel

Brief Description of Morphology:

Generally flat-lying topography.

Observations:

There is approximately 0.40 m of sediment composed of angular limestone and sub-angular precambrian clasts supported by a sandy-silt matrix overlying the bedrock surface.

Comment:

It is very difficult to distinguish the weathered bedrock surface from the drift. The inclusion of the precambrian clasts distinguishes the material at this station as till.

STATION NUMBER: 19

UTM: E 32855 N 45745
TOWNSHIP: Athol CON. V LOT: 12
ELEVATION: 78 metres above sealevel

Brief Description of Morphology:

The bedrock surface, bedrock joints and the overburden.

Observations:

Similar to Station 18 the bedrock surface is covered with 0.20 to 0.40 m of sediment. The sediment is composed of angular limestone clasts and sub-angular precambrian clasts supported by a sandy-silt matrix.

There were no striations observed on the bedrock surface and the joints are oriented approximately 60° and 125°. The gaps between the joints oriented 125° were greater than 50 mm and were up to 1.10 m deep. These joints were filled with angular clasts of limestone and a sandy-silt sediment. There was small amounts of calcite along the margins of the joints and on the underside of the limestone beds of the joints.

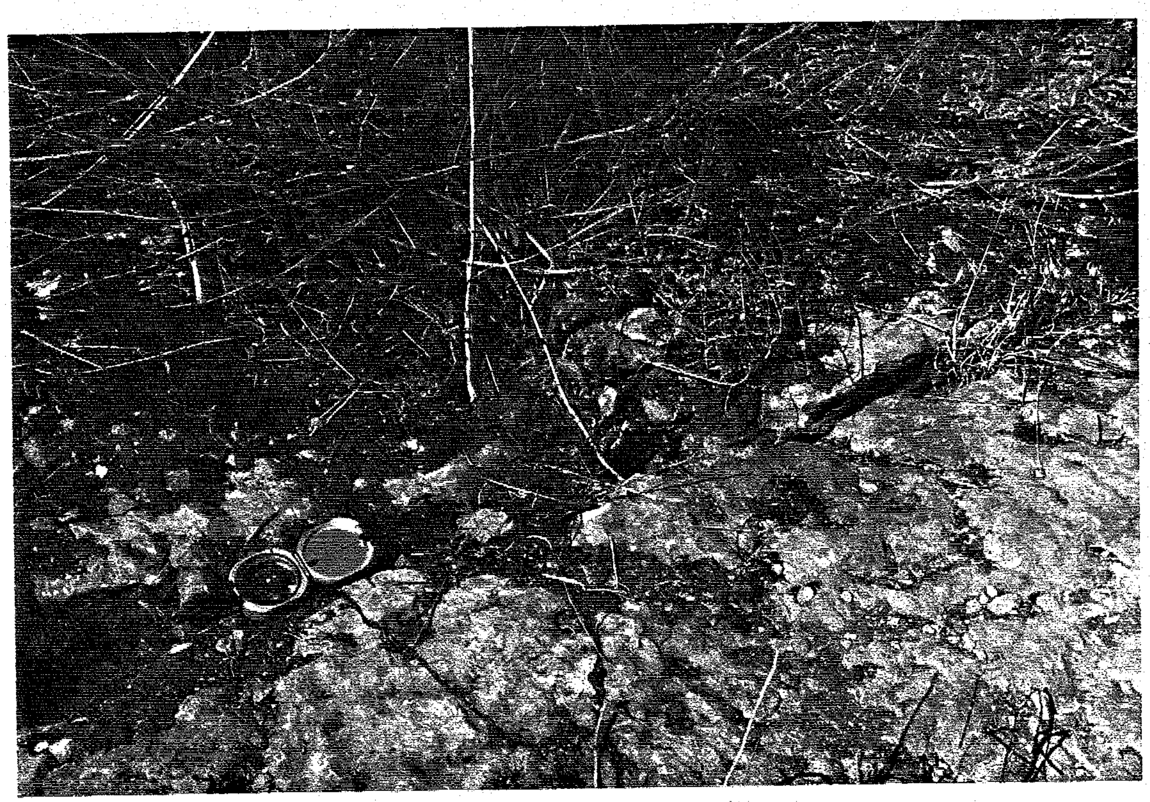
Comment:

Similar to Station 18 the sediment that overlies the bedrock surface is till and not a weathered mantle.

The calcite which was observed is probably due to karst activity. However, it seems that the amount of calcite is minor with respect to the size of joint. Therefore, it appears that karst activity occurred after the joint opened and is not the cause of the gap being so wide.

Diagram and/or Picture:

Additional Comments: A Ducks Unlimited pond is located east of this Station. The lack of water in the pond is probably due to the gaps (crevasses) in the limestone.



Joint oriented approximately 125° which is open greater than 5mm.

STATION NUMBER: 20 UTM: E 32825 N 45790
TOWNSHIP: Athol CON. V LOT: 12
ELEVATION: 78 metres above sealevel

Brief Description of Morphology:

Excavation to bedrock surface.

Observations:

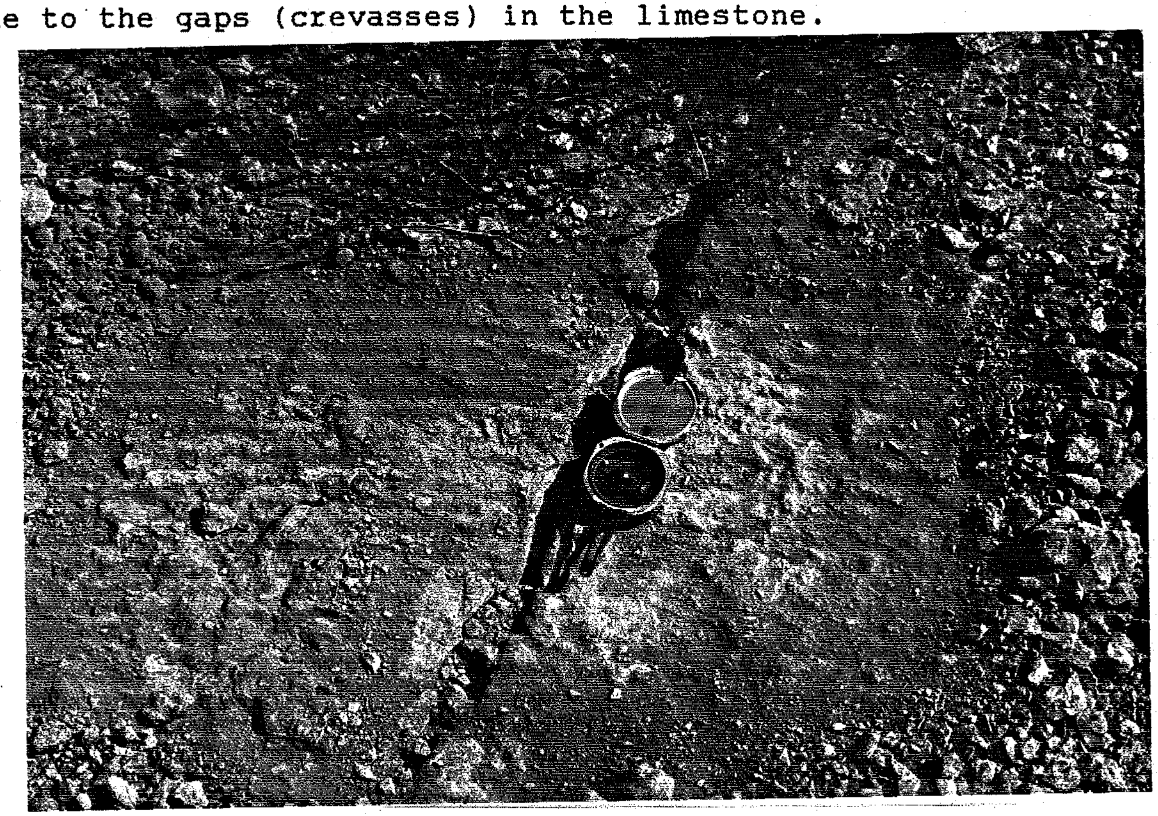
There was 0.65 to 0.70 m of sediment overlying the bedrock surface. Similar to the previous two stations the sediment is composed of angular limestone and sub-angular precambrian supported by a sandy-silt matrix. No striations were observed on the bedrock surface.

The joints which were observed are oriented principally 125° and 65°, although a few were oriented 88°. Most of the joints oriented 125° and a few of the other joints had gaps greater 50 mm.

Comment:

The sediment which overlies the bedrock is classified as till and not weathered rock principally because of the quartzite clasts.

Additional Comments: A Ducks Unlimited pond is located east of this Station. The small amount of water in the pond is probably due to the gaps (crevasses) in the limestone.



Joint oriented approximately 125° which is open greater than 5mm.

STATION NUMBER: 21

UTM: E 32795 N 45817
TOWNSHIP: Athol CON. V LOT: 13
ELEVATION: 82 metres above sealevel

Brief Description of Morphology:

Same feature as station 16.

Observations:

The linear ridge is approximately 0.65 m thick and is composed of medium to fine sand and fine gravel. The clasts are rounded and the maximum observed clast size was 35 mm. These clasts are predominately of paleozoic origin although a few precambrian clasts were observed.

Located approximately 30 m south and aligned approximately parallel with the sorted ridge is a linear ridge composed of unsorted material. With respect to the surrounding drift this ridge has more matrix.

South of the ridge described above the bedrock surface is covered with 0.10 to 0.15 m of unsorted material. The drift is composed of angular limestone and precambrian clasts supported by a sandy-silt matrix.

Comment:

The sorted ridge is a shoreline deposit deposited in the upper shoreface or foreshore environments. The unsorted ridge is either an offshore bar or a crevasse fill.

STATION NUMBER: 22 - 25, 228 **UTM:** E 32897 N 45765 (St. 22)
TOWNSHIP: Athol CON. V LOT: 11
ELEVATION: 79 metres above sealevel

Brief Description of Morphology:

The bedrock topography, sediment and morphology south of the western pond created by Ducks Unlimited.

Observations:

South of the pond (St. 22) and along the creek, the sediment consists predominately of organics, generally peat. However, closer to the pond the bedrock is generally less than 0.30 m deep. In addition, the bedrock is waved and the crests are oriented 148°, and have an amplitude of 0.30 to 0.40 m.

East of the pond there is a positive linear feature oriented approximately 148° and is approximately 0.80 m. high (St. 23). This feature is very difficult to identify on the ground because it is covered by up to 0.50 m of unsorted sediment. Angular precambrian clasts with diameters up to 0.95 m are found upon the feature. A road crosses the feature and it was possible to observe the bedrock. Joints oriented approximately 60°, 125° and 148° were observed. Sweet clover grows in abundance upon this feature.

On the eastern side of the feature the surface is waved and these waves are oriented approximately 148°. There is less sediment in the troughs of these wave than there is at the crest (80 mm versus 0.15 m). In a few area the sediment was excavated to bedrock (0.30 m of drift). The surface of the bedrock was loose and calcium carbonate precipitate was found on the underside of the weathered pieces.

Just south of the pond (St. 24) the drift has been excavated to form a berm. This drift consisted of unsorted sediment with clasts up to 1.20 m in diameter. Joints oriented 125° and 060° were observed; and most of the joints oriented 125° are open greater than 0.08 m. In addition, circular depressions with diameters greater than 2.30 m were observed.

Immediately south of the pond, just east of the creek (St. 25) and west of the positive linear feature the bedrock topography is waved. The crests of these waves are oriented 148°, and have an amplitude of 0.30 to 0.40 m. These waves, which have a wavelength of approximately 22 m can be traced to Station 20. In absolute elevation the crests of the waves appear to be at a progressively lower elevation towards the west.

Just south of the pond (St. 25), on the eastern side of one of these waves, the bedrock surface is polished. On this surface there are striations oriented approximately 260°. In addition, orientated approximately parallel with the striations are flutes. When tapped with a hammer these flutes sound 'hollow'.

The striations and flutes on the polished surface described above abruptly terminate along a lineament oriented 125°. In addition, there appears to be a 50 to 100 mm rise in the bedrock topography along this lineament. The bedrock on the western side of this lineament has rubbled. None of the striations or flutes bend or flow around this lineament.

Another area which is extensively striated and grooved is located southeast of the one described above along the modern shoreline (St. 228). At this location the surface is striated in two directions, 255° and 295°. Many of the striations oriented 295° are cross-cut by ones oriented 255°. These 255° oriented striations are funnelled through sichelwannen oriented 252°. A portion of the exposure is rubbled and the forms described above do not terminate against it, but rather flow either around or up it.

<u>Comment</u>:

It appears that the positive linear feature is a ``pop-up'' similar to those described by White <u>et al.</u> (1974). The unsorted sediment abutting the feature may be a till suggesting that the feature is preglacial. However, the termination of the striations against a lineament suggests that some movement has occurred since the glacier covered the area.

The topography around all the stations appear to be tectonically controlled. On the east side of the positive feature the joints have gaps greater than 80 mm. Calcium precipitate is found in abundance in this area. On the western side of the feature though, the joints tend to be tighter. In addition, the bedrock topography is waved.

<u>Diagram and/or Picture:</u>

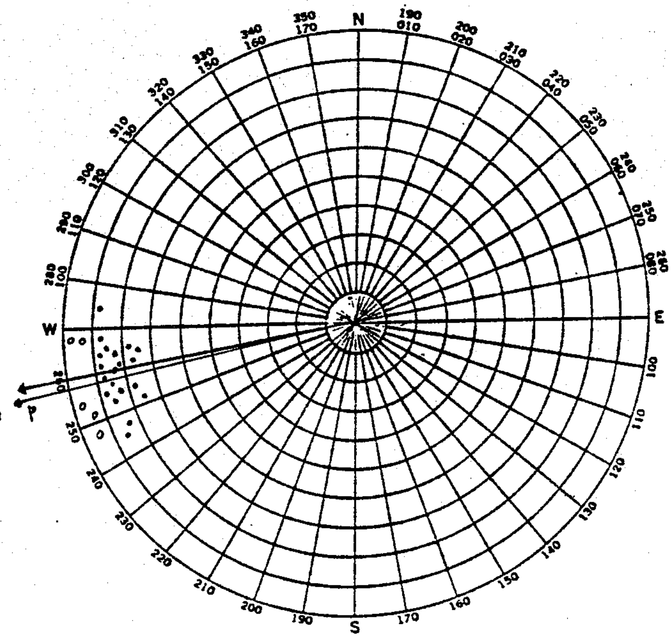
Striated bedrock surface at Station 228. Notice that p-forms flow around the bedrock rise.

STRIATIONS PROJECT

Station 25 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 25

Location:



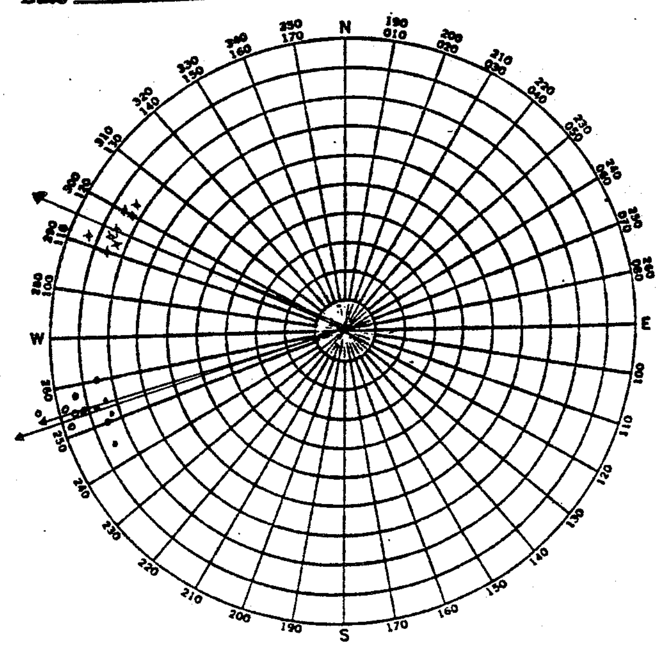
- • direction 1
- × direction 2
- ⚬ p-forms, sichelwannen or cavettos

STRIATIONS PROJECT

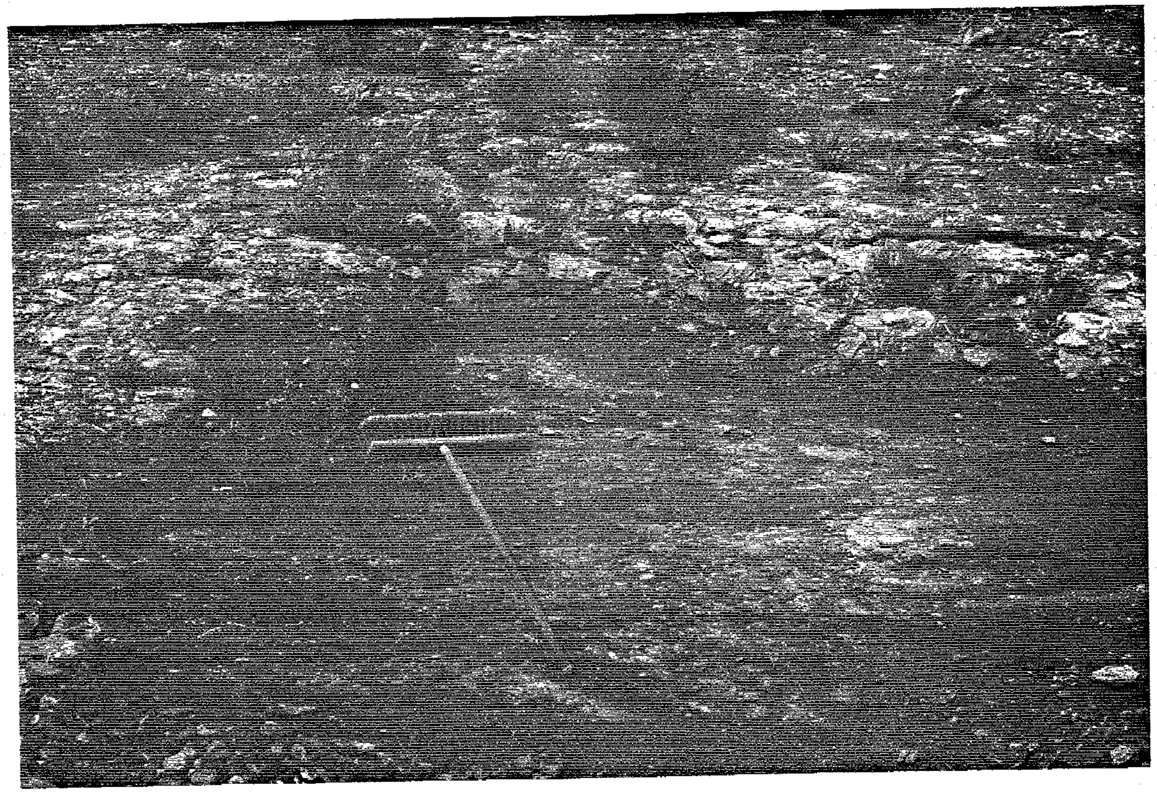
Station 228 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 19

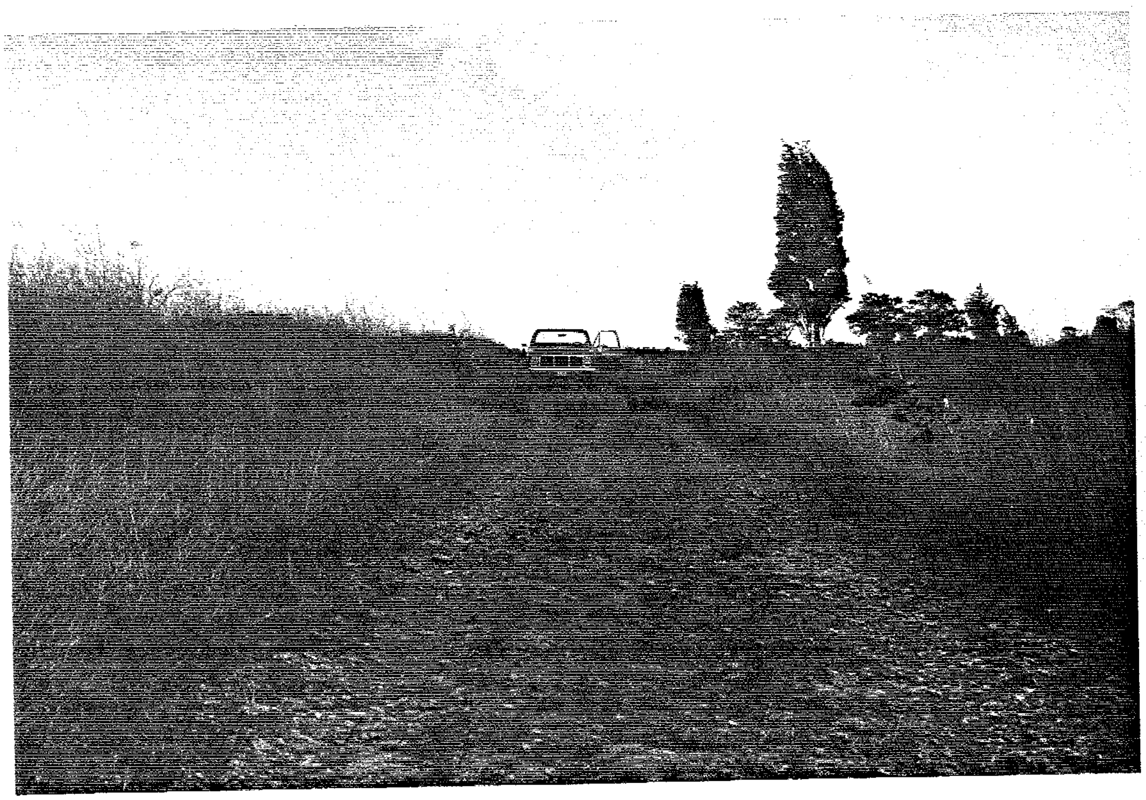
Location:



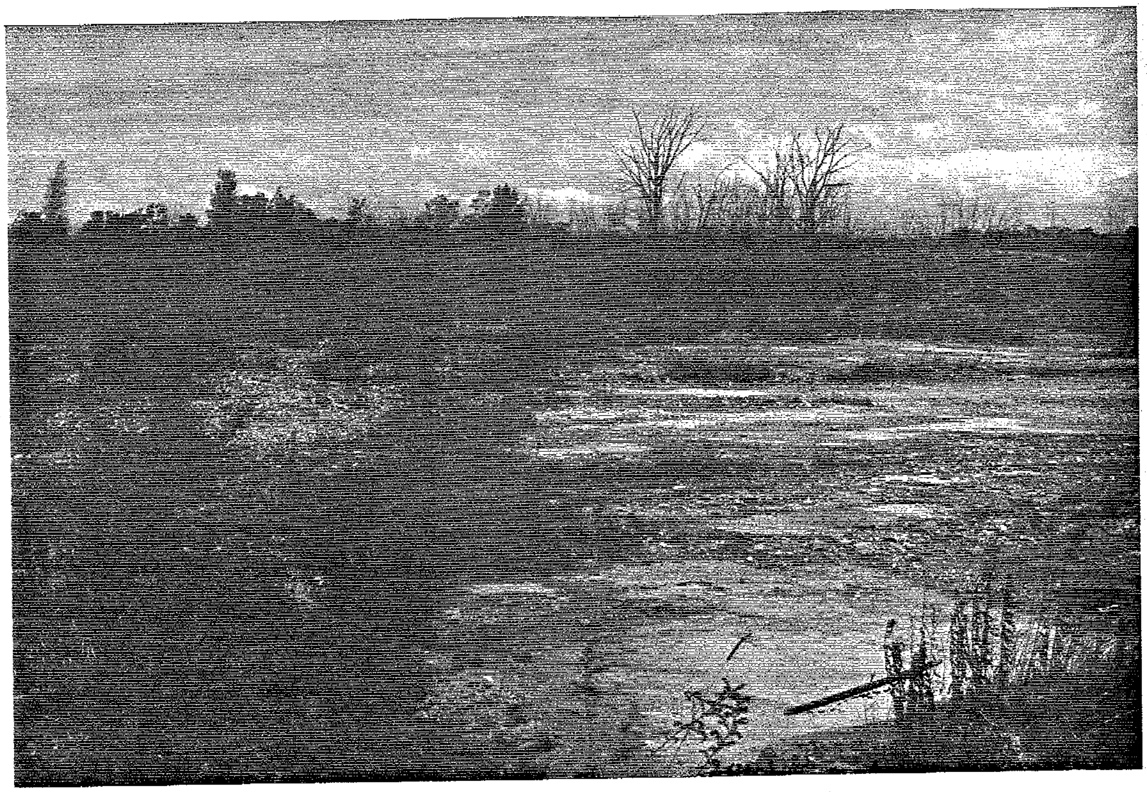
- • direction 1
- × direction 2
- ⚬ p-forms, sichelwannen or cavettos



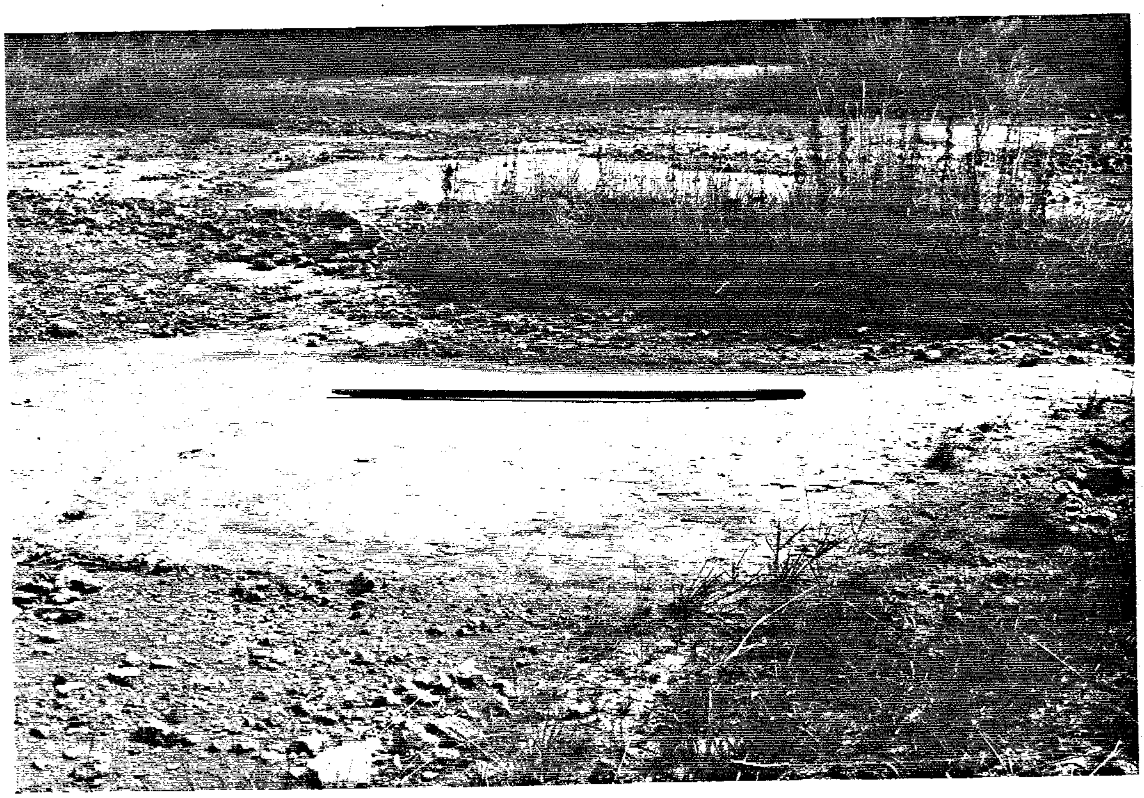
Small collapse of the bedrock surface which may be karst (St. 24).



High-lighted areas are type B waves. Amplitude of these waves is approximately 0.10 to 0.15 m (St. 25).



The polished surface on the right side of the photograph is striated. These striations terminate abruptly against a lineament oriented 125° (St. 25).



This is the same exposure as that shown above. Notice that in contrast to St. 228 the striations do not flow around bedrock high.

STATION NUMBER: 26 - 35 UTM: E 32865 N 45867 (St. 29)
TOWNSHIP: Athol CON. IV, V LOT: 9-13
ELEVATION: 82 metres above sealevel

Brief Description of Morphology:

Sediment and features north of the western pond created by Ducks Unlimited.

Observations:

Station 26 - Bedrock surface with joints oriented approximately 060°, 125° and 170°. Large gaps along the joints oriented 125°.

Station 27 - There is approximately 0.40 to 0.60 m of unsorted sediment overlying the bedrock surface. The joints at this exposure are oriented approximately 125° and 060°. Gaps between 20 to 40 mm are found along the joints oriented 125°.

Station 28 - Linear feature approximately 1 to 2 m high at 84 m ASL (275 feet). This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. It appears that the cycles and sediment coarsen downward. The side which is facing south is the highest side. Just south of the ridge there is little matrix mixed with the limestone and precambrian clasts.

Station 29 - Striated bedrock surface. Two kinds of abrasion forms; sichelwannen and striations. The sichelwannen are oriented approximately 248° and the striations are oriented 262°. Along a few of the joints oriented 125° the striations have been laterally displaced by 5 mm. The structure of the sichelwannen do not change on either side of the same joints.

Station 30 - Linear feature approximately 1 to 1.5 m high at 85 m ASL. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. This feature abuts an east/west rise on the south side. South of this ridge the bedrock surface is covered by 0.20 to 0.30 m of unsorted sediment. Precambrian clasts up to 0.50 m in diameter are found within this sediment. Gaps along joints oriented 125° are up to 0.10 m wide. Unsorted sediment is found within a few of these joints.

Station 31 - Positive linear feature and circular depression. The positive linear feature oriented approximately 148° and is approximately 0.80 m. high. This feature is very difficult to identify on the ground because it is covered by up to 0.50 m of unsorted sediment. Angular precambrian clasts with diameters up to 0.95 m are found upon the feature. A road crosses the feature and it was possible to observe the bedrock.

Joints oriented approximately 60°, 105°, 125° and 148° were observed, and these appear to be closer and more divergent than what is usually found. Many of the joints oriented 125° are open greater than 50 mm. Sweet clover grows in abundance upon this feature.

Station 32 - Linear feature approximately 0.60 to 1.2 m high at 85 m ASL. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand.

Station 33 - Drainage ditch/creek, depression and small linear feature. The is a tree alignment which cross the ditch. At the point where the alignment crosses (oriented approximately 125o) the bedrock surface three steps with approximately 0.67 m total displacement (north side up). Yellow layers (calcium) are found at the end of the ditch in the depression. The small linear feature south of the road and depression is oriented approximately 35° and is composed of up to 0.26 m of unsorted material with precambrian clasts.

Station 34 - Excavation on north side of the road between the IV and V concessions. Joints oriented 125° and 135° were observed. The material which overlies the bedrock is approximately 0.60 m thick and is unsorted. Precambrian clasts up to 0.92 m were seem within this sediment. The upper 0.40 m of the bedrock has weathered yellow.

Station 35 - Waved surface; crest of waves oriented 132o. There is 0.30 m of sediment covering the bedrock. This material consists of unsorted sediment and many precambrian clasts were observed to be with it. These clasts are up to 0.45 m in diameter. South of the road there is an old excavation. Joints in the bedrock at the base of this excavation are oriented 060°, 100° and 130°. Many of the gaps along these joints are greater than 50 mm. Drops up to 50 mm along adjacent sides of these joints are common. It is possible that the bedrock surface has buckled in this area. When tapped with a hammer these buckles sound 'hollow'. A east to west rise terminates on the west side of the excavation. This rise is up to 2.5 m above the floor of the excavation.

<u>Comment</u>:

The linear hills (Stations 28, 30 and 32) are ancient shoreline deposits of the Belleville Phase of Lake Iroquois. The lake was on the south side of the ridges when they formed. The matrix deficient area south of these features is the shallow water zone where the wave orbits eroded sediment that was deposited ultimately along the shore.

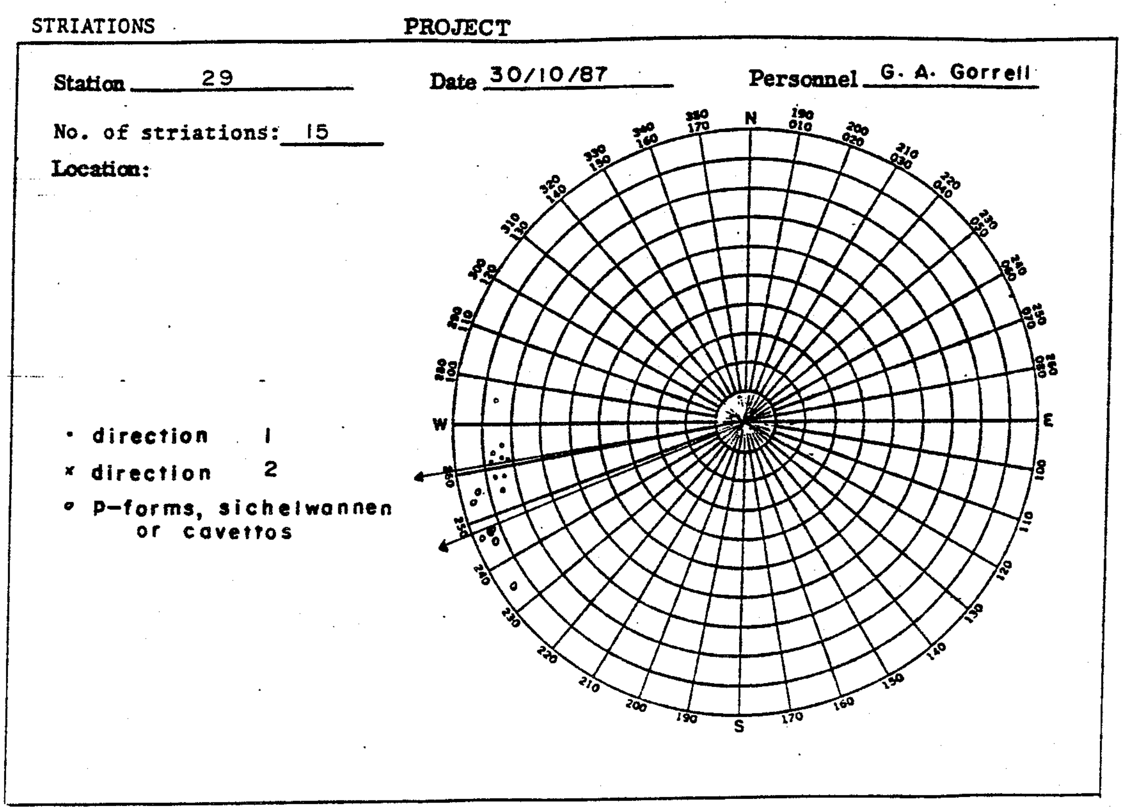
It appears that the positive linear feature (St 31) is a ''pop-up'' similar to those described by White <u>et al.</u> (1974).

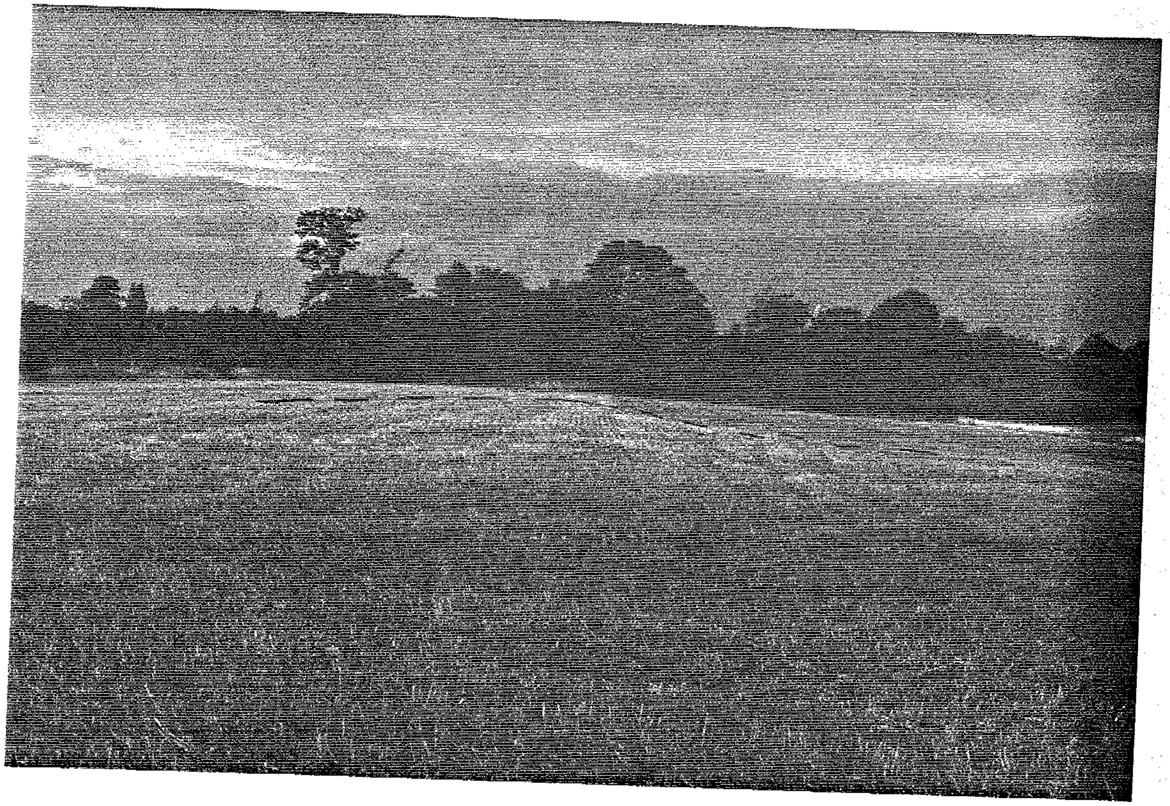
The unsorted sediment abutting the feature may be a till suggesting that the feature formed before the glacier retreated form the area. However, the striated surface (St. 29) suggests that the bedrock has shifted subsequent to the striations being made. This is because the striations are laterally, not horizontally, displaced (see abrasion section in report).

The predominate joint orientation is 060° and 125° (St. 26, 27, 29, 30 and 31). However, the joints oriented approximately 125o appear to be open wider and more frequently than the other joints. It is possible that dilation due to glacial unloading is responsible for this.

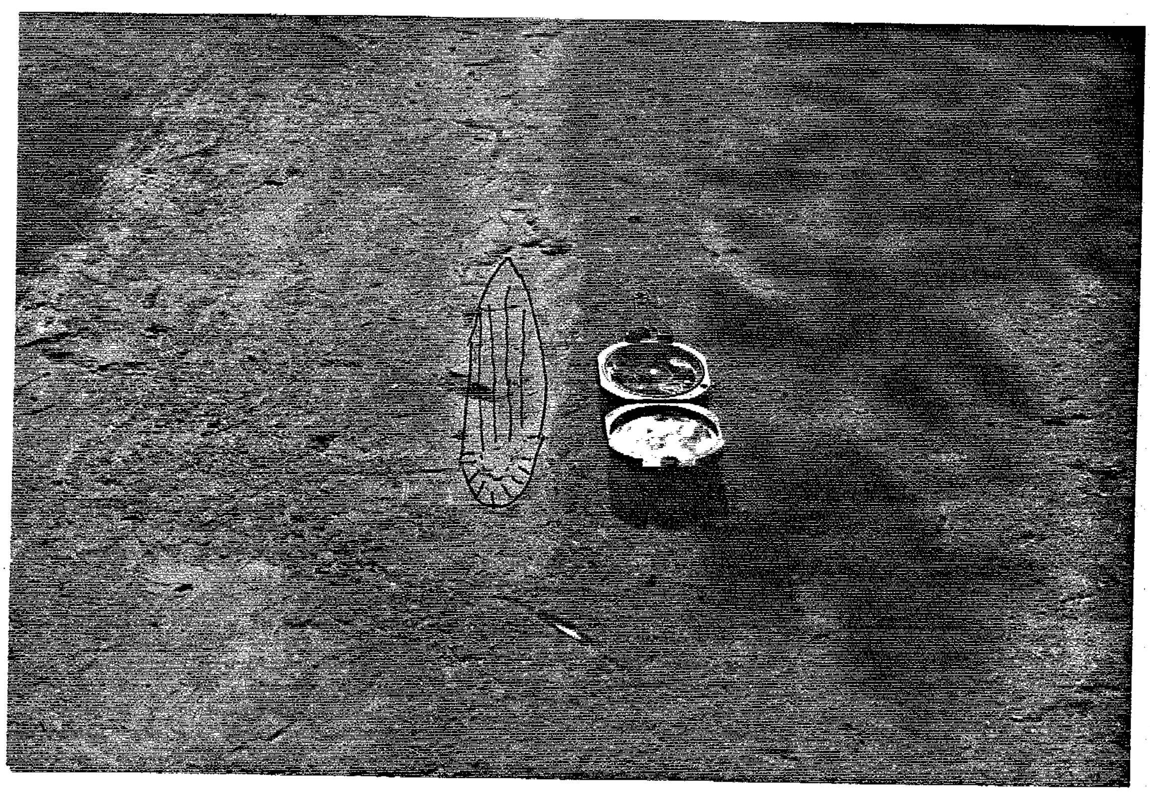
It is not known whether the buckles at Station 35 are due to solution of the limestone at depth which cause collapse or due to neo-tectonic movement. Both of these process are discussed in the report.

<u>Diagram and/or Picture:</u>





High-lighted ridge is an ancient shoreline composed of sorted sediment consisting of fining upward cycles (St. 28).



The high-lighted area is a p-form. The flow was from the bottom to the top. These forms do not change direction where the surface has risen at a joint (St. 29).

STATION NUMBER: 36 - 41 UTM: E 32955 N 45850 (St. 40)
TOWNSHIP: Athol CON. IV, V LOT: 7 -9
ELEVATION: 73-85 metres above sealevel

Brief Description of Morphology:

Sediment, morphological features between the two ponds created by Ducks Unlimited.

Observations:

Station 36 - Linear feature which is approximately 1.0 to 1.5 m high. The steepest and highest portion of this feature is on the southern side. The feature is not composed entirely of sediment. Two test pits were dug and it was found that 0.40 to 1.0 m of unsorted material overlies a bedrock rise. The thickest sediment accumulation is on the southern side (steep side) of the feature. Angular precambrian clasts with diameters up to 0.80 m are found within this sediment.

Station 37 - Five beach levels along the modern shoreline. From the lake to the backshore the levels are:

1) lower level - sediment grain-size is from medium sand to fine gravel (clasts , 20 mm)
2) second level- sediment grain-size ranges from 10 to 40 mm
3) third level- sediment grain-size is similar to second level
4) fourth level- sediment grain-size ranges from 0.10 to 0.20 m
5) fifth level- sediment grain-size ranges 20 to 60 mm

Behind the last level is a wet area which consists of 0.10 to 0.15 m of silt over bedrock. East of the north/south road and along the modern shore the bedrock has 'popped'. This 'pop-up' is oriented approximately 125° and extends out into the lake. Many precambrian clasts are found along the shore in this area.

Station 38- Waved topography. The crests of these waves are oriented approximately 125° and the troughs are filled with clayey-silt sediment. This sediment is at least 0.20 m thick. Angular precambrian clasts with diameters up to 0.40 m are found within this sediment. Where the bedrock is exposed it was observed that the joints are oriented 060° and 125°. Many of the joints oriented 125° are open wider than 50 mm.

Station 39- Linear feature approximately 1 to 1.5 m high at 85 m ASL. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The ridge is up to 40 m wide and the highest side is facing south. Immediately south of this ridge the bedrock surface is covered by 0.20 to 0.30 m of unsorted sediment. There is little matrix within this sediment. A 2.5 m. high ridge diverges from the southwest corner of this feature. This ridge consists of unsorted sediment and angular clasts up to 2.2 m in diameter. A linear depression, greater than 1.10 m deep, is found on the west side of the beach. The sediment within the depression has sunk approximately 0.40 m. This depression, which is oriented approximately 128o, is filled with unsorted sediment.

Station 40- A linear feature which is approximately 0.20 to 0.30 m high. Consists of unsorted sediment with precambrian clasts up to 1.80 m in diameter. A linear depression at least 1.10 m deep is beneath the ridge where it was removed at a road excavation. This depression is filled with sediment similar to that described above.

Station 41- A bedrock surface which has been abraded. The abrasions consist of striae and cavettos. The cavettos are oriented 259° and the striations are oriented 265°. In addition, the bedrock surface is waved, with the waves oriented 152°.

Comment:

The linear ridge (St. 39) is an ancient shoreline deposit of the Belleville Phase of Lake Iroquois. The lake was on the south side of the ridge when it formed. The matrix deficient area south of these feature is the shallow water zone where the wave orbits eroded sediment that was deposited ultimately along the shore.

The 'pop-up' (St 37), east/west rise (St 36) and waved topography (St 38 and 41) indicate that tectonic activity had occurred. These features do not indicate necessarily that the movement was neo-tectonic. The main reason is that the unsorted sediment deposited adjacent to these features is probably a till, This indicates that the features had to be present when the glacier flowed over the area. The unsorted sediment in the linear depression (St. 39 and 40) support this, for this material was probable deposited when the ice covered the area.

The cavettos and striations indicate that two abrasion processes had operate. The cavettos were probably formed by meltwater (Gjessing, 1967; Gray, 1981) and the striations by direct action of tools at the base of the glacier.

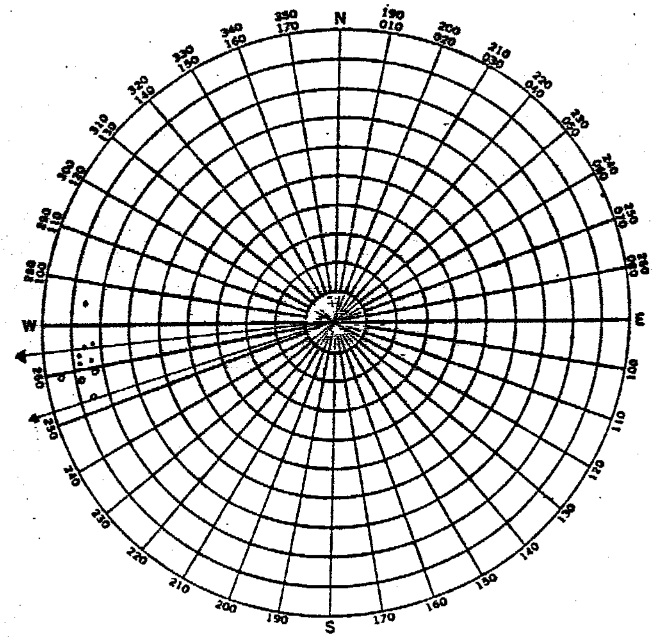
Diagram and/or Picture:

STRIATIONS PROJECT

Station 41 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 10

Location:



• direction 1
× direction 2
• p-forms, sichelwannen or cavettos

High-lighted ridge is an ancient shoreline composed of sorted sediment consisting of fining upward cycles (St. 34).

STATION NUMBER: 42 - 60 UTM: E 32875 N 45990 (St 50)
TOWNSHIP: Athol CON. IV LOT: 5 - 11
ELEVATION: 90 metres above sealevel

Brief Description of Morphology:

Sediment and features east of County Road 24 and north of the IV, V concession line.

Observations:

Station 42 - Linear feature approximately 1.0 to 1.5 m high at elevation 89 m ASL. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. These cycles are 30 to 50 mm thick.

A 61.0 m wide gap separates two portions of this ridge. In the centre of this gap is a linear depression approximately 0.25 m deep and 1.08 m wide. Large angular precambrian clasts with diameters up to 0.50 m are found within this depression. No sorted sediment was found on either side of the gap. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. This gap is not anthropogenic, there is no evidence that the gap is an old excavation. This gap can be traced south to Station 31.

There is a small excavation on the western side of the gap. It appears that there are larger joint gaps closer to the linear depression.

Station 43 - a) Unsorted sediment 0.15 to 0.25 m deep consisting of sandy-silt and angular clasts of limestone and rounded clasts of precambrian origin.
b) Unsorted sediment similar to (a) but is only 0.10 to 0.15 m deep. Joints oriented 148° can be seen as vegetation alignments.
c) Waved topography where crests are oriented approximately 125°. The amplitude of the waves is approximately 0.15 m. The surface is rising gently to the northwest.
d) A positive linear feature oriented approximately 125°. The bedrock is on the surface. There appears to be 30 to 60 mm of vertical displacement, up to 0.70 m of longitudinal displacement and 0.10 m lateral displacement on adjacent sides of the joints. This linear feature can be traced directly south into the linear depression described at Station 42.
e) A 1.50 m wide linear stone pile oriented 060° which is 7.0 m north of a fence line. This stone pile can be traced for 1.5 km to the crevasses at Station 73. On either side of this pile the bedrock surface is no more than 0.20 m below the surface. However, in the centre of the pile the bedrock was not encountered at depths greater than 0.50 m below the adjacent surfaces.

Station 44 - Three linear ridges 1.0 to 2.2 m high that have branched from one large ridge. The elevation of these features is approximately 94 m ASL (310 feet). These ridges consist of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand.

Station 45 - This station consists of a linear ridge at elevation 94 m ASL that is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The highest side of this ridge is on the west to north west side of the feature; the southeast side of the feature is at a higher elevation than the northwest. There is 0.04 to 0.40 m of sediment above the bedrock surface in this area.

Station 46 - This station is southeast of Station 45. There is 0.04 to 0.40 m of sediment above the bedrock surface in this area. The thickness of the drift increases away from the sorted ridge. Joints oriented 055° and 145° were observed in this area. The joint with the largest gap (0.40 m) is the one that is oriented sub-parallel (055°) to the scarp upon which the sorted ridge (St. 45) developed upon. Precambrian clasts with diameters up to 0.45 m are lodged within the open crevasses.

Station 47 - This Station is located north of Station 42. The surface is waved and the crests of the waves are oriented approximately 148°. The wavelength of the waves is approximately 6.0 m and the amplitude is 50 mm to 0.10 m. The troughs of these waves are filled with unsorted sediment and clasts up to 0.60 m.

Station 48 - This station is located east of Station 47. A stone pile similar to the one describe at station 43 (e) is found at this station. Positive circular features are found on both sides of this stone pile. These features are 3 to 5 m in diameter. In addition, the ground surface is waved and these waves are oriented approximately 148°. In contrast to other areas, the surface of the ground in the area appears rubbled rather than cover with drift. Precambrian clasts were found only in the linear stone pile.

Station 49 - This station is located at the southwest corner of the tree lot. Greater than 0.30 m of organic rich unsorted sediment covers the bedrock surface.

Station 50 - This station is located on a linear depression oriented approximately 130°. Precambrian clasts with diameters up to 0.35 m are lodged within this depression. The healthiest apple trees in the area are growing on this lineament.

Station 51, 59 and 60 - These stations describe a 5 to 6 m high hill that is oriented approximately 055° to 065°. The steepest side of the high is on the south. On the crest of the hill (which is 12 m wide) are four small ridges approximately 0.4 to

0.7 m high consisting of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. These sorted ridges are approximately at elevation 93 m (305 feet) ASL. On either side of these sorted ridges the surface is waved and the crests of the waves are oriented approximately 060° and 148°. The wavelength of the waves is approximately 6.0 m and the amplitude is 50 mm to 0.10 m. The troughs of these waves are filled with unsorted sediment and clasts up to 0.60 m. Two small excavations had been dug at the crest of the hill and they indicate that the drift is no greater than 0.50 m. In addition, they indicate that the bedrock surface is buckled rather than stepped along the southern margin.

Station 52 - This station is located south of Stations 51 and 59. A small water hole has been made by blasting a hole in the bedrock. Overlying the bedrock is 0.60 m of unsorted sediment. The upper 0.25 m of this material is oxidized and little of the original structure could be seen. The lower 0.35 m though, is clayey-silt similar to that seen at Station 1.

Station 53 - There is an abrupt 0.70 m local rise in relief at this station. A small excavation was dug on the top of this rise and it was found that 0.10 to 0.15 m of sediment overlie bedrock. Precambrian clasts with diameters up to 0.60 m are resting on this bedrock surface.

Station 54 - This station consists of a linear ridge at elevation 89 m ASL that is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The ridge is 12 to 14 m wide. A smaller ridge branches off the side of the main ridge on the west side. This ridge is composed of the same material as the main ridge.

Station 55 - This station describes the striae and grooves observed at the base of a ditch. Two stria directions were seen and these are oriented approximately 256° and 283°. In addition grooves were observed on the surface and these are oriented 252°. Many of the striae converge into these grooves.

Station 56 - This station consists of a 1.0 to 1.5 m high linear ridge at elevation 87 m ASL that is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The southern side of the ridge has the greatest change in local relief. There is a smaller proportion of matrix in the sediment at the base of the hill on the southern side than in adjacent areas.

Station 57 - This station consists of two 1.0 to 1.5 m high linear ridges at elevation 85 m ASL. These ridges are composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The southern side of the feature is the highest side and there is a smaller proportion of matrix in the sediment at the base of the hill on this side than in adjacent areas. Precambrian clasts with diameters up to 0.70 m were seen in the sediment in adjacent areas.

Station 58 - This station consists of a 1.0 to 2.0 m high linear ridge at elevation 88 m ASL. The ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand.

Two gaps which are approximately 14.0 m wide separate portions of the ridges. In the centre of these gaps are linear depressions approximately 0.25 m deep and 1.08 m wide. These depressions are oriented approximately 125°. Large angular precambrian clasts with diameters up to 0.50 m are found within the depressions. No sorted sediment was found on either side of the gaps. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. The gap are not anthropogenic, there is no evidence that the gaps are old excavations.

The shape of the linear ridge changes on the eastern side of the eastern gap. Rather than consisting of a single ridge with one steep side, the ridge consists of three benches. Excavating between these levels indicates that the feature developed upon a bedrock rise.

South and north of the ridge the topography is waved. The crests of these waves are oriented approximately 060° and 125°. There is a smaller proportion of matrix in the troughs of these waves than at the crests.

Comment:

The linear ridges (St. 42, 44, 45, 51, 54, 56 - 60) are ancient shoreline deposits of the Belleville Phase of Lake Iroquois. These shorelines are at three different elevations; 85 m, 89 m and 94 m ASL. The lake was on the south side of the ridges when they formed. The drift on the southern side of the features have smaller proportion of matrix because this is the shallow water zone where the wave orbits eroded sediment that was deposited ultimately along the shore.

The grooves and striations indicate that two abrasion processes had operated. The grooves were probably formed by meltwater (Gjessing, 1967; Gray, 1981) and the striations by direct action of tools at the base of the glacier.

The absence of the shorelines where they cross linear depressions is discussed in the report.

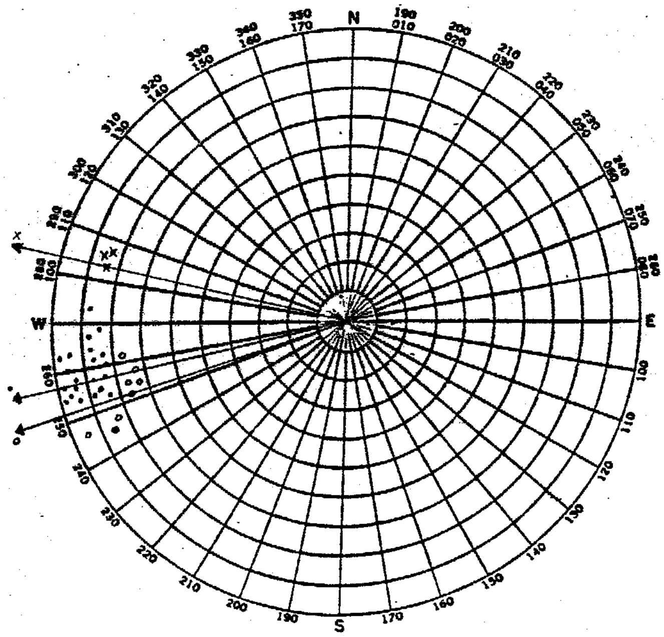
Diagram and/or Picture:

STRIATIONS PROJECT

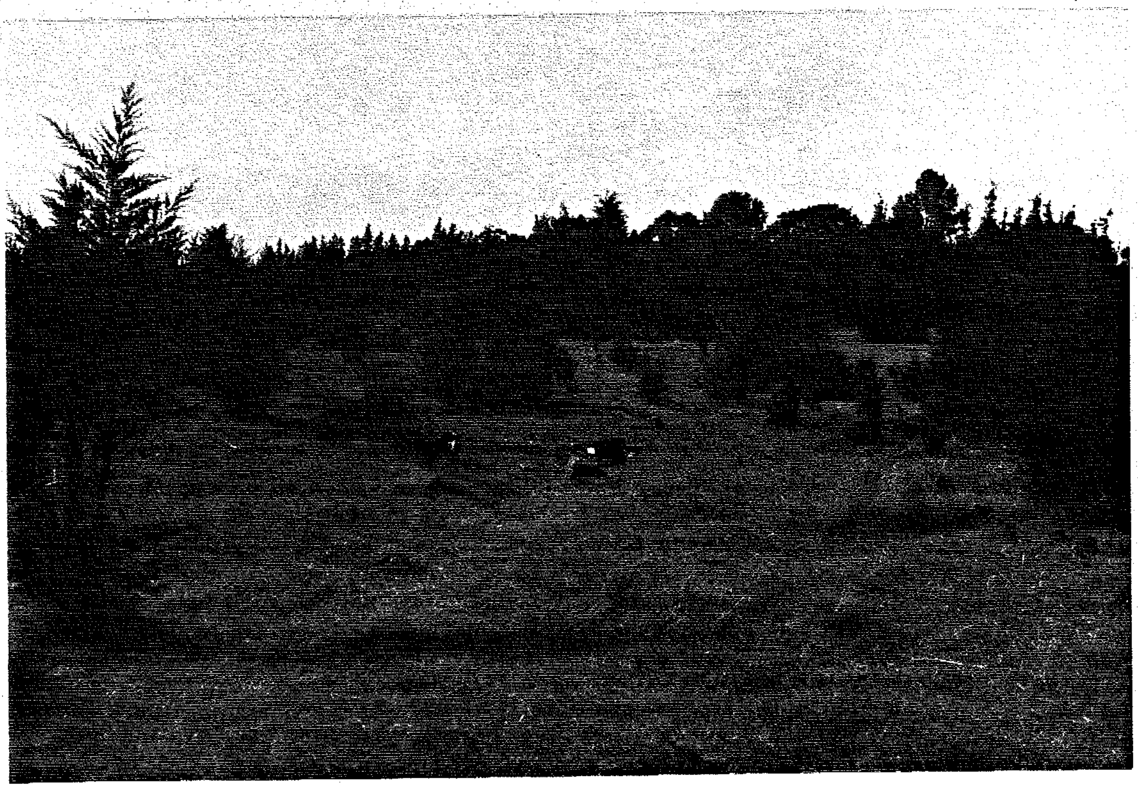
Station 55 Date 30/10/87 Personnel G. A. Gorrell

No. of striations: 32

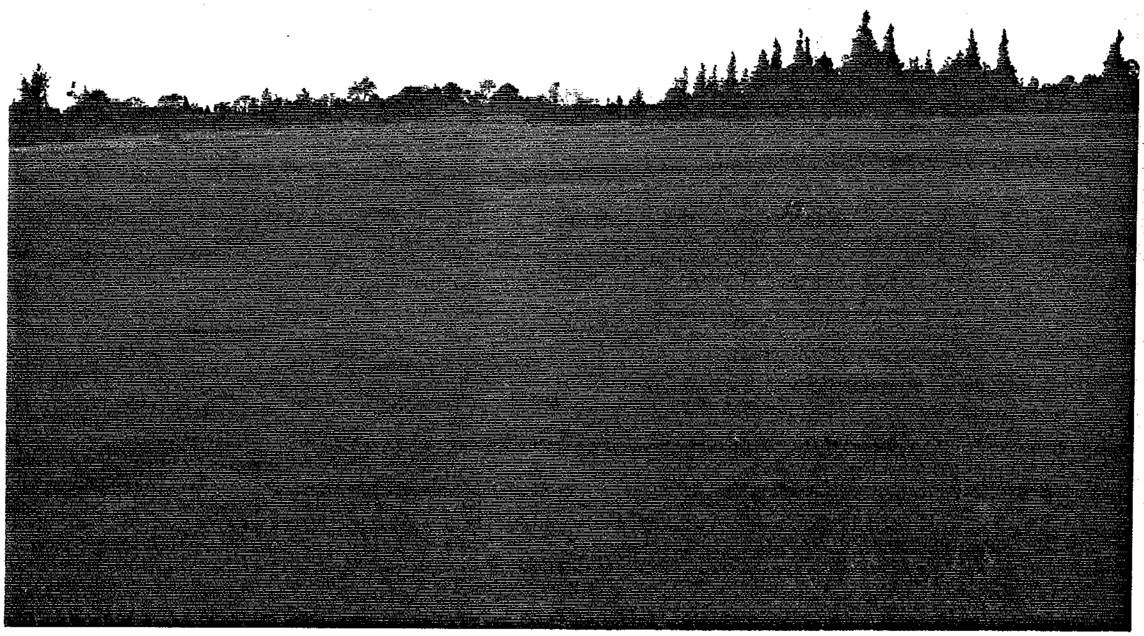
Location:



- • direction 1
- × direction 2
- ∘ p-forms, sichelwannen or cavettos



This is not an anthropogenic feature but a linear depression. Where a shoreline crosses this feature it does not exist (St 42).

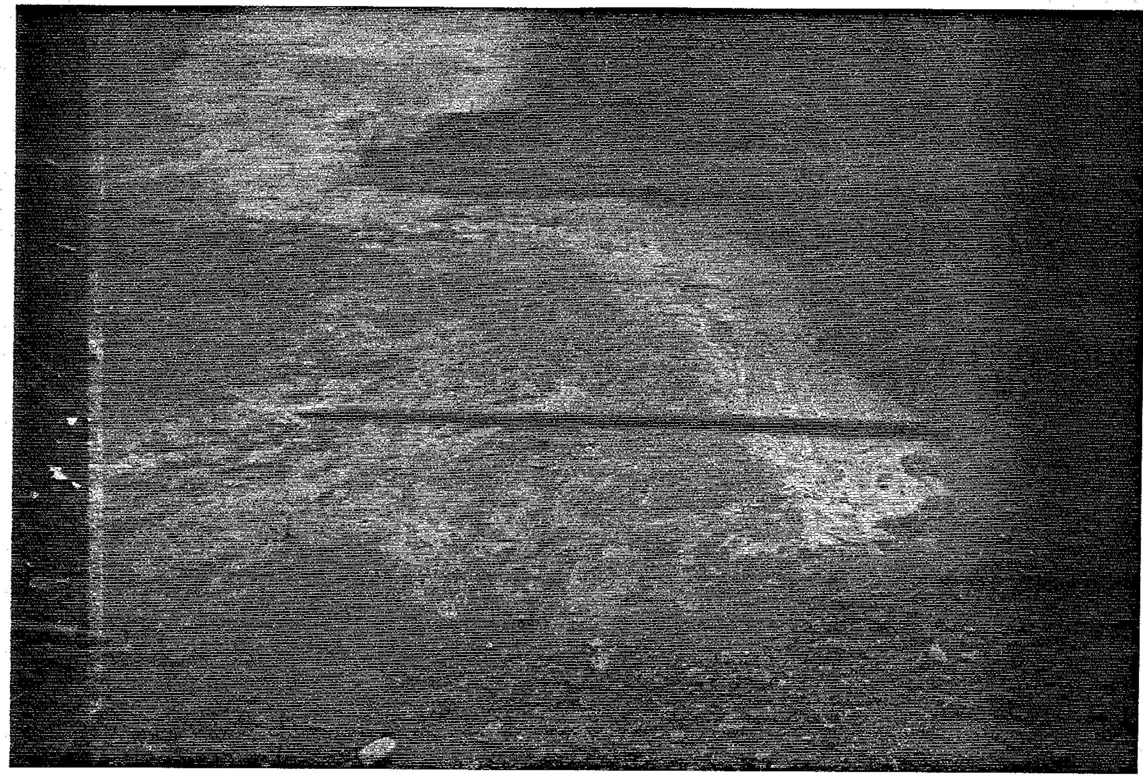


These are type A waves at Station 43b.

The linear depression shown above changes aspect to become a positive linear feature. This ridge is oriented approximately 125° (St. 43d).

This is a close-up of the buckle at Station 43d.

This is at the top of the 6.0 m high bedrock rise (St 51). The shoreline feature which was deposited upon it is waved (type A).



This is a bedrock surface which is striated and grooved. The grooves are oriented 245° and the striations are oriented 260° (St. 55).

This is a gap in the shoreline deposit (St. 58). A linear depression is found at this gap.

STATION NUMBER: 61 - 71 UTM: E 33055 N 46002 (St. 65)
TOWNSHIP: Athol CON. IV LOT: 2 - 5
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology of the area one concession north of Gull Pond.

Observations:

Station 61 - This Station consists of a 1.0 to 2.0 m high linear ridge at elevation 85 m ASL. The ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. There is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. Joints oriented approximately 060° and 125° were seen where the bedrock was exposed.

Station 62 - This Station is a linear feature approximately 0.5 to 1.5 m high at elevation 86 m ASL. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. These cycles are 30 to 50 mm thick.

A 18.0 m wide gap separates two portions of this ridge. This gap is oriented approximately 125°. In the centre of this gap is a linear depression approximately 0.25 m deep and 1.08 m wide. Angular precambrian clasts with diameters up to 0.50 m are found within this depression. No sorted sediment was found on either side of the gap. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. This gap is not anthropogenic, there is no evidence that the gap was an old excavation.

Station 63 - This Station consists of a linear ridge at elevation 90 m ASL. It is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The ridge is 18 m wide. There is a smaller proportion of matrix in the sediment at the base of the hill on the southern side ridge than in adjacent areas. Just west of the north/south road the ridge splits in two. These ridges are composed of the same material as the single ridge.

North of the ridge the sediment is greater than 1.0 m thick. Approximately 0.10 m of organic-rich soil overlies greater than 1.0 m of rubbly unsorted sediment. This zone of thicker drift is oriented approximately 060°.

South of the ridge is a small circular depression and many positive circular features. Although there is less than 50 mm of sediment over the bedrock surface along the edges of the depression there is greater than 1.0 m of clay-rich sediment in the centre. In addition the topography in this area is waved. The crests of these waves are oriented approximately 060°.

Station 64 - This Station is located at the junction of the east/west and the north/south road southeast of Station 63. Joints oriented 060°, 096° and 125° with gaps greater than 50 mm wide were observed within the ditch. The majority of these open joints are oriented 125°. In addition, there is a slight buckle or rise in the bedrock surface. The west side of this 8.0 m wide buckle is higher in elevation than the east side.

Station 65 - This Station consists of a 1.0 to 2.0 m high linear ridge at elevation 85 m ASL. It is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The southern side of the ridge has the greatest change in local relief. There is also a smaller proportion of matrix in the sediment at the base of the hill on its southern side than in adjacent areas.

There is a linear depression where the buckle described in Station 65 crosses the ridge. This linear depression can be traced north into a 3.0 by 4.0 m elliptical depression. Parallel to this linear depression on the ridge are hummocky zones. The amplitude of these hummocks is 0.20 to 0.30 m.

Station 66 - This Station is east of Station 65 on the same linear feature. It consists of a 1.0 to 2.0 m high linear ridge at elevation 85 m ASL. It is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The southern side of the ridge has the greatest change in local relief. There is also a smaller proportion of matrix in the sediment at the base of the hill on its southern side than in adjacent areas.

On the north side of the ridge the sorted sediment has collapsing into ten crevasses (There is also one on the south side). Eight of these crevasses are oriented 125° and one is oriented 060°. There appears to be vertical and lateral displacement along adjacent sides of the joints. The west side of the vertical displacement is generally the higher side. In addition, many of sides of the crevasses have been extensively modified by solution (ie. scalped).

The largest crevasses is oriented 148o. The gap between adjacent sides is approximately 0.35 m. In addition, the west side of the crevasses is approximately 0.80 m higher than the eastern side. When examined of the colour infra-red mosaic, this crevasse can be trace directly into a positive linear feature (St. 83).

East of the ridge composed of sorted sediment is a 1.0 to 1.5 m high bedrock rise. It is probable that this rise also underlies the sorted ridge. South of this rise the topography is waved. The crests of these waves are oriented approximately 148°. However, the orientation of these waves appears to change to 100° where they cross the bedrock rise. This orientation changes quickly to 125° northward. This change in wave orientation could not be observed near the sorted ridge.

Station 67 - Linear feature approximately 1 to 2 m high at elevation 91 m ASL (300 feet). This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. There is also a smaller proportion of matrix in the sediment at the base of the hill on its southern side than in adjacent areas.

This feature crosses a lineament (linear depression) just east of the north-south road. The bedrock surface in this area is waved. The wavelength of the waves is approximately 22 m and the amplitude is approximately 40 mm. The peat-rich area discussed at Station 63 begins exactly where the lineament and sorted ridge cross.

Station 68 - This Station is located east of Station 67 on the same ridge. The elevation of the feature at this location is 90 m ASL. However, instead of developing on top of a bedrock ridge, the feature has formed on the side of a bedrock rise. In addition, instead of one ridge, there are two; each approximately 0.20 to 0.50 m high. North and south of the sorted ridges the surface is waved. There is a smaller proportion of matrix in the troughs of the waves than at the crests. The wave crests are oriented approximately 060° and 125°.

Station 69 - This Station is located at the second fence-line east of the north-south road. The elevation of the ridge at this location is approximately 90 m ASL. At this location the ridge discussed at Stations 67 and 68 crosses a lineament oriented approximately 125° (Station 84) and one oriented 148° (Station 66). Where the sorted ridge crosses the lineaments the ridge does not exist. No sorted sediment was found on either side of the gap. This gap is not anthropogenic, for there is no evidence that the gap is an old excavation.

Sorted sediment was found at the base of the gap. Just south of the sorted ridge, the 148° lineament consists of a series of circular depressions. These depressions are no greater than 0.25 m deep.

Station 70 - This Station consists of two 1.0 to 1.5 m high linear ridges approximately 22 m wide separated by a gap approximately 38 m wide. These ridges are approximately at elevation 90 m ASL. The north ridge is 0.10 to 0.30 m higher than the southern ridge. These ridges are composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. There is a smaller proportion of matrix in the sediment at the base of the hill on southern side of the ridge than in adjacent areas. Precambrian clasts with diameters up to 0.70 m were seen in the sediment in adjacent areas. Similar to Station 68 the sorted ridges have developed upon a rise in the bedrock surface.

Station 71 - This Station is located northeast of Station 70 on the same linear ridge. This linear feature is approximately 1.0 to 1.5 m high at elevation 90 m ASL. It consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. These cycles are 30 to 50 mm thick.

A 12.0 m wide gap separates two portions of this ridge. In the centre of this gap is a linear depression approximately 0.25 m deep and 0.80 m wide. This depression is oriented approximately 125°. Angular precambrian clasts with diameters up to 0.90 m are found within this depression. No sorted sediment was found on either side of the gap. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. This depression is not anthropogenic, there is no evidence that it is an old excavation. This depression can be traced south to an east/west rise whereupon it changes aspect to become a positive linear feature at Station 86.

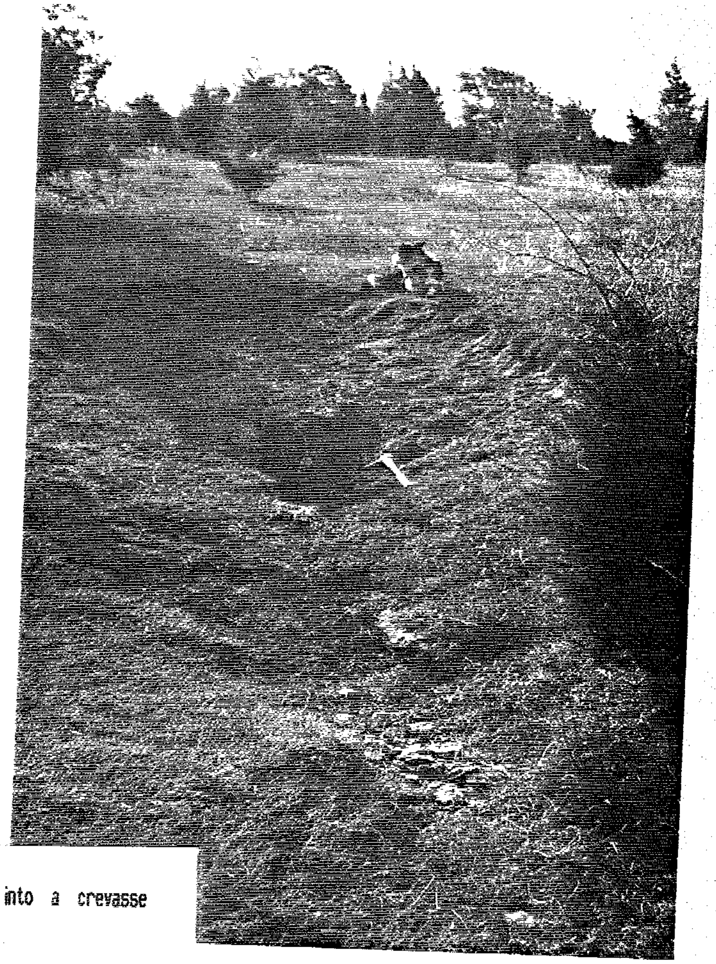
The ground surface is waved, both in the linear depression and in the area adjacent to it, south of the sorted ridge. These waves are oriented approximately 152°. The amplitude of these waves decreases westward.

Comment:

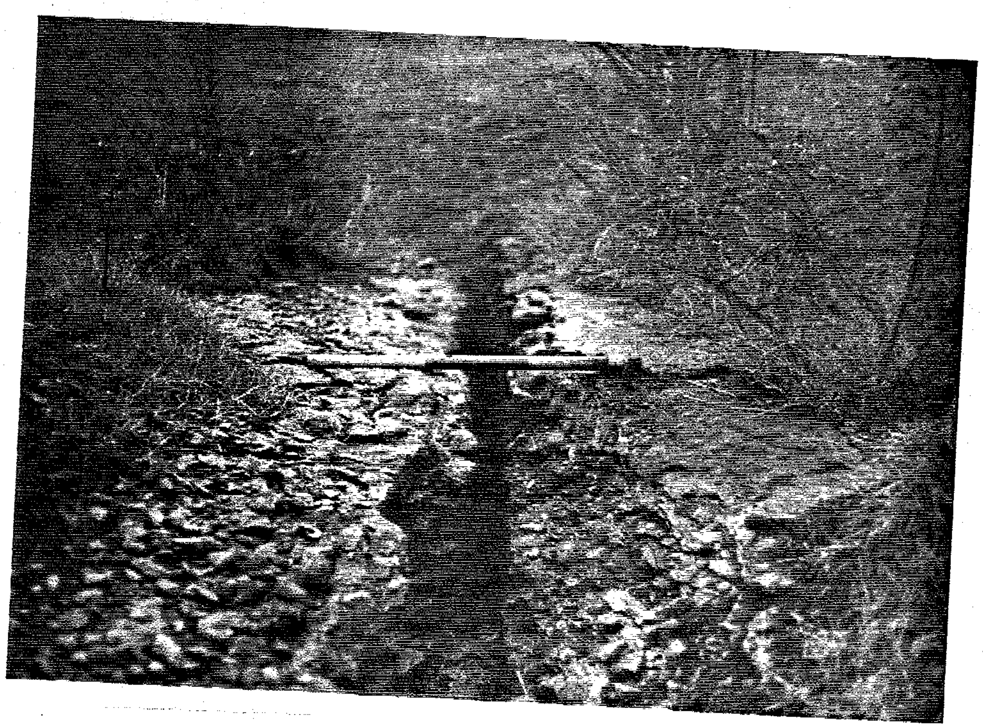
The linear ridges (St. 61 - 63 and 65 - 71) are ancient shoreline deposits of the Belleville Phase of Lake Iroquois. These shorelines are at two different elevations; 85 m and 90 m ASL. The lake was on the south side of the ridges when they formed. The drift on the southern side of the features have smaller proportion of matrix because this is the shallow water zone where the wave orbits eroded sediment that was deposited ultimately along the shore. The absence of the shorelines where they cross lineaments (St. 62, 65 - 67, 69 and 71) is discussed in the report.

The pop-up (St 64), east/west rise (St 66, 68, 70 and 71) and waved topography (St 63, 67 and 71) indicate that tectonic activity had occurred. These features do not indicate necessarily that the movement was neo-tectonic. This is discussed further in the report.

Diagram and/or Picture:

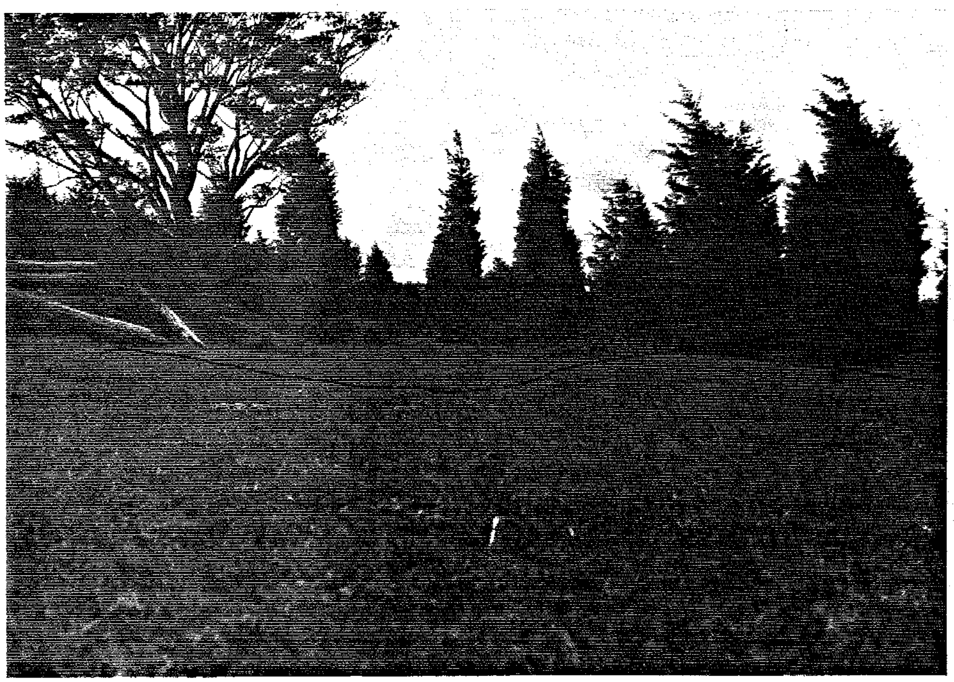


The ancient shoreline is currently collapsing into a crevasse (St. 66).



One side of the crevasse is usually higher than another (St. 66).

At Station 69 the ancient shoreline does not exist where it crosses a linear depression.



Type A waves are found in the area where the shoreline has disappeared (St. 71).

STATION NUMBER: 72 - 75 UTM: E 32760 N 45885 (St. 72)
TOWNSHIP: Athol CON. IV LOT: 11 - 13
ELEVATION: 90 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and features near Stations 42 - 60.

Observations:

Station 72 - This Station is located west of Station 42. At this location there is a linear feature approximately 0.5 to 1.2 m high. It is at approximately elevation 90 m ASL (295 feet). This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. It appears that the cycles and sediment coarsens downward. The side which is facing south is the highest side.

Station 73 - This Station is located northeast of Station 72. At this location there is a linear feature approximately 1.5 to 2.5 m high. It is located approximately at elevation 93 m ASL (305 feet) and was deposited upon a bedrock scarp. This ridge consists of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. It appears that the cycles and sediment coarsen downward.

The surface of the feature is pitted with small 1.5 m by 1.0 m circular depressions and divided by a 1.5 m deep linear depression. The orientation of this depression is approximately 060°. This depression can be traced to a large crevasse on the west side of the feature (St. 74). In addition, if a 060° bearing is taken on each of the small circular depressions, these can also be traced to crevasses. It is possible that the large linear depression which bisects the beach is the same one observed at Station 43 and the abrupt drop of the bedrock surface at Station 138.

Station 74 - This Station is located west of Station 73 in the area where the crevasses are found. These crevasses are oriented approximately 060° and are up 25 m long and up to 0.25 m wide. If each of these crevasses are followed eastward onto the sorted ridge, a circular depression is found. In addition, at the southern end of this crevasses zone the ground surface abruptly rises 0.30 to 0.80 m. This abrupt rise corresponds to the linear depression which bisects the sorted ridge. In addition, this rise corresponds exactly to the 0.80 m rise of the bedrock surface at Station 138.

South of this zone the ground surface is waved. These waves are oriented approximately 105° and 125°. There is a smaller proportion of matrix in the troughs of these waves than at the crests.

Station 75 - This Station consists of a 1.5 to 2.5 m high and 32 m wide linear ridge located approximately at elevation 88 m ASL. It is composed of fining upward cycles of clast supported fine gravel and plane bedded medium to fine sand. The southern side of the ridge has the greatest change in local relief. There is a smaller proportion of matrix in the sediment at the base of the hill on the southern side than in adjacent areas.

Comment:

The linear ridges (St. 72, 73 and 75) are ancient shoreline deposits of the Belleville Phase of Lake Iroquois. These shorelines are at three different elevations; 88 m, 90 m and 93 m ASL. The lake was on the south (St 72 and 75) and western (St 73) sides of the ridges when they formed. The drift on the southern side of Station 72 and 75 and on the western side of Station 73 have a smaller proportion of matrix because these are the shallow water zones where the wave orbits eroded sediment that was deposited ultimately along the shore.

The sinking of the shoreline sediment is definitely recent. However, there can be many processes that can cause the collapse. These reasons are discussed in the report.

Diagram and/or Picture:

High-lighted ridge is an ancient shoreline composed of sorted sediment consisting of fining upward cycles (St. 73).

A linear depression bisects the beach at Station 73. This depression can be traced (060°) to a crevasse (below).

STATION NUMBER: 76 - 86 UTM: E 33175 N 45947 (St. 82)
TOWNSHIP: Athol CON. IV, V LOT: 5 - 8
ELEVATION: 81 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and features northwest of Gull Pond.

Observations:

Station 76 - This Station is located on the modern shoreline on the west side of Gull Pond. The colour infra-red mosaic indicates that a lineament crosses the shoreline at this point. On the ground this lineament cannot be seen. However, the infra-red mosaic indicates that the shape of the modern shoreline changes on either side where the lineament crosses it. On the west side of the lineament there are 6 modern beach levels. On the east side of the lineament, the highest level disappears and only 5 levels remain. In addition, the depth of the water in Gull Pond is noticeably shallower where the lineament crosses it.

Station 77 - This Station is located north of Station 76 upon a positive linear feature. It is oriented approximately 148° and is up to 0.95 m high and 25 m wide. On the east side of the feature there is 0.62 m of unsorted sediment composed of clayey-silt while at the crest there is 0.10 m of sediment. There is consistently more sediment on the sides of the feature than on the crest of the feature is traced north (to Station 81).

There is another linear ridge 100 to 150 m east of this Station. Although it does not have the same amplitude as the one described above, the sediment on either side of it is similar. Sweet clover grows in abundance on both of these features.

Station 78 - This Station is located west of Station 77. The ground surface in the vicinity of this Station is waved. The wave crests are oriented approximately 125° and the wavelength is approximately 6.0 m. This is a smaller proportion of matrix in the troughs of the waves than on the crests. Clasts of mainly precambrian origin with diameters up to 0.85 m are found in the troughs.

Station 79 - This Station is located east of Station 78. The surface of the ground at this Station is waved. In contrast to the waves at Station 78 these waves have a higher amplitude (up to 0.25 m) and the wavelength is larger (15 to 24 m). In addition, in the troughs of the waves the sediment is not matrix deficient. These crests of the waves are oriented approximately 148° and appear to cross the north-south oriented road where it is waved.

Between Station 78 and 79 there is a circular depression. This depression is up to 0.30 m deep. Precambrian clasts with diameters up to 0.85 m are seen in this depression.

Station 80 - This Station is located approximately 1.5 km northwest of Station 79. It consists of a 1.5 to 2.0 rise of the bedrock surface. The bedrock has not buckled but is stepped. The steps are facing north. Unsorted material composed of clayey-silt abuts the feature.

Station 81 - This Station is located north of Station 77, just south of the pond created by Ducks Unlimited. Type B waves were observed at this station. In addition, a few of the waves have 'popped'. The popped waves can be traced south to the linear features described at Station 77. The drift, which generally consists of unsorted sediment composed clayey-silt material is always thicker on the sides (up to 0.50 m) of the buckles than on the top. It appears that more sediment was deposited on the west side of the buckles than on the east. These pop-ups are oriented approximately 148o and are approximately 18 m wide.

Striations were also observed on the bedrock surface. These striations are oriented approximately 259°. These striations were found only on the east side of a few of the waves. They terminated abruptly on the crest of the waves.

Station 82 - This station is located east of Station 81. It consists of 16 m wide linear ridge oriented approximately 110° to 120° covered with sweet clover. The ridge is not symmetrical on either side its crest. There is approximately 20 to 40 mm of sediment on the crest of this ridge overlying the bedrock. The thickness of the sediment overlying the bedrock thickens on the sides of the feature to greater than 0.15 m. The material on the crest and west side of the feature consists of sandy-silt material and fine gravel. The clasts range in size from 20 to 80 mm. However, on the east side of the ridge the sediment consists of clayey-silt.

It was possible to observe the bedrock underlying the sediment where a road has been built over the ridge. The rock has definitely 'popped' or buckled. The amplitude of this buckle is approximately 0.40 m to 0.60 m.

Type B waves were observed on the east and west sides of the pop-up. These waves are oriented approximately parallel with the linear ridge. Although much of the surface has been rubbled (due to weathering, anthropogenic processes or tectonic activity) a few striations were observed. These striations are oriented approximately 250°.

Station 83 - This Station is located northwest of Station 82. On the colour infra-red mosaic four lineaments were observed in this area. The lineament with the largest amplitude is oriented approximately 148° and can be traced southward to Station 77 and 81 and be traced northward to the largest crevasse at Station 66. On the west side of this lineament there are many circular depressions with diameters up to 2.5 m which are up to 0.20 m deep. Depressions with the same amplitude can be seen in the ditch by the road north of the station. Approximately 60 to 70 mm of clayey-sediment overlies the bedrock on the crest of this feature.

Two other lineaments were observed to run parallel to subparallel of the largest one. The lineament on the east side of the largest lineament is oriented 148° and can only be distinguished by the sweet clover which grows upon it and the small, less than 50 mm rise. The sediment which covers it is similar to the clayey-silt which covers the largest one. In the ditch north of the station a small rise in the bedrock topography could be detected. The lineament on the west side of the feature is a linear depression oriented approximately 145°. It is a least 1.0 m deep and filled with clayey-silt.

The fourth lineament is oriented approximately 125° and can be traced southeastward to Station 82 and northwestward to Station 64. This lineament cross-cuts the three lineaments described above. On the west side of the linear depression described above, the lineament is a linear depression. However, once it crosses the linear depression it changes aspect to a positive linear feature. West of the linear depression it is approximately 1.6 m high and is covered with up to 60 mm of clayey-silt. Precambrian clasts with diameters up to 0.40 m were observed on top of this feature. The ground surface on the west side of the feature is 0.20 to 0.40 m higher than the east side.

Station 84 - This station is located northeast of Station 83 and deals with observations obtained on the north and south sides of the road. South of the road are mounds of sediment which are parallel with the road. These mounds were deemed to be anthropogenic.

North of the road there is an 0.5 to 0.80 m rise that is oriented approximately east to west. No sorted sediment was found upon this ridge although this rise can be traced westward to the sorted ridge described at Station 66. Type A waves were observed to cross this rise. On the south side of the rise these waves are oriented approximately 148°. However, the orientation of the waves on the north side of the rise on the side closest to Station 83 change once they cross the rise to 100° and then to 125°. This change was not as evident farther east.

The east to west oriented rise is bisected by a linear depression oriented approximately 122°. This depression is filled with clayey-silt and precambrian clasts with diameters up to 0.65 m. The ground surface in this linear depression is up to 0.10 m below the surrounding surface. Type A waves oriented approximately 148° are observed in the vicinity of the linear depression.

Station 85 - This Station is located east of Station 84. At this Station the east to west oriented rise is much more pronounced. Similar to Station 84 no sorted sediment was found upon this ridge.

South of the rise a small 0.60 m deep excavation was found. The material which was excavated from this pit consisted of unsorted sediment consisting of sandy-silt material.

North of the east to west oriented rise there is a linear depression. This linear depression can be traced northwestward to the depression described at Station 71 and traced southeastward to a positive linear feature (Station 86). A large circular depression is found on the north side of the east/west rise where the aspect of the lineament changes from positive to negative. This depression is filled with approximately 0.14 m of sediment; 60 mm of clayey-silt material overlain by 80 mm of soil.

Station 86 - This Station is located east of Station 85. As mentioned above, this Station describes a positive linear feature oriented approximately 125°. Where the road crosses the feature the bedrock in the ditch has buckled. The amplitude of this buckle is approximately 50 to 100 mm. Southeast of this crossing the features relief is much greater. A test pit was dug on the crest of the feature and it was found that 0.10 to 0.25 m of covered the feature. The upper 0.15 m of this sediment consists of medium to fine angular to sub-angular gravel. This gravel overlies 50 to 80 mm of very silty unsorted sediment.

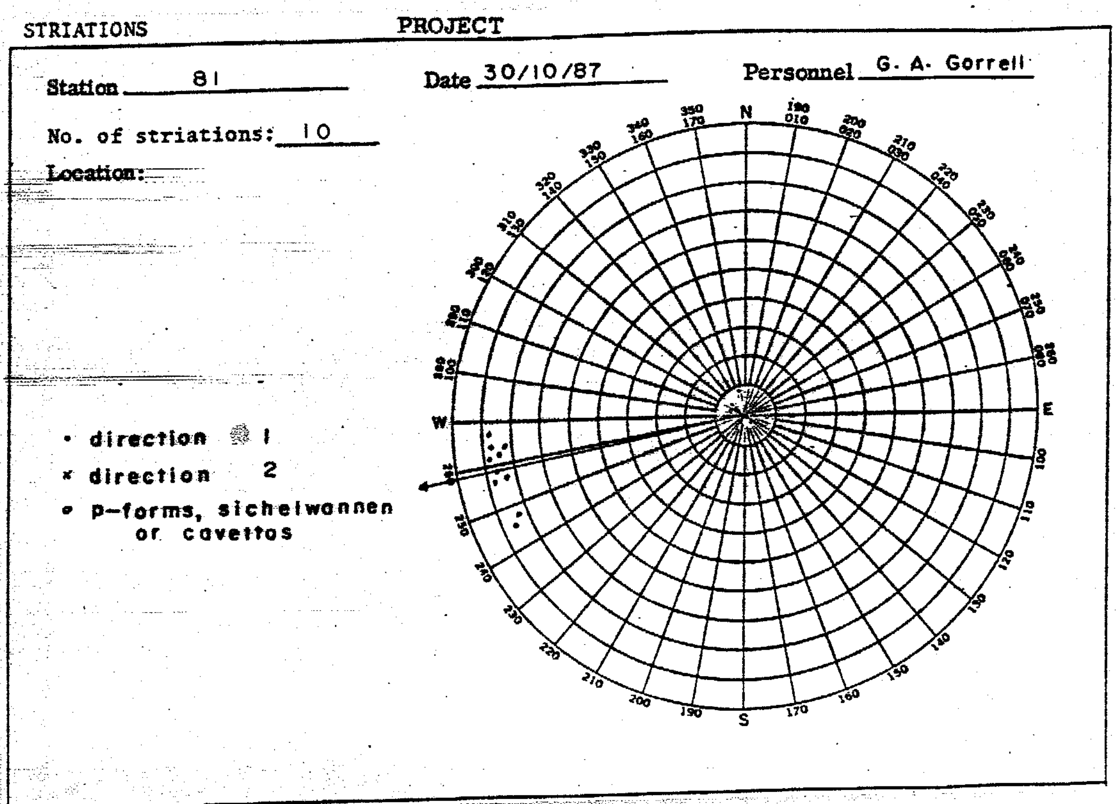
A drainage ditch has been excavated across the feature and it was observed that the bedrock which underlies the gravel is buckled. The amplitude of this buckle is approximately 0.10 to 0.20 m. It appears that the greatest uplift was on the western side of the buckle. This positive linear ridge cannot be traced east of the road which goes south to Gull Pond.

Comment:

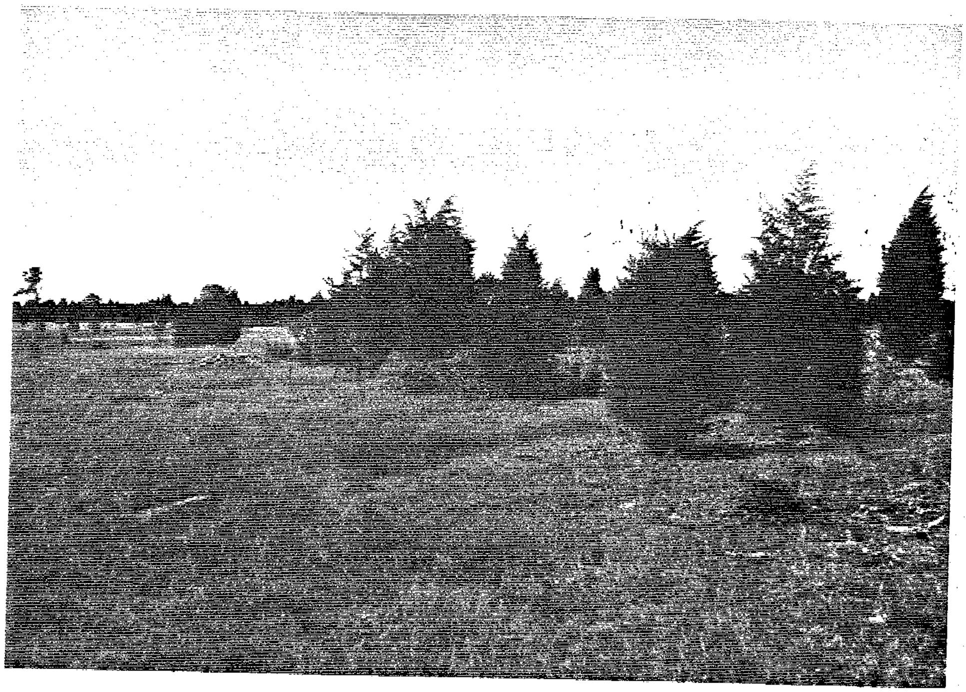
It appears that the positive linear features (St 77, 82, 83 and 86) are 'pop-ups' similar to those described by White et al. (1974). The unsorted sediment abutting the features may be a till suggesting that the feature formed before the glacier retreated form the area. However, the terminated striated surface (St. 81) suggests that the bedrock has shifted subsequent to the striations being made.

The small amount of matrix in the sediment on the top of the pop-up at Station 86 may be due to winnowing of the sediment by waves. This suggests that the water did not stabilize at 82 m ASL (270') in this area to form a beach. Rather the water level was above the 82 m elevation.

Diagram and/or Picture:



A pop-up oriented approximately 110° to 120° at Station 82.



A typical east to west oriented bedrock high. Many lineaments change aspect after they cross these rises (St. 85).

Type A waves at Station 84.

STATION NUMBER: 87 - 95 UTM: E 33155 N 46132 (St. 89)
TOWNSHIP: Athol CON. IV LOT: 1
ELEVATION: 85 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment along and 1 km west of the Athol and South Marysburgh Township lines.

Observations:

Station 87 - This Station is located approximately directly on the Township line. The bedrock surface is covered by greater than 0.20 m of matrix rich unsorted sediment. Precambrian clasts with diameters up to 0.70 m in diameter are seen of the surface.

Station 88 - This Station is located north of Station 87 on the Township line. At this location two ponds have been made by blasting holes in the bedrock. The ground-water in these pond is artesian. These ponds are located on a lineament oriented approximately 030°. The bedrock surface in this area is covered by 0.30 m of drift. This drift is similar to that described at Station 87.

Station 89 - This Station is located North of Station 88 on the Township line. The drift covering the bedrock surface had been removed and it was possible to see a striated and grooved bedrock surface. The grooves are oriented approximately 254° and the striations are oriented approximately 295°. In addition, the joint orientation was observed to be approximately 030° and 125°. The joints oriented 030° were all open greater than 60 mm.

Station 90 - This Station is located north of Station 89 on the Township line. There is greater than 1.20 m of unsorted sediment overlying the bedrock surface. This sediment is composed of clayey-silt; few clasts greater than 0.10 m were evident. In addition, small, less than 10 mm, clay layers are interbedded with the unsorted sediment. Small depressions with diameters less than 3 m pit the surface. These depressions are located upon a lineament oriented approximately 125°.

Station 91 - This Station is located north of Station 90 on the Township line. Greater than 1.10 m of sediment similar in texture to Station 90 overlies the bedrock surface.

Station 92 - This Station is located west of Station 91 and north os Station 68. This Station is located on a lineament oriented approximately 148°. Just north of the shoreline feature described at Station 66 the lineament is a positive linear feature, with approximately 0.70 m of relief. The unsorted sediment which overlies the surface was excavated. The surface did not appear to have buckled, although the bedrock when tapped with a hammer sounded hollow. On this lineament a water hole had been blasted in the rock and 0.20 m to 0.30 m of unsorted sediment similar to that described at Station 88 was observed to overlie the bedrock surface. Precambrian clasts with diameters up to 0.85 m were also seen on the surface.

Station 93 - This Station is located west of Station 92. Type A waves were observed on the surface. These crests of these waves are oriented approximately 152°. The sediment overlying the bedrock surface is similar in texture to that described at Station 1.

Station 94 - This Station is located north of Station 92 upon the same lineament. However, the lineament at this Station is not a positive linear feature but a linear depression. The depression has been excavated to provide water for the land owners cattle. The excavation indicates that the depression is at least 3 m deep and filled with unsorted sediment similar in texture as that described at Station 1. Precambrian clasts with diameters up to 0.65 m were seen incorporated with this sediment. The bedrock surface is covered with less than 0.25 m on either side of this depression. The owner says that this hole never dries up.

Station 95 - This Station is located between Stations 64 and 84. North of the road there is an 0.5 to 0.80 m rise that is oriented approximately east to west. No sorted sediment was found upon this ridge although this rise can be traced westward to the sorted ridge described at Station 66. Type A waves were observed to cross this rise. On the south side of the rise these waves are oriented approximately 148°. However, the orientation of the waves on the north side of the rise on the side closest to Station 83 change once they cross the rise to 100° and then to 125°. This change was not as evident farther east.

Comment

The unsorted sediment overlying the bedrock surface is similar in texture to the sediment describe at Station 1. This sediment is probably a till.

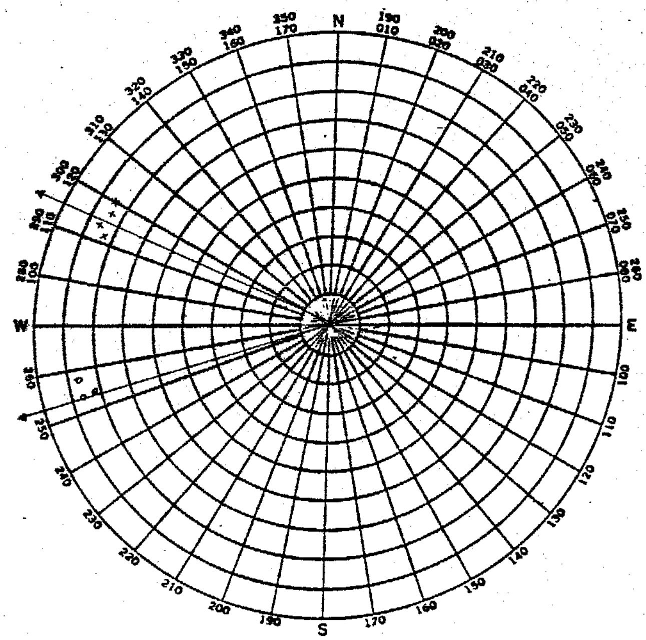
Diagram and/or Picture:

STRIATIONS PROJECT

Station 89 Date 30/10/87 Personnel G. A. Gorrell 9

No. of striations: 7

Location:



· direction 1

× direction 2

∘ p-forms, sichelwannen or cavettos

The water in this pond is artesian (St. 88).

STATION NUMBER: 96 - 107 **UTM:** E 33222 N 45980 (St. 102)
TOWNSHIP: Athol/S. Marys. **CON.** V, bl. 15
LOT: 1 -3, 6 - 8;
ELEVATION: 81 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology in an area up to 2 km northeast of Gull Pond.

Observations:

Station 96 - This Station is located north of Gull Pond. It is an anthropogenic feature probably created by the military when they used the area.

West of this anthropogenic feature and just north of Gull pond are two lineaments. The western most lineament is a positive linear feature which is oriented approximately 152 . It is up to 0.30 m high and 6.0 m wide. It is possible that this is a Type B wave. East of this lineament the bedrock abruptly drops 0.70 to 0.85 m.

Station 97 - This Station is located east of Station 83. This Station is on a 1.0 m bedrock rise oriented approximately northeast to southwest. The steep side of this ridge faces south. This feature is covered with 0.20 m to 0.25 m of unsorted sediment. Type A waves oriented approximately 148° are seen south of the feature.

Station 98 - This Station is located south of Station 82 and east of Station 96. This station is upon a positive linear feature. It is oriented approximately 104° and is up to 50 mm high and 12 m wide. This feature can be traced southward to the modern shoreline where the rock can be seen to be definitely buckled (Station 229). The amplitude of this buckle is much greater than the amplitude of the feature at Station 98. The drift covering this feature is up to 0.80 m deep and consists of unsorted material similar to that described at Station 77.

The lineament (St. 229) is definitely a pop-up and appears to have buckled along a vein of calcite. What appears to be unsorted sediment consisting of silt, clay and fine gravel is adjacent to this vein. However, on closer examination this material does not have any fragments of precambrian origin, suggesting that it is rock which has been powdered.

There is another lineament east of the positive linear feature, yet west of Station 99. This lineament is a linear depression oriented approximately 104°. Unsorted sediment is found within this depression.

North of the Gull Pond road are type A waves oriented approximately 060°. The wavelength of these waves is approximately 22 m. These waves can be traced to Station 99.

Station 99 - This Station is located upon an asymmetrical positive linear feature. It is oriented approximately 108° and is up to 1.4 m high and 20 m wide and can be traced northwestward to Station 82. There is generally more sediment on the side of the feature than on the crest (See Station 82). A few animal holes were observed on the feature, and these holes indicate that the bedrock is less than 0.20 m below the surface.

Type A waves, oriented 060° and 148°, cross this feature. Where they cross the are deflected, north for the 060° waves and east for the 148° waves. The surface on the western side of this feature is at a higher elevation than the eastern side.

Station 100 - This Station describes the bedrock surface south of Station 99. Where lineament described at Station 99 crosses the road the bedrock was observed to be 0.10 to 0.12 m higher than the adjacent bedrock surfaces. The bedrock on the western side appears to be higher than the bedrock surface on the eastern side. However, it was difficult to distinguish if the rock has buckled because the bedrock has weathered extensively.

East of where the positive linear feature crosses the ditch two other lineaments were observed. These are linear depressions up to 80 mm wide oriented approximately 106°. The bedrock surface on the western sides of these depressions is higher than the bedrock surface on the eastern sides. Unsorted sediment consisting of sandy-silt was found within these depressions.

Station 101 - This Station is located northeast of Station 101. This is a linear depression oriented approximately 116°. Large angular precambrian clasts with diameters up to 0.50 m in an unsorted matrix are found within this depression.

Station 102 - This Station is located west of Station 101. Three linear depressions were observed at this Station. From south to north these depressions are oriented 120°, 109° and 109° respectively. The centre depression can be traced to the linear depression described at Station 101. Large angular precambrian clasts with diameters up to 0.67 m in an unsorted matrix are found within these depressions. The bedrock surface on the western side of each of these depressions is higher than the eastern side.

Station 103 - This Station is located northwest of Station 102 on the centre depression. It was observed that 0.15 m to 0.25 m of unsorted sandy-silt sediment overlies the bedrock surface.
Station 104 - This Station is located east of Station 103 adjacent to the north to south oriented road. The sediment overly-

ing the bedrock surface was removed and it was possible to observe the bedrock surface. The joints were observed to be oriented approximately 030°, 060° and 125°. In addition, a bedrock rise oriented approximately east/west crosses the excavation. This rise is not anthropogenic because it was observed on aerial photographs taken before the sediment was excavated. The steepest side of this rise faces southward.

Station 105 - This Station is located east of Station 104. The east/west oriented rise described at Station 104 can be seen at this Station. At this Station the rise is approximately 2.0 m high and is covered by up to 0.25 m of unsorted sandy-silt sediment. Precambrian clasts with diameters up to 0.72 m are seen on the surface of this feature. It appears that there is more unsorted sediment abutting the feature on the steep south side than there is on the top of the feature.

Station 106 - This Station is located east of Station 105. Type A waves oriented approximately 148° are seen on the surface at this Station. Clasts with diameters up to 0.85 m are in the troughs of these waves. The wavelength of these waves is approximately 6.0 m.

Station 107 - This Station is located east of Station 106. This station is located upon a positive linear feature. It is oriented approximately 148° and is up to 0.25 m high and 6.0 m wide. It does not appear that this feature is a bedrock buckle, for a 0.30 m deep hole was dug at the crest of the feature and it was found that the feature is composed of sandy-silt sediment.

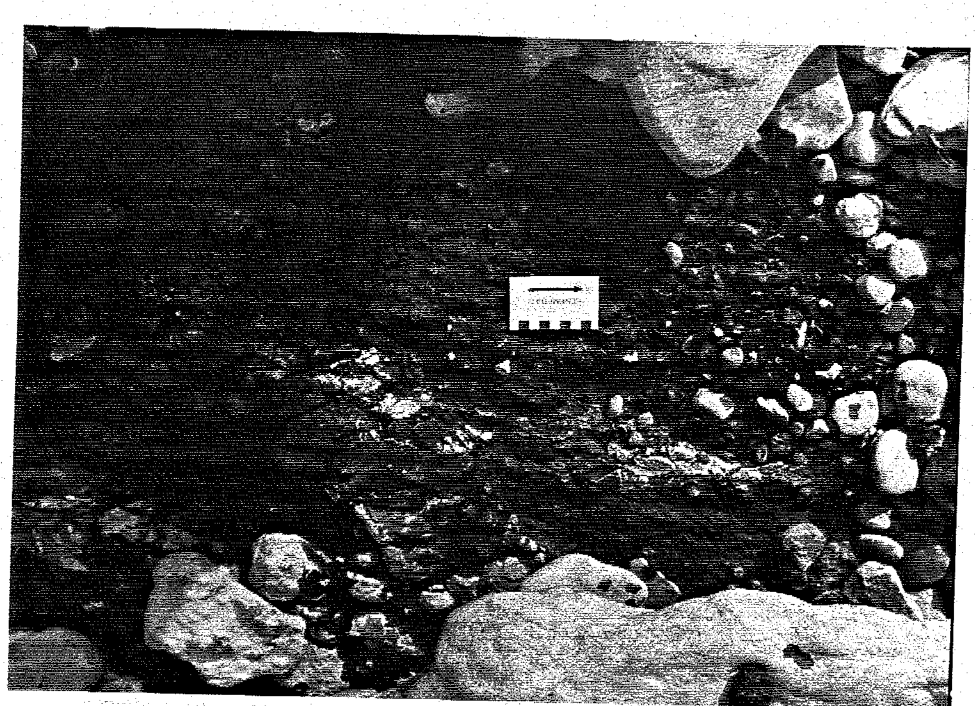
A linear depression oriented approximately 025° is found at the southern end of the positive linear feature. This depression is filled with unsorted sediment with a sandy-silt texture.

<u>Comment:</u>

It appears that the positive linear features (Stations 98, 99, 100 and 229) are pop-ups similar to those described by White <u>et al.</u> (1974). The unsorted sediment abutting the features may be a till suggesting that the feature formed preglacial or during the glacial period. The unsorted sediment in the linear depression support this, for this material was probable deposited when the ice covered the area. This is discussed further in the report. In addition, presence of the calcite vein and rock powder at the centre of buckle suggests that the forces which form a buckle are distributed along zones of weakness.

The unsorted sediment overlying the bedrock surface is similar in texture to the sediment describe at Station 1. This sediment is probably a till.

Diagram and/or Picture:



A close-up of the bedrock at the crest of a pop-up (St. 229). The yellowed material is calcite and the darker material adjacent to it is powdered rock.

STATION NUMBER: 108 - 126 UTM: E 33392 N 46133 (ST. 119)
TOWNSHIP: S. Marysb. CON. Bl. 15 LOT: 1 - 8
ELEVATION: 88 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology east of the Point Petre Wildlife area.

Observations:

Station 108 - This Station is located on the eastern border of the Wildlife area. This station is located where a 025° and a 148° cross. The lineament oriented 025° is a linear depression. The centre of this depression is 20 mm to 60 mm lower than the surrounding surface. The sediment within the depression fines downward. The upper 100 mm consists of clasts with diameters up to 50 mm. This overlies sediment which is unsorted; consisting of sandy-silt.

The lineament oriented 148° is a positive linear feature. It is up to 0.25 m high and 6.0 m wide. It is composed of unsorted sediment consisting of sandy-silt and clasts up to 0.20 m in diameter.

Station 109 - This Station is located east of Station 108 within the first privately owned property east of the Wildlife area. It consists of a linear ridge at elevation 88 m ASL oriented approximately east to west. The ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. The sediment on the southern side of the feature has a smaller proportion of matrix than the adjacent areas.

A smaller ridge extends southward from the western margin of the feature describe above. This ridge is composed of cross-laminated medium to fine sand. This sediment within this ridge fines southward.

Station 110 - This Station is located east of Station 109. At this Station the sorted ridge described at Station 109 crosses a positive linear feature. The positive linear feature is oriented approximately 110° to 125°, and is up to 2.2 m high and 20 m wide. This positive linear feature is covered by less than 1.0 m of sediment. The bedrock surface beneath this sediment appears to have buckled.

The sorted ridge is not vertically displaced by the positive feature which is approximately 1.0 m lower in elevation. Rather, the sorted ridge bends towards the southeast, conforming to the side of the positive linear feature. However, a circular depression is located where the sorted ridge bends southwest. This depression is filled with sorted sediment which has been modified extensively by pedological processes.

Station 111 - This Station is located southwest of Stations 109 and 110. It is located on a linear depression oriented approximately 025°. Large angular precambrian clasts with diameters up to 0.20 m in an unsorted matrix fill this depression. Type B waves oriented approximately 060° were observed in the fields surrounding this station.

Station 112 - This Station is located northwest of Stations 109 and 110 and north of Station 111. This station is located on linear ridges at elevation 88 m ASL. These ridges are composed of fining upward cycles of plane bedded or planar cross-bedded medium to fine sand and cross-laminated fine to medium sand. The sediment on the southern side of the features have a smaller proportion of matrix than the adjacent areas.

A portion of the southern ridge has been excavated to bedrock. This bedrock surface is striated and the striae are oriented approximately 256°.

The bedrock surface is exposed also, at the corner of the Wildlife area, east of this excavation described above. One striae oriented approximately 244° was observed. However, many of the joints oriented approximately 125° were opened greater than 60 mm.

Station 113 - This Station is located north of Station 109 and east of Station 112. The Station is located on a linear ridge at elevation 89 m ASL. This ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. The sediment on the western side of the feature has a smaller proportion of matrix than the adjacent areas.

Station 114 - This Station is located east of Station 113 on the northern portion of the lineament described at Station 110. This positive bedrock feature is oriented approximately 148° (at this Station) and is up to 1.4 m high. Where exposed, the joint orientation is approximately 125° and 148°. A small ridge, parallel with the east/west road, is connected to this positive linear feature. A small excavation was dug on this east/west rise and it was found that 0.30 m to 0.40 m of clayey-silt overlies bedrock.

Station 115 - This Station is located south of Station 109 and east of Station 111. Two lineaments, one oriented 030° and one 060°, cross at this station. The lineament oriented 060° is a bedrock rise which is covered by less than 0.10 m of sediment with a very high proportion of clasts. The other lineament is a linear. Angular clasts with diameters up to 30 mm are found within this depression.

A watering hole has been blasted in the bedrock where these two lineaments cross. A linear depression oriented approximately 125° filled with unsorted sandy-silt begins at the point where the lineaments cross.

Station 116 - This Station is located east of Station 115 on the same positive linear feature described at Station 110. The orientation of this asymmetrical ridge changes. Near the modern shoreline the ridge is oriented 110°, while 0.50 km northwest of the shoreline the ridge is oriented 130°. The feature is up to 10 m wide and is covered in many places with precambrian clasts up to 0.70 m in diameter in a clayey-sand-silt matrix.

Near the modern shoreline the positive feature appears to divide into two. Where exposed on the modern shore the bedrock has definitely buckled and is approximately 0.20 m higher in elevation than the surrounding bedrock surfaces. In addition, the distance between the joints on this buckle is closer than usual. Many of the joints are oriented parallel with the buckle.

Type A waves were observed on the northeast side of this pop-up. The crests of these waves are oriented approximately 125° and have a wavelength of approximately 6 m.

Station 117 - This Station is located between Stations 110 and 116 on the same linear ridge described at those stations. A 15.0 m wide gap separates two portions of the sorted ridge described at Station 109. In the centre of this gap is a linear depression approximately 0.25 m deep and 1.08 m wide oriented approximately 150°. Angular precambrian clasts with diameters up to 0.30 m are found within this depression. No sorted sediment was found on either side of the gap. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas.

This gap is not anthropogenic for there is no evidence that the gap is an old excavation. This gap can be traced south to the positive linear feature described at Station 116.

Station 118 - The gap joins the positive linear feature (Station 116) at the exact point where lineaments oriented 030° and 060° (described at Station 115) cross. The relief of the pop-up decreases where these lineaments cross it. In addition to this decrease in elevation, the orientation of the pop-up changes (See Station 116).

On the west side of the pop-up the lineament oriented 060° is an east/west rise. However, on the eastern side of the pop-up the lineament changes its aspect to a linear depression. This linear depression is filled with angular precambrian clasts with diameters up to 0.40 m in an unsorted matrix.

The lineaments oriented 030° and 060° are joined approximately 250 m east of the pop-up by a lineament to form a positive circular feature. On the northern, eastern and southern sites of this positive circular feature are Type A waves oriented approximately 125°. These waves are not found inside of the positive circular feature. Instead, the ground surface is pitted. The highest point of land on the eastern side of the pop-up appears to be at the centre of this circular feature.

Station 119 - This Station is located east of Station 117. This station consists of a linear ridge at elevation 88 m ASL. The ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. The sediment on the southern side of the feature has a smaller proportion of matrix than the adjacent areas.

The ridge is not a single ridge but a series of Type A waves oriented approximately 060°. The bedrock is less than 0.10 m below the surface in the troughs of each of these waves. This indicates that the sorted sediment had developed on a east/west rise.

Station 120 - This Station is located north of Station 119. Type A waves are very pronounced in this area. These waves are oriented 025° and 060°.

Station 121 - This Station is located least of Station 119, south of the sorted ridge. Type A waves were observed in this area. These waves are oriented 148° and become more pronounced closer to the sorted ridge. A few small test pits were dug at the crests of the waves and it was found that up to 0.30 m of unsorted sediment overlies the bedrock. The proportion of matrix to clasts decreases closer to the sorted ridge. In addition, a 60 to 90 mm gap in the width of the joint was found beneath the troughs of the waves.

Station 122 - This Station is located north of Station 121 upon the 0.70 m high ridge composed of sorted sediment. This sorted ridge is at elevation 88 m ASL. The ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. The sediment on the southern side of the feature has a smaller proportion of matrix than the adjacent areas. Type A waves oriented approximately 148° were observed south and north of the ridge. The crests of these waves have a much smaller amplitude where they pass through the ridge.

A 15.0 m wide gap separates two portions of this ridge. In the centre of this gap is a linear depression approximately 0.25 m deep an 1.08 m wide. Angular precambrian clasts with diameters up to 0.50 m are found within this depression. No sorted sediment was found on either side of the gap. However, there is a smaller proportion of matrix within the sediment immediately south of the sorted ridge than in adjacent areas. This gap is not anthropogenic, there is no evidence that the gap is an old excavation. This gap can be traced north to Station 227.

Station 123 - This Station is located east of Station 122. The ridge consisting of sorted sediment cannot be traced to this area. There is a ridge, but it is a bedrock rise covered with less than 0.29 m of unsorted sediment. The drop in elevation is much greater on the south side if this ridge than it is south of Station 122 and 119. In addition, a linear depression oriented approximately 106° cross the ridge just west of the north to south oriented road. Angular precambrian clasts with diameters up to 0.40 m are lodged in this depression. Underlying these clasts is a clayey-silt sediment. This depression can be traced to Station 227.

Station 124 - This Station is located east of Station 119. This station, which is approximately at elevation 88 m ASL, is located on the same ridge described at Station 119. It is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. The sediment on the southern side of the feature has a smaller proportion of matrix than the adjacent areas. Traced eastward towards Station 122, the ridge abruptly decreases in height and bends towards the north.

Station 125 - This Station is located south of Station 124, where the ridge abruptly bends northward. It is located on a smaller ridge which extended southward from the abrupt northward bend of the sorted ridge described at Station 124. This ridge is composed of cross-laminated medium to fine sand. This sediment within this ridge fines southward.

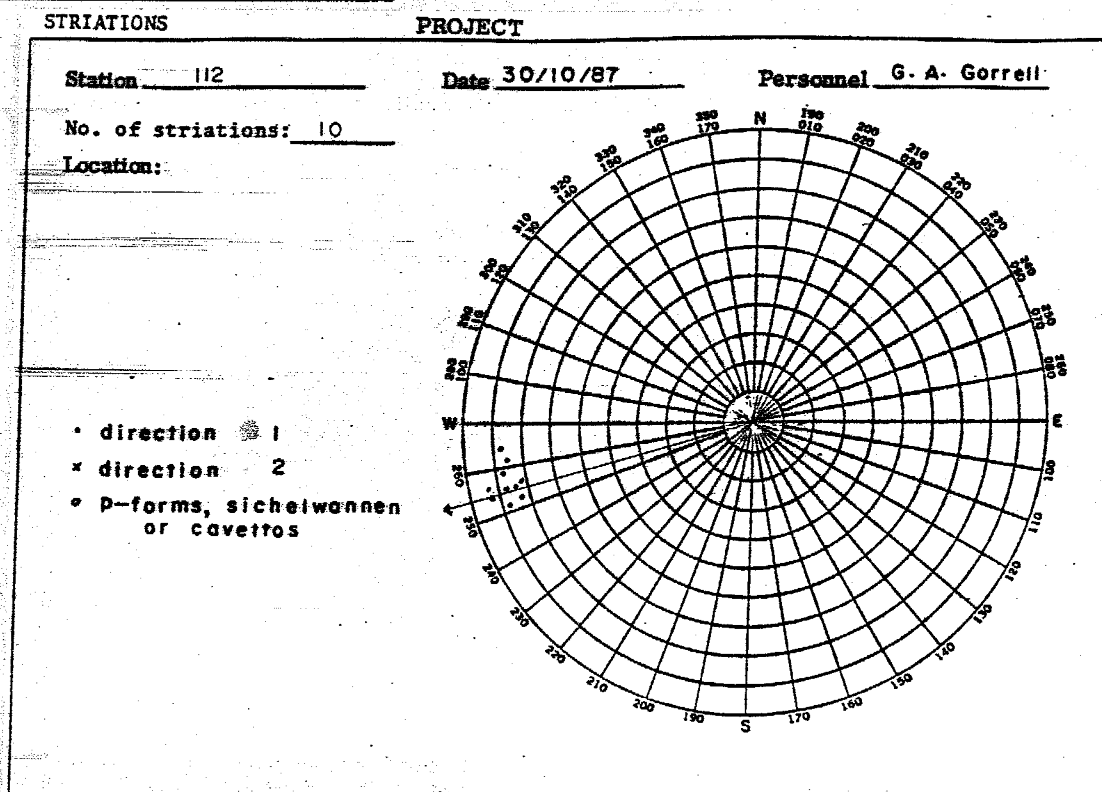
Station 126 - This Station is located south of Station 125. It is located on a spindle shaped depression approximately 750 m long and 40 m wide and is oriented approximated 060o. The base of this depression is 1.0 to 1.2 m below the adjacent surfaces. There is greater than 0.25 m of clayey-silt unsorted sediment at the base of this depression. Type A waves were observed on the surfaces adjacent to the depression.

<u>Comment</u>:

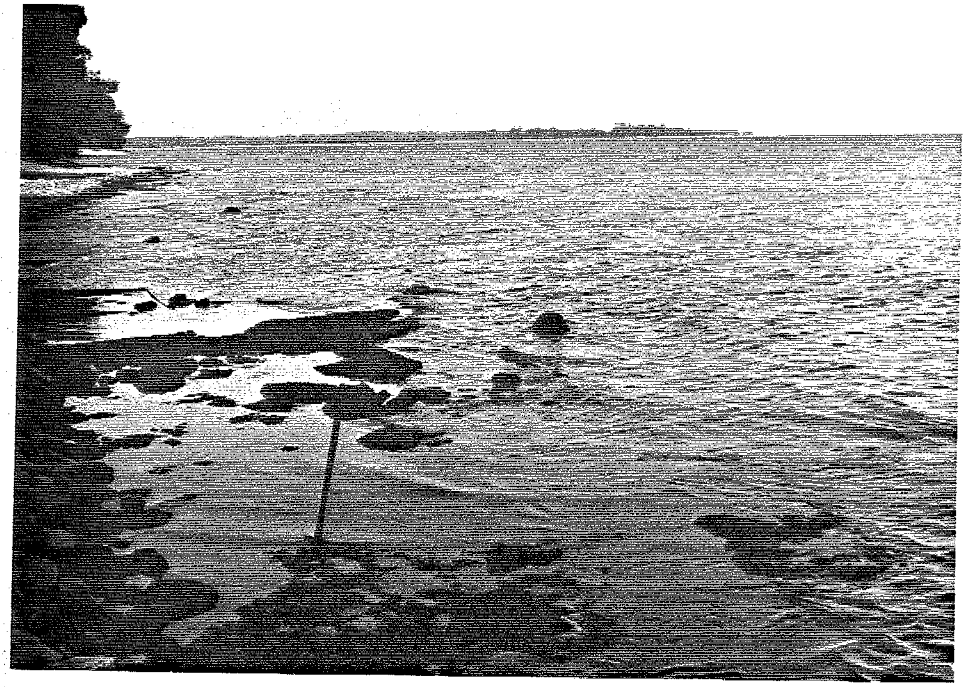
The linear ridges (St. 109, 110, 112, 113, 117, 119, 122, 124 and 125) are ancient shoreline deposits of the Belleville Phase of Lake Iroquois. These shorelines are located at only one elevation; 88 m ASL. The lake was on the south side of the ridges when they formed. The drift on the southern side of the features has a smaller proportion of matrix because this is the shallow water zone where the wave orbits eroded sediment that was deposited ultimately along the shore. The absence of the shorelines where they cross lineaments (St. 117 and 122) is discussed in the report.

The pop-up (St 110, 114 and 116) and east/west rises (St 115 and 123) suggest that tectonic activity had occurred. These features do not indicate necessarily that the movement was neotectonic. This is discussed further in the report.

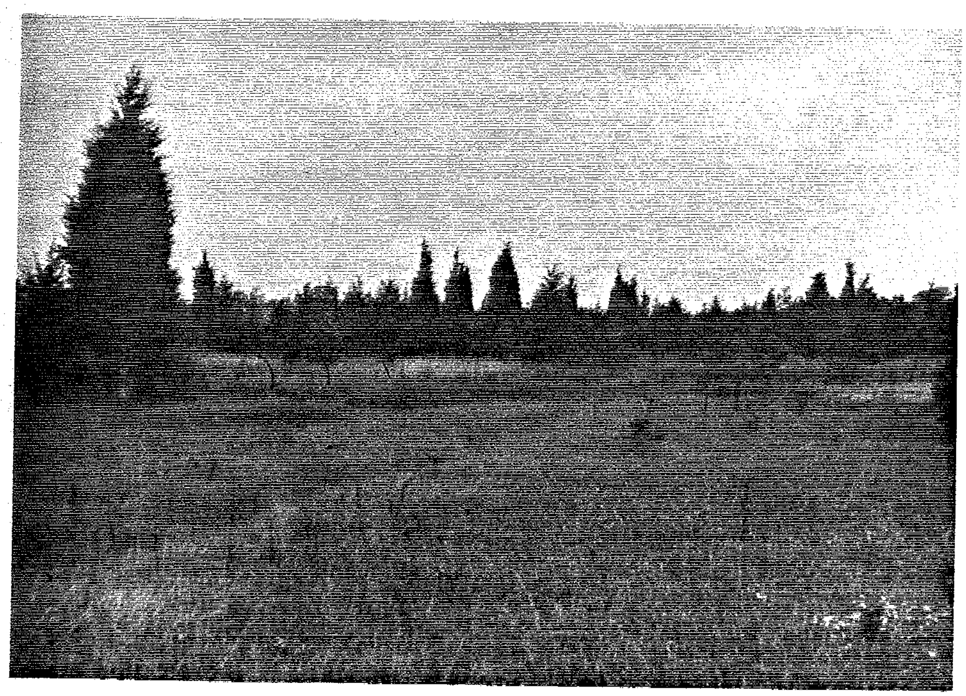
Diagram and/or Picture:



* The rise in the background is a pop-up (St. 116).



The same pop-up shown above but along the modern shoreline. Notice that the rock is buckled.



High-lighted ridge is an ancient shoreline composed of sorted sediment consisting of fining upward cycles (St. 122). Type A waves are very pronounced in the foreground.

STATION NUMBER: 127 - 137, 144 **UTM:** **E** 33553 **N** 46260 (St. 34)
TOWNSHIP: S. Marysb. **CON.** RPEB **LOT:** 11 - 15
ELEVATION: 85 **metres above sealevel**

Brief Description of Morphology:

These Stations describe the sediment and morphology south-west of South Bay.

Observations:

This portion of the study area has more lineaments than any other. The largest lineament (Station 133a and e and 134) is a positive linear feature oriented approximately 148o to 154o. It is up to 1.4 m high and 35 m wide. This feature is covered with precambrian clasts with diameters up to 1.6 m. These clasts are not incorporated within matrix. Rather, the boulders rest upon the bedrock surface. Three pits were dug and it was found that the bedrock is covered with less than 0.25 m of sediment. This sediment is unsorted and is composed of sandy-silt and clasts less than 50 mm.

The lineament can be traced northward to the scarp (St. 136) that was identified by Carson (1981) as the contact (St. 144) between the Lindsay and the Verulum Formations. There is an apron of unsorted clayey-silt where the lineament crosses the escarpment. On either side of this apron the scarp is much steeper, and covered with less sediment. The lineament can be seen on the 1:10,000 aerial photographs to continue northward below the scarp.

Type A waves were observed throughout the area. These waves are oriented 060° and 125° (Station 128, 133a, 134 and 135) and have a wavelength of approximately 6.0 m. However, the waves as they cross the lineament they are deflected slightly. For example, a wave crest which is oriented 060° east of the lineament, is oriented 070° upon the lineament and then changes back to 060° on the west side of the lineament. The lineaments oriented 125° are deflected in the same manner.

These waves have also affected the sediment deposited after the glacier retreated form the area. At Station 128 a linear ridge at elevation 89 m ASL crosses the waves. This ridge is composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand. Where the ridge crosses waves oriented 125° the sorted ridge has collapsed and is also waved.

On either side of the large lineament are plateau-like hills (Stations 127, 128, 131, 132, 133c) which are 1.2 to 1.4 m high. In plan, these features resemble stream-lined forms such as sand dunes. However, these ridges are bedrock rises covered with less than 0.30 m of unsorted sediment composed of sandy-silt and clasts with diameters less than 50 mm.

In the lows at the base of the plateau-like hills are thicker accumulations of sediment. At the base of the plateau in the northwest corner of this area (Station 127) 0.25 m of medium to coarse sand and fine gravel overlies a minimum of 1.3 m of rhythmically bedded silt and clay. A pond was excavated in this area and the sediment below the clay appears to be unsorted and composed of clayey-silt and medium to fine gravel. The rhythmically bedded sediment has high concentrations of marl. In other areas (Station 133b) the sediment does not consist of rhythmites but of unsorted sediment consisting of a clayey-silt.

Linear depressions (Stations 127, 129, 133c, 133d, 133e and 134) cross all the features described above. These depressions are oriented approximately 100°. They are filled with unsorted sediment consisting of sandy-silt.

In a few areas (Station 127, 133c and 133e) the bedrock on either side of the depressions appears to have horizontally and laterally moved. For example, at Stations 127 and 134 the depressions appear to have pulled apart 0.17 m, moved laterally 0.20 m and horizontally lifted (east side higher) 20 mm.

There is some evidence that solution of the limestone had occurred. At Station 130 the bedrock has buckled at the base of a pond excavated for the cattle grazing the area. On the underside of the limestone beds is calcium precipitate. In addition, Station 137 is located on a circular depression. This depression, which is on the western side of the large lineament, is less than 0.30 m deep. However, this depression is very evident on the colour infra-red mosaic and the black and white photographs. This suggests that the feature is deep-seated.

Other possible indications that solution had occurred are the sub-rounded holes at the top of many of the bedrock beds (Station 132a). These holes are elongated towards 160°. In addition, many of the joints (Station 132a) on either side of these holes have smoothed undercut edges.

On the eastern side of the area is an elongated sinuous hill approximately 1.0 to 1.4 m high. Two small pits were dug on this hill and it was found that less than 0.25 m of unsorted sandy-silt sediment with clasts less than 40 mm overlies the bedrock. The eastern side of this hill is much steeper than the western.

The orientation of the waves change abruptly near this sinuous hill. The waves change from orientation 125° to 080°, then change to 100° and then back to 125°.

Comment:

It appears that the positive linear features (Stations 133a and 134) are pop-ups similar to those described by White *et al.* (1974). The unsorted sediment and the abutting and overlying the feature may be a till suggesting that the feature formed preglacially or during the glacial period. The unsorted sediment in the linear depressions and the large boulders on top of the lineament support this, for this material was probable deposited when the ice covered the area. This is discussed further in the report.

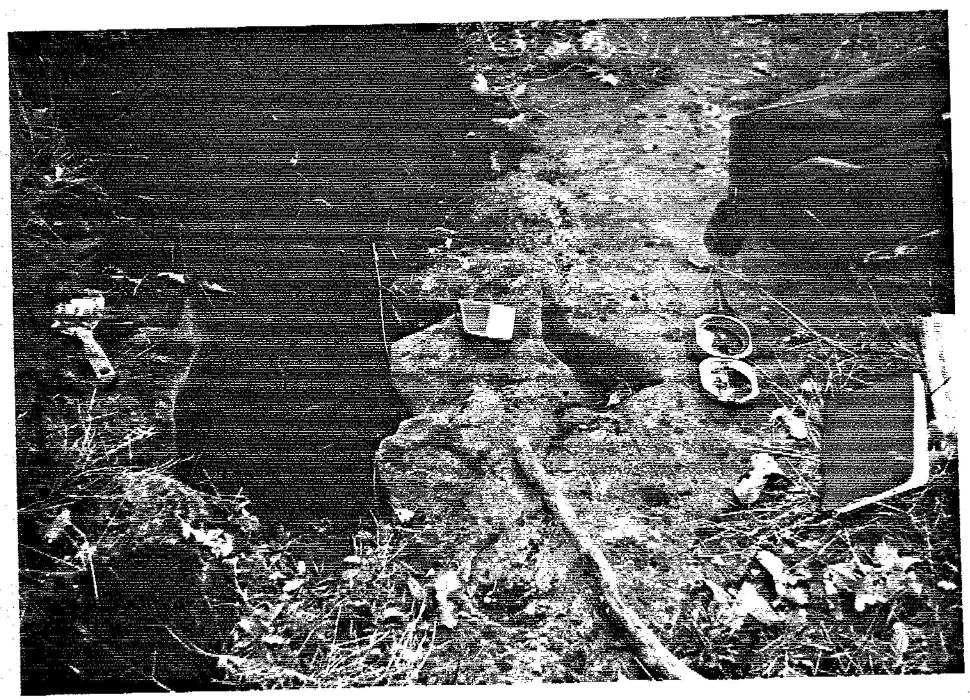
The unsorted sediment at the base of the plateau-like hills is similar in texture to the sediment describe at Station 1. This sediment is probably a till.

The origin of the plateau-like hills is difficult to determine. These hills are definitely bedrock rises covered thinly and abutted with unsorted sediment. In addition. the forms are stream-lined suggesting that they have been sculpted by some processes. It is possible that these features were sculptured either by the glacier or by meltwater. The importance of each processes is discussed in the text.

Diagram and/or Picture:

The ground surface along a lineament oriented approximately 125° (St. 127). The joints on either side of the gap are displaced by approximately 0.20 m. The gap is filled with unsorted sediment.

A ancient shoreline is configured with Type A waves (St. 128).



The bedrock surface at Station 132b. The bedrock in the gap is polished and has undercut edges. The hole in the bedrock on the right is at least 0.30 m deep.

This rise is a pop-up oriented approximately 148^0 with less than 0.20 m of sediment covering it (St. 133e).

Type A waves which configure the ground at Station 135.

STATION NUMBER: 138 - 143, 230 UTM: E 32710 N 45935
TOWNSHIP: Athol CON. IV LOT: 13 - 16
ELEVATION: 82 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology at the base and along the margins of the scarp which extends from Point Petre to Village of Cherry Valley.

Observations:

There is little sediment along the eastern margin of the scarp. At the crest of the scarp, along County Road 24, there is less than 0.25 m of sediment overlying the rock (Stations 138 and 143). It was possible to determine the principle orientation of the joints in the ditch beside the road where the sediment had been excavated.

The joints are oriented approximately 080°, 125° and 148°. Many of these joints are open greater than 0.15 m. A few of these joints appear to have pulled apart. At one location (St. 138) there is a bulge on one side of the wall of the crevasse which corresponds exactly to a hollow in the adjacent side. In addition, there is a 0.80 m rise in the bedrock surface near the junction of County Road 24 and 13th and 14th lot line road. This bedrock rise correspond to the linear depression which bisects the shoreline feature described at Stations 73 and 74. It appears that north of this bedrock rise the joints are more frequently open than south of the rise.

Along the eastern margin of the scarp are 3 to 4 terraces (St. 139 and 143). These bedrock terraces, which are located on the convex side, are covered thinly with sorted medium to very fine sand. Bedrock is exposed all along the base of the scarp. At the very base of the scarp, the sediment is greater than 2.0 m deep and consists of coarse to medium sand. The lithology of this material appears to be mainly precambrian. This material is at the base of the scarp all along the valley (St, 139, 140, 142 and 230).

The western margin of this scarp is not nearly as high and as continuous as the eastern margin (St. 140 and 230). It is characterized as being intermittently composed of sculpted and truncated bedrock rises (St. 140, 142 and 230) and stream-lined hills oriented 238°, composed of unsorted clayey-silt (St. 140). The sculpted and truncated bedrock rises appear to be on the concave side of the valley or scarp.

Type A waves oriented approximately 060°, are very evident along the immediate western side of the valley (St. 143). The amplitude of these waves decreases westward until they were no longer observed (St. 141). However, the pattern is still evident on the colour infra-red mosaic and black and white photographs.

Comment:

The examination of the margins of this valley on aerial photographs and in the field indicates that the valley walls have been sculpted and stream-lined by glacial processes. The base of this valley is filled with medium to coarse sand which is at least 2.0 m deep (Stations 138, 139 and 230) and large bodies of unsorted sediment (Stations 1, 138 and 139). This valley can be traced directly into the Village of Cherry Valley where a glacio-fluvial sedimentary body had been deposited (Leyland, 1982). This suggests that although the valley was formed tectonically, it was subsequently sculpted by a southwestern-flowing glacier and possibly later by meltwater which flowed under high pressure gradients. The relative importance of each glacial processes is currently unknown.

Diagram and/or Picture:

STATION NUMBER: 145 - 147 **UTM:** E 33795 N 46230 (St. 146)
TOWNSHIP: S. Marysb. CON. LOWLP LOT: 7 - 11
ELEVATION: 77 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology north of Petticoat Point.

Observations:

Just north of Petticoat Point are three lineaments (St. 146). The largest one, which is oriented approximately 005° is a linear depression and a positive linear feature (Map 1). It is a positive linear feature at the modern shoreline. The bedrock is exposed there, and it appears that it has buckled. It remains a positive linear feature until it crosses a linear depression oriented approximately 125°. At that point it changes aspect to a linear depression.

The depression, which is approximately 6.0 m wide, is filled with unsorted clayey-silt sediment and has boulders lodged within it. It remains a linear depression until it crosses another linear depression oriented 125°, where it changes its aspect back to a positive linear feature.

The second linear depression that the largest lineament crosses, also changes its aspect. From the modern shore to where it crosses the largest lineament it is a linear depression. It is filled with sediment similar to that described above. However, where it crosses the large lineament its aspect changes to a positive linear feature. It remains a positive linear feature until it crosses an east /west rise where upon it changes its aspect to a linear depression. The relationships are shown below.

East of the area where the lineaments is an area that is morphologically waved (St. 147). These waves are similar to Type A waves. However, the amplitude of the waves is much greater. In addition, the troughs of these waves are wider and elliptical, and are often filled with sediment which is rich in marl.

Sediment which is rich in marl is found north of the area where the lineaments cross (St. 145). In this area the sediment consists of rhythmically bedded silt and clay which is waved. These waves are oriented approximately 270° (090°) and are up to 1.0 m thick. The basal 0.10 to 0.20 m of the waves is rich in marl.

Comment:

It appears that the positive linear features (Station 146) are pop-ups similar to those described by White _et al._ (1974). The unsorted sediment abutting the features may be a till suggesting that the feature formed preglacially or during the glacial period. The unsorted sediment in the linear depression support this, for this material was probable deposited when the ice covered the area. This is discussed further in the report.

The wave topography is similar to the Type A waves described in the report. These waves probably formed due to transportation of sediment through the joints. The joints may have been open due to solution by meltwater. However, the marl-rich sediment at in the troughs of the waves, indicates that the ground-water in this area is always close to the surface. This suggests that the solution of the joints in this area may be recent.

Diagram and/or Picture:

STATION NUMBER: 148 -169, 199, 200 and 210 - 214

UTM: E 33164 N 46516

TOWNSHIP: S. Marysb. **CON.** C, D **LOT:**

ELEVATION: 94 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology in the valley south of the Village of Milford.

Observations:

The amount of alteration which may be attributed to glacial processes appears to be extensive throughout this valley. One of the most obvious examples that may be attributed to glacial alteration is the terraces along the sides of the valley (Stations 159, 164, 167 and 168) and the p-forms on the bedrock surface (St. 211). Although these terraces are covered by both sorted and unsorted sediment, the unconsolidated sediment represents only a veneer upon the underlying bedrock (Station 154, 159, and 168). Where the valley is straight (Stations 156, 158 and 159) these terraces are found on both sides. However, where the valley bends (Station 168) the terraces are found only on, what was during glacial periods the convex bank of the channel. There are no terraces on the near vertical concave bank. In addition, where the bend ends, a 3.0 m deep trough has truncated the bedrock (Station 164).

Remnants of circular bedrock cuts up to 14 m high and 6 m in diameter (Stations 163 and 164) are found adjacent to this trough, just at the point where the bend, ends. In addition, and just south of the concave bank are crevasses which consist of a series of elliptical holes (Station 163) whose long axis is oriented parallel with the sides of the valley. Many of these holes have large precambrian clasts lodged into them. Not all of these holes are located where joint sets intersect.

There are also large circular depressions adjacent to the valley (St. 212). These depressions are filled with a minimum of 1.0 m of medium to fine sand. It is not known what underlies the sand in the centre of the depression.

Within the valley are sedimentary bodies consisting of sorted sediment. East of Milford, there is a broad flat topped sedimentary body (Station 148 - 150) consisting of trough cross-bedded and planar cross-bedded coarse to medium sand with a paleocurrent oriented approximately 260°. A few normal and reverse faults are found on the southern side of this sedimentary body.

This system can be traced laterally west through the valley (Stations 154-157, 161, 165, 166, 199 and 200) where it grades into fining upward cycles consisting of, in ascending order:

1) planar cross-bedded medium to fine sand, cross-laminated (Type B) fine sand and rhythmically bedded silt and clay,

2) normally graded sand with very thin silt caps.

Small scours are inter-spaced throughout the sediment (Stations 155 and 199). These scours are filled with, in ascending order, rhythmites of silt and clay and massive fine to silty sand.

Small fluidized channels are found throughout both of the cycles (Stations 151, 155, 165, 166 and 199). In many cases these channels are truncated at the contact with the bed overlying it. Many of these channels are bent in the downstream direction. In addition, small normal and high-angle reverse faults are found throughout the cycles. In many cases the sediment has folded prior to faulting (Stations 151, 154, 199 and 200).

In the valley just south of Milford there is also a steeped sided ridge (Stations 151 and 165) consisting of normally and reversed faulted sequences of:

1) massive fine sand with clayey-silt to silty-clay caps and

2) rhythmically bedded silt and clay.

This ridge is adjacent to the sedimentary body which consists of trough cross-bedded and planar cross-bedded coarse sand described above. However, the top of the ridge is as much as 5.0 m higher than the surrounding coarse sediment.

A good exposure consisting of rhythmically bedded silts and clays is found at Station 154. The examination of the exposure indicates that it consists of numerous cycles of sediment which grade from very fine sand to silt interbedded with thick clay layers. The examination of the exposure also revealed that this fine sediment has been folded and faulted. The faults are oriented approximately 060° and 152°.

At Station 200 an exposure was dug in the small 1.0 to 1.5 m high ridge which is found at elevation 88 m ASL along the north to south oriented road (see Maps). The section consists of fining upward cycles of fine sand and silt in clay. Interbedded with these cycles are small channels filled with massive to plane bedded sand.

At the crest of the valley are linear mounds of sediment.

These mounds can be divided into two groups. These groups are:

1) Linear ridges composed of fining upward cycles of clast supported fine gravel and plane bedded or planar cross-bedded medium to fine sand (Station 162). The sediment on the northern side of the feature has a smaller proportion of matrix than the adjacent areas. These ridges at approximately 100 m ASL.

2) Linear mounds (Stations 152, 153, 160 and 214) which are approximately 500 m long and have a wavelength of approximately 55 m and are oriented approximately 250°. They are composed of up to 1.5 m of rhythmically bedded silts and clays. The underlying bedrock surface does not conform to these mounds.

South of the area where the mounds consisting of rhythmically bedded units are Type A waves (St. 213). These waves are oriented approximately 125°. This area is just south of the scarp.

<u>Comment</u>:

The large clasts which are lodged into the elliptical holes may be boulders carried by the glacier or by meltwater. If the crevasses were open during glaciation they would be a zone of low pressure and therefore a preferred area of deposition (Rothlisberger, 1972; Shreve, 1972; Weertman, 1972; Nye, 1973; Boulton, 1974). Because the clasts are so large, they would not be able to fit down the crevasses and would be lodged in the crevasses as the glacier flowed over it or would become wedged as the meltwater flowed down and through the crevasses.

The convex and concave bank configuration and bedrock trough indicates that preferential erosion has occurred. This erosion is similar to that found along bends in modern rivers. This suggests that large volumes of meltwater may have been discharged through the valley. That there had been substantial discharges of water through the valley would explain the large and small-scale circular cuts. These forms are similar to potholes cut by meltwater described by Gjessing (1967). The discharge of large volumes of meltwater through the valley is supported further by the presence of glaciofluvial sediments along the valley walls (Stations 148, 149, 154, 163 and 166) and the sculpted 'rock drumlin' at McMahan Bluff on the eastern end of the valley. This is further supported by the presence of sichelwannen and p-forms at Station 211.

The linear ridges (St. 162) are ancient shoreline deposits of either the Belleville Phase or the Sidney Phase of Lake Iroquois. These shorelines are at elevations higher than attributed for the Belleville Phase in the area. The lake was on the northern side of the valley when the shoreline formed. The drift on the northern side of ridges have a smaller proportion of matrix because these are the shallow water zones where the wave orbits eroded sediment that was deposited ultimately along the shore.

The linear ridge at Station 200 exhibits possible backshore bedding. The small channels which have truncated the cycles of fine sand and silt are probably runnels formed within the backshore portion of a shoreline.

A more detailed explanation is given in the report.

Diagram and/or Picture:

Diagram and/or Picture:

STRIATIONS

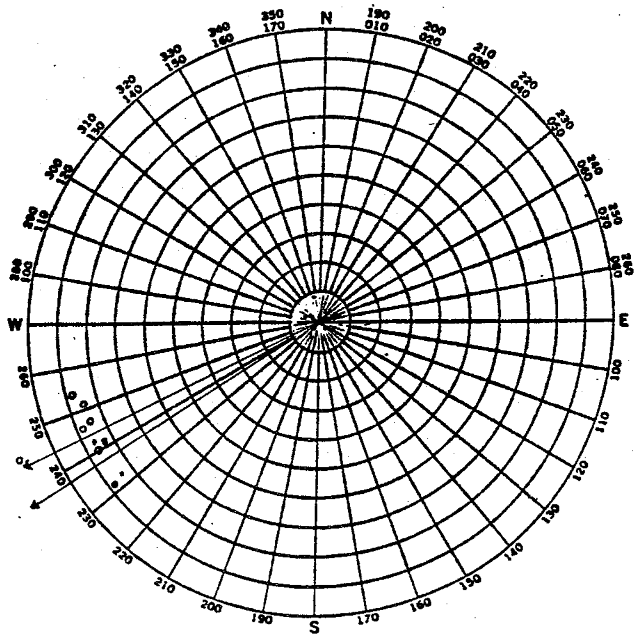
PROJECT

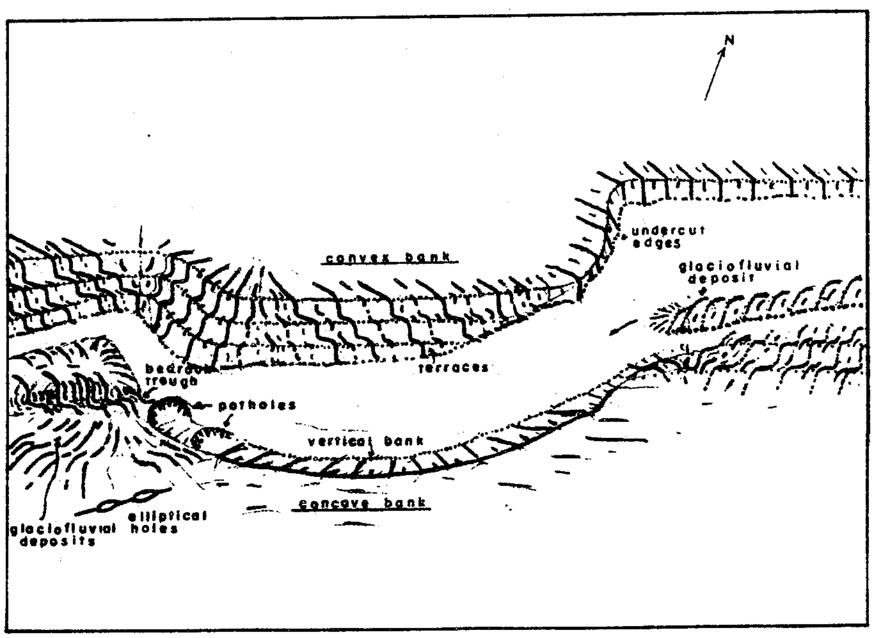
Station 211 **Date** 30/10/87 **Personnel** G. A. Gorrell

No. of striations: 9

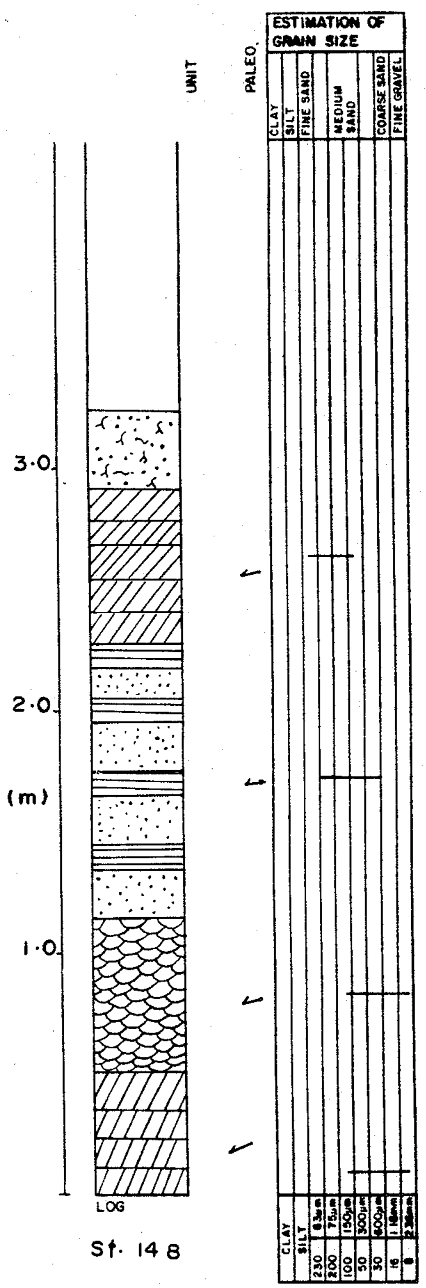
Location:

- • direction 1
- × direction 2
- ● p-forms, sichelwannen or cavettos

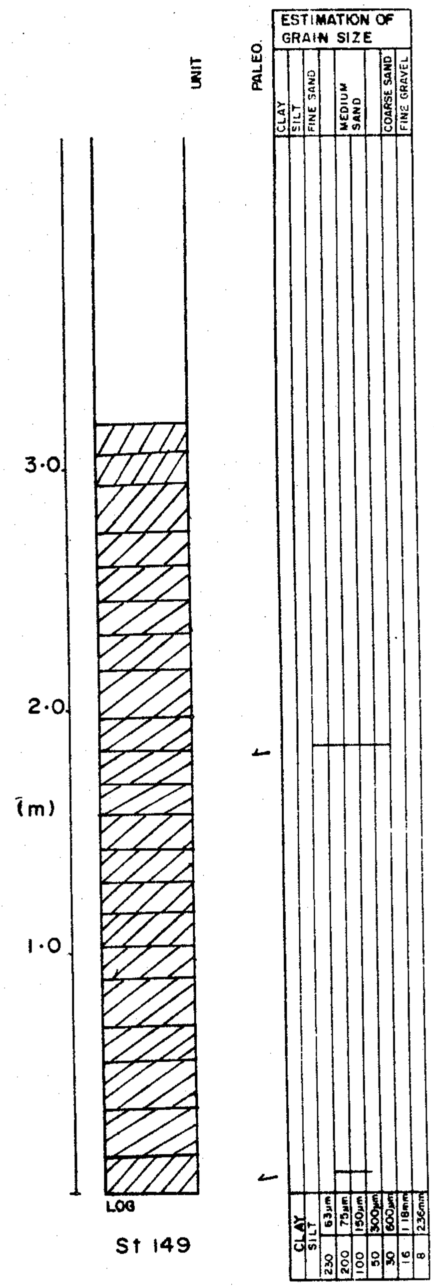




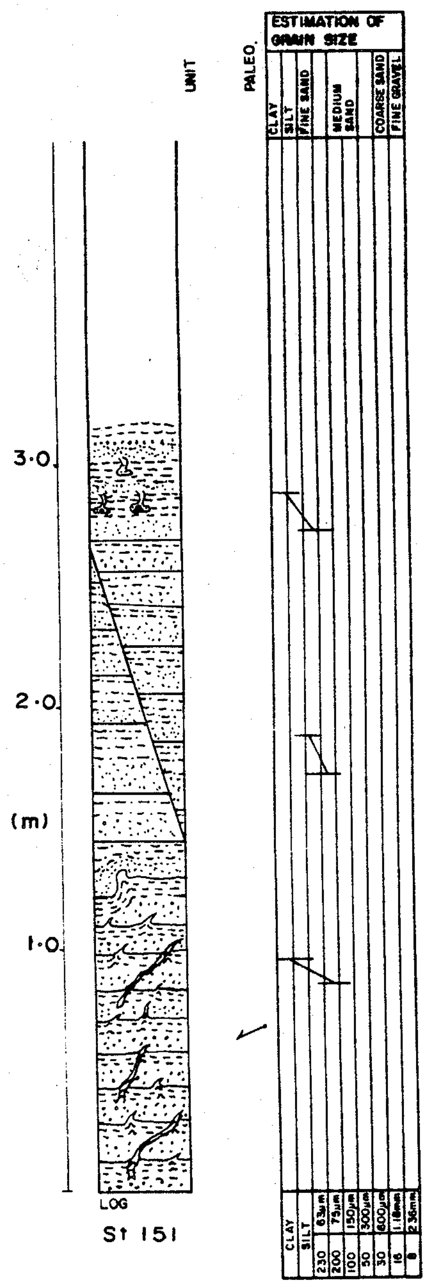
Abrasion forms which are along the valley west of Milford.

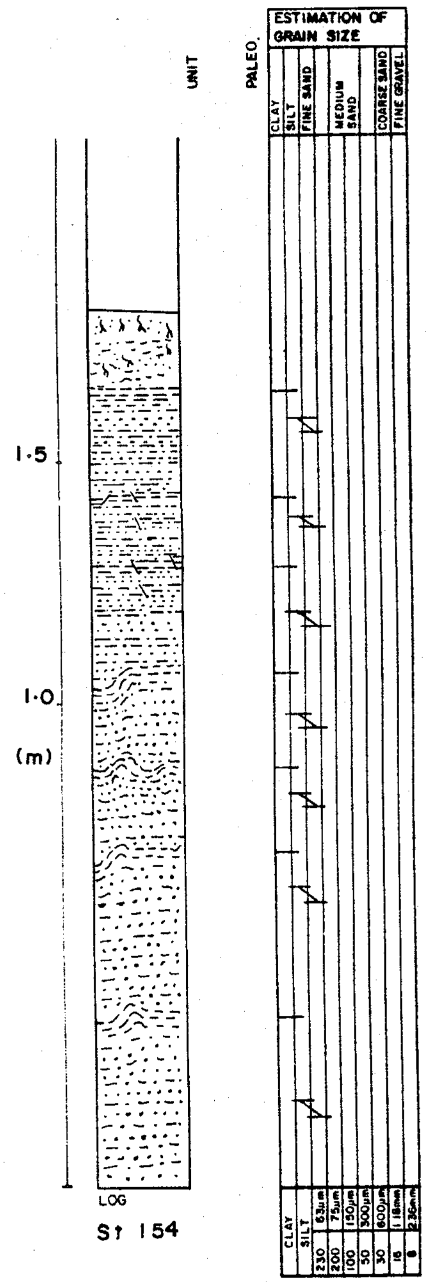


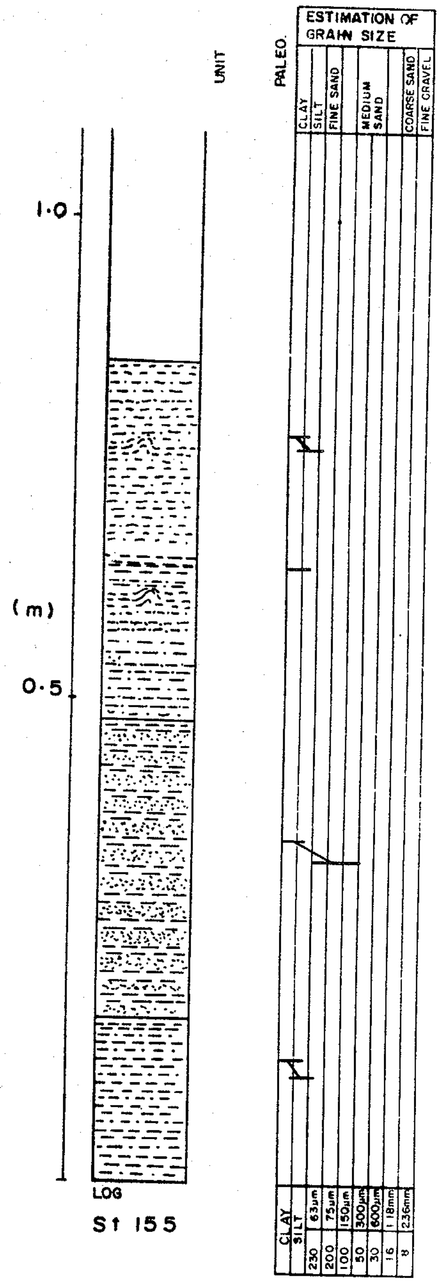
ESTIMATION OF GRAIN SIZE
UNIT
PALEO.
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
3·0
2·0
(m)
1·0
LOG
St· 148
230
200
100
50
30
16
8
63µm
75µm
150µm
300µm
600µm
1.18mm
2.36mm

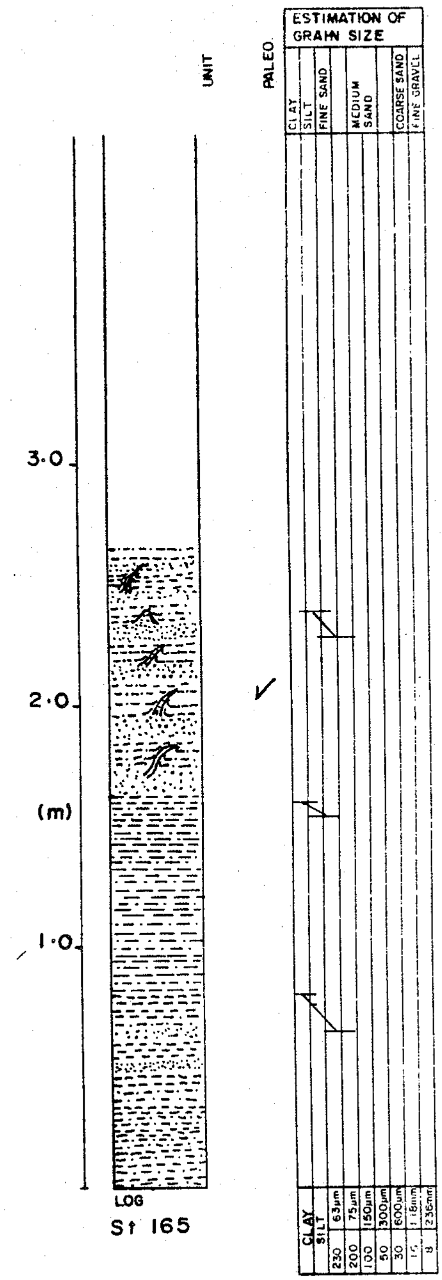


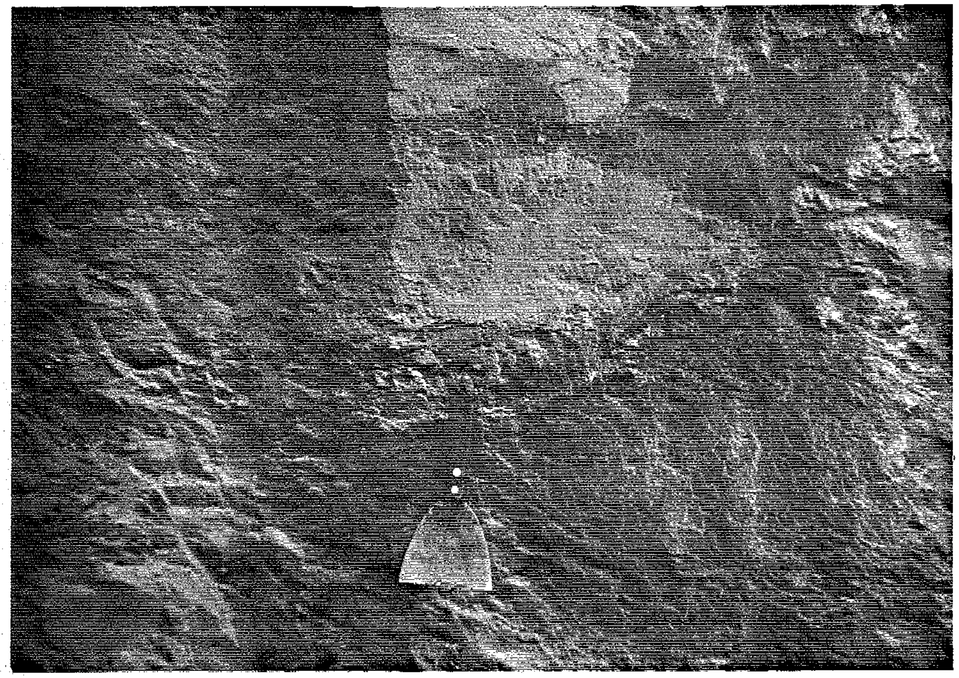
ESTIMATION OF GRAIN SIZE
UNIT
PALEO.
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
3·0
2·0
(m)
1·0
LOG
St 149
230
200
100
50
30
16
8
63µm
75µm
150µm
300µm
600µm
1.18mm
2.36mm


UNIT
PALEO.
ESTIMATION OF GRAIN SIZE
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
3·0
2·0
(m)
1·0
LOG
230
200
100
50
30
16
8
63µm
75µm
150µm
300µm
600µm
1·18mm
2·36mm
St 151

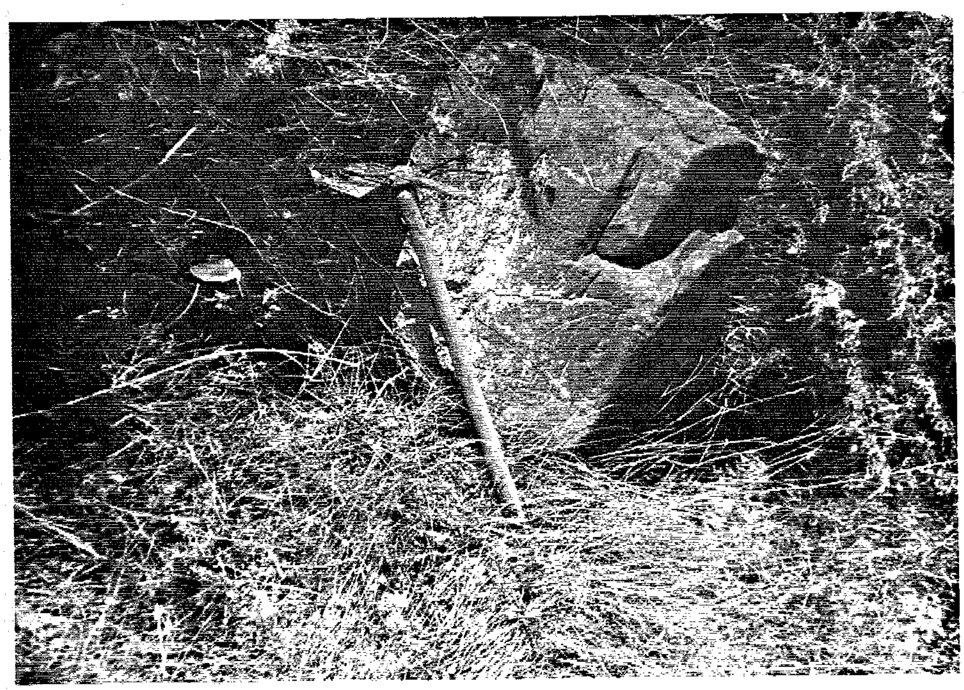

UNIT
PALEO.
ESTIMATION OF GRAIN SIZE
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
1·5
1·0
(m)
LOG
230
200
100
50
30
16
8
63µm
75µm
150µm
300µm
600µm
1·18mm
2·36mm
St 154


UNIT
PALEO.
ESTIMATION OF GRAIN SIZE
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
1·0
(m)
0·5
LOG
St 155
CLAY
SILT
230 63µm
200 75µm
100 150µm
50 300µm
30 600µm
16 1·18mm
8 2·36mm

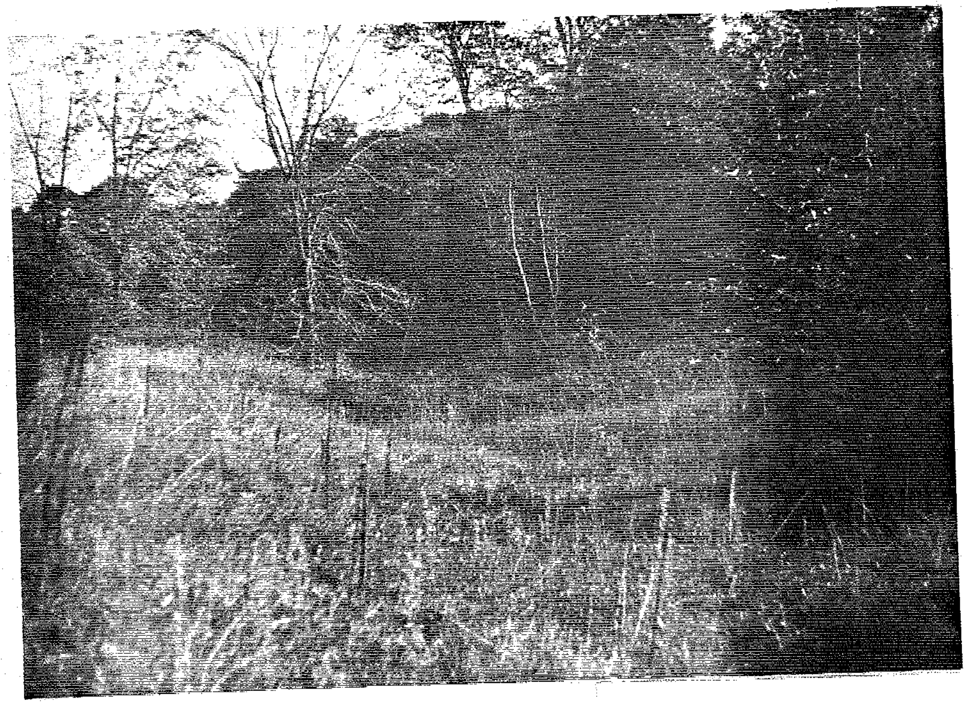

UNIT
PALEO.
ESTIMATION OF GRAIN SIZE
CLAY
SILT
FINE SAND
MEDIUM SAND
COARSE SAND
FINE GRAVEL
3·0
2·0
(m)
1·0
LOG
St 165
CLAY
SILT
230 63µm
200 75µm
100 150µm
50 300µm
30 600µm
16 1·18mm
8 2·36mm



Convoluted and dewatered sediment in a linear ridge south of the Village of Milford (St. 151).



This boulder is wedged in a crevasse (St. 163).

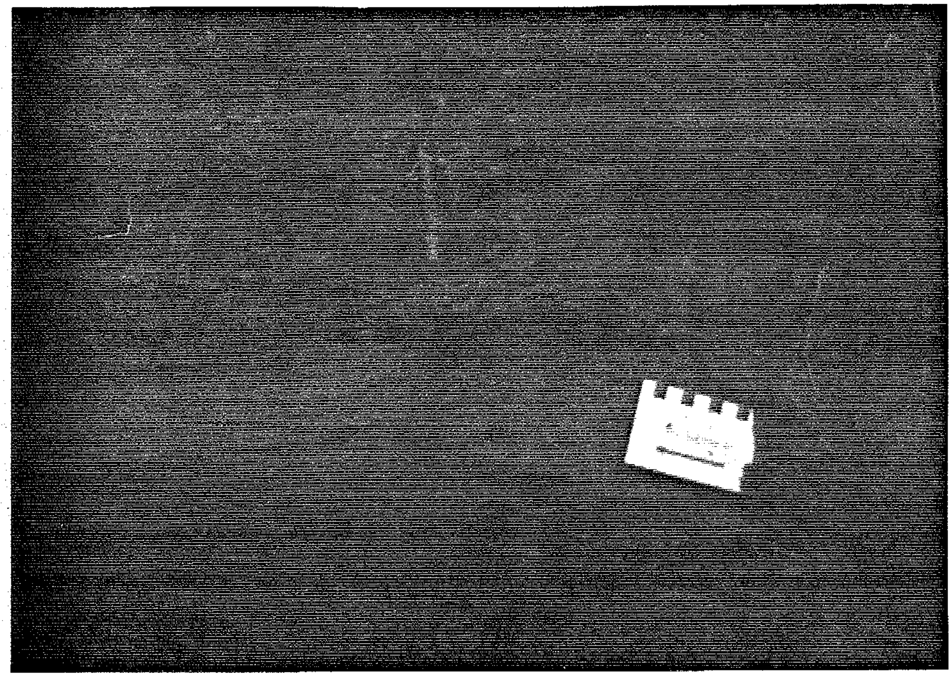


This is the trough in the bedrock at Station 164. This trough is located where the valley ceases to bend.

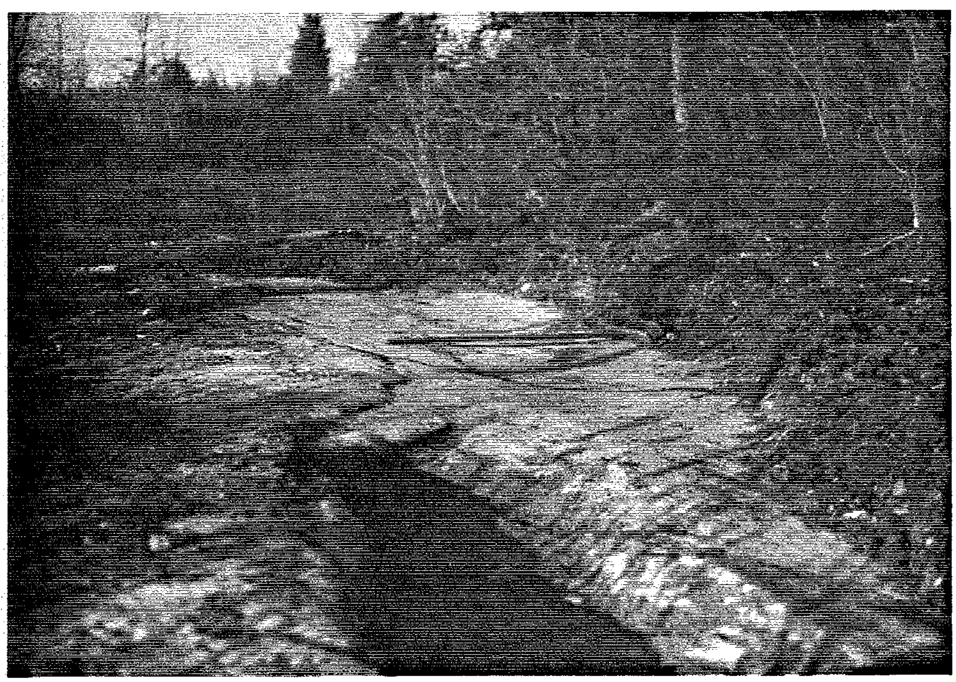
The edge of a circular depression (pothole) at Station 164.

Convoluted and dewatered sediment in a linear ridge west of the Village of Milford (St. 165).

This ridge has been interpreted as being an englacial ridge (St. 167). The convolutions were interpreted as being caused by sediment collapse due to removal of underlying support.



Convoluted and dewatered sediment in a linear ridge west of the Village of Milford (St. 151). The convolutions were interpreted as being caused by rapid sedimentation.



The p-forms on the bedrock surface at Station 211.

STATION NUMBER: 170 - 198 **UTM:** E 32963 N 46287
TOWNSHIP: Athol; S. Marysb, CON. III; I LOT: 1 - 5
ELEVATION: 101 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology along the valley which is south of the Village of Milford and just north of Royal Street.

Observations:

The amount of alteration which may be attributed to glacial processes appears to be extensive throughout this valley. One of the most obvious examples that may be attributed to glacial alteration is the terraces along the sides of the valley (Stations 173, 176, 185, and 191). Although these terraces are covered by both sorted and unsorted sediment, the unconsolidated sediment represents only a veneer upon the underlying bedrock.

At the crest of the hill are linear ridges composed of fining upward cycles of either clast supported fine to coarse gravel and plane bedded medium sand (Stations 173, 176 and 191) or planar cross-bedded and cross-laminated medium to fine sand (Stations 177 and 191). These ridges are approximately at elevations 98 m, 99 m and 101 m ASL (320, 325 and 330 feet).

Linear ridges similar to the ones described above are found south of the valley (Stations 170, 172 and 192). These ridges are composed of sediment similar to that found at Stations 173, 176 and 191. These ridges are approximately at elevations 93 m and 98 m ASL (305 and 320 feet).

Smaller ridges consisting of finer sediment are found on the terraces below the crest of the valley (Stations 173, 176, 178, 180, 181, 183, 185, 191 and 198). These ridges, which are located on the edge of the terraces, are composed of rhythmically bedded very fine sand and silt. The ridges range in thickness from 0.30 m to greater than 1.1 m.

At the base of the hill there is a trough in the bedrock filled with rhythmically bedded silts and clays (Stations 174, 182, 186, 187, 190, 193 and 195). The rhythmites consist of numerous cycles which grade from very fine sand to silt interbedded with thick clay layers. These rhythmites (and trough) are a minimum of 1.50 m deep. Small stone layers are found interbedded with these rhythmite layers.

In a few areas striae and grooves were seen along the margins of the bedrock trough (Stations 174 and 194). The striae were oriented approximately 256° and 288° and the grooves are oriented 240°. In addition, p-forms where seen (Station 174) to run down the side of the bedrock trough.

At one location two troughs filled with rhythmites separate a whaleback-shaped bedrock knoll (Stations 187, 188 and 190). The gentle, or stoss side of the knoll is on the northeast. The joint orientation on this knoll was principally 020° and 110° and many of them were open greater than 0.20 m. The crevasses oriented 020° were open for tens of metres and filled with clayey-silt and sandy-silt. Angular precambrian boulders with diameters up to 2.0 m were lodged in many of these crevasses. However, the joints oriented 110° were not open (as often) for such an extent. It was found that along the 110° orientation the joints tend to consist of elliptical holes where the long axis is oriented westward. These holes are filled with sediment similar to the 020° crevasses.

South of the crest of the valley, on top of the hill, it is very easy to distinguish the orientation of the joints (Stations 175, 177, 178 and 185). This is because many of the joints are open greater than 0.20 m and small depressions (< 0.10 m deep) can be observed on the surface and are oriented 025o, 100o and 125°. These crevasses, which are greater than 1.0 m deep (length of probe), are filled with unsorted sandy-silt to clay-silt sediment. Angular precambrian clasts with diameters up to 0.75 m were observed to be wedged within these crevasses.

The orientation of the joints north of valley was determined from the orientation of the Type A waves seen at Stations 181 and 198). The orientation of the wave crests north of the valley is approximately 060° and 125°.

In addition to the crevasses, larger lineaments were observed to cross the surface. Linear depressions oriented approximately 120° to 125° are at Stations 171, 172, 176, 180 and 189. These depressions are filled with unsorted sandy-silt to clay-silt sediment. Angular precambrian clasts with diameters up to 0.75 m were observed to be wedged within these depressions. In addition, positive linear features are found at Stations 184 and 189. These features are oriented approximately 125° and is up to 0.60 m high and 7.0 m wide. Both of these features are abutted with unsorted clayey-silt.

Type B waves were observed on the western side of the valley. These waves are oriented approximately 250° and have an amplitude of up to 1.10 m. The wavelength of these features is approximately 25 m. These waves are in close proximity to the trough with rhythmites.

<u>Comment</u>:

The linear ridges (St. 170, 172, 173, 176, 177, 179, 191 and 192) are ancient shoreline deposits of either the Belleville

Phase or the Sidney Phase of Lake Iroquois. These shorelines are at elevations higher than attributed for the Belleville Phase in the area. The lake was on the northern side of the valley when the shoreline formed. The drift on the northern side of ridges have a smaller proportion of matrix because these are the shallow water zones where the wave orbits eroded sediment that was deposited ultimately along the shore.

The examination of the margins of this valley on aerial photographs and in the field indicates that the valley walls have been sculpted and stream-lined by glacial processes. The relative importance of each is discussed in the report.

It appears that the positive linear features (Stations 184 and 189) are pop-ups similar to those described by White et al. (1974). The unsorted sediment abutting and overlying the feature may be a till suggesting that the feature formed preglacial or during the glacial period. The unsorted sediment in the linear depressions and the large boulders on top of the lineament support this, for this material was probably deposited when the ice covered the area. This is discussed further in the report.

The large clasts which are lodged into the elliptical holes may be boulders carried by the glacier or by meltwater. If the crevasses were open during glaciation they would be a zone of low pressure and therefore a preferred area of deposition (Rothlisberger, 1972; Shreve, 1972; Weertman, 1972; Nye, 1973; Boulton, 1974). Because the clasts are so large, they would not be able to fit down the crevasses and would be lodged in the crevasses as the glacier flowed over it or would become wedged as the meltwater flowed down and through the crevasses.

Diagram and/or Picture:

STRIATIONS

PROJECT

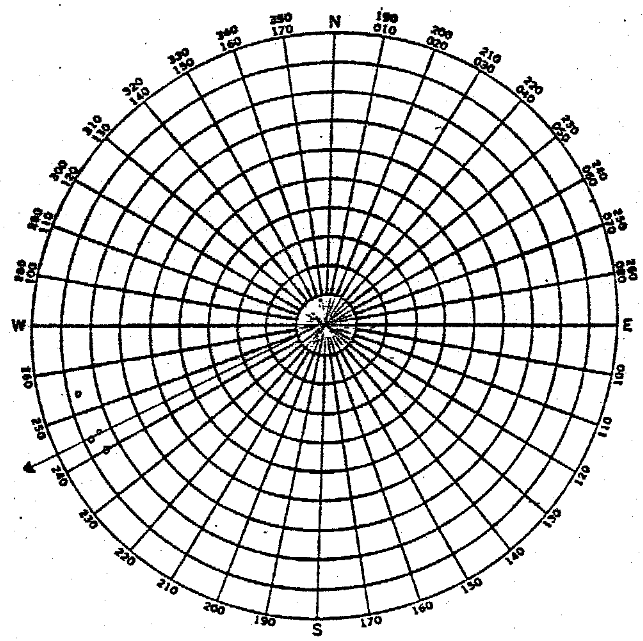
Station 174

Date 30/10/87

Personnel G. A. Gorrell

No. of striations: 4

Location:



• direction 1

× direction 2

• p-forms, sichelwannen or cavettos

STRIATIONS

PROJECT

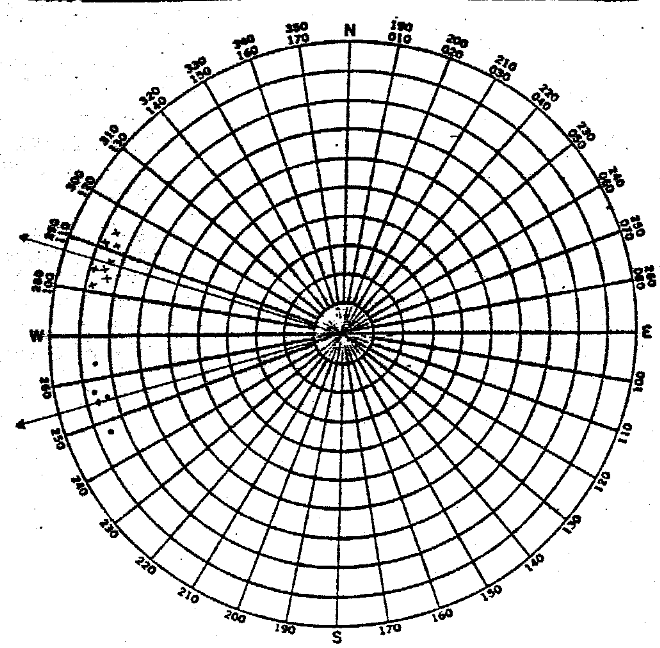
Station 194

Date 30/10/87

Personnel G. A. Gorrell

No. of striations: 13

Location:



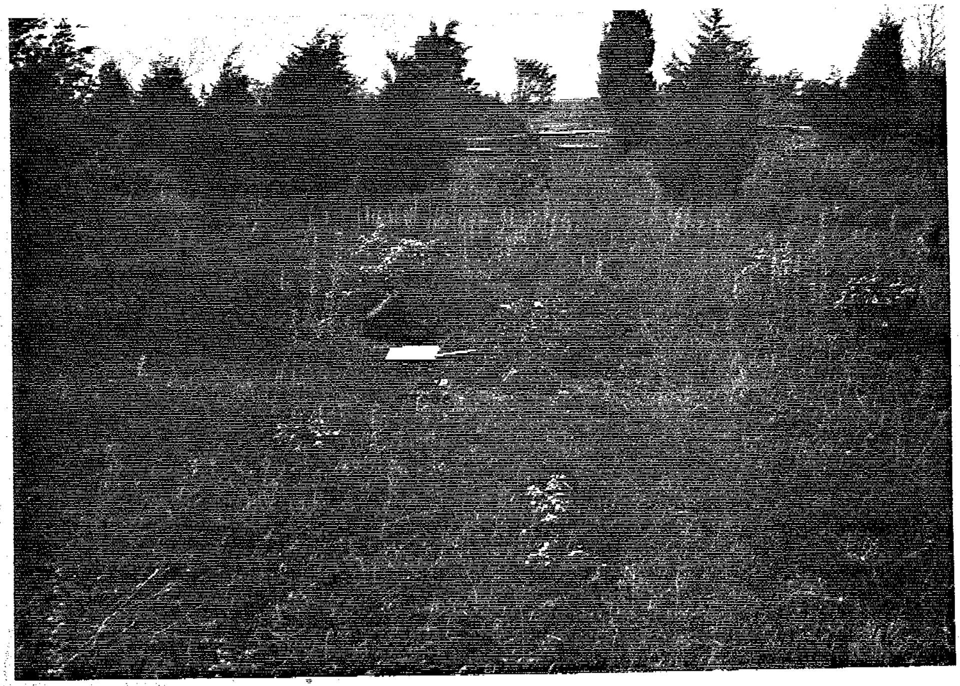
• direction 1

× direction 2

• p-forms, sichelwannen or cavettos

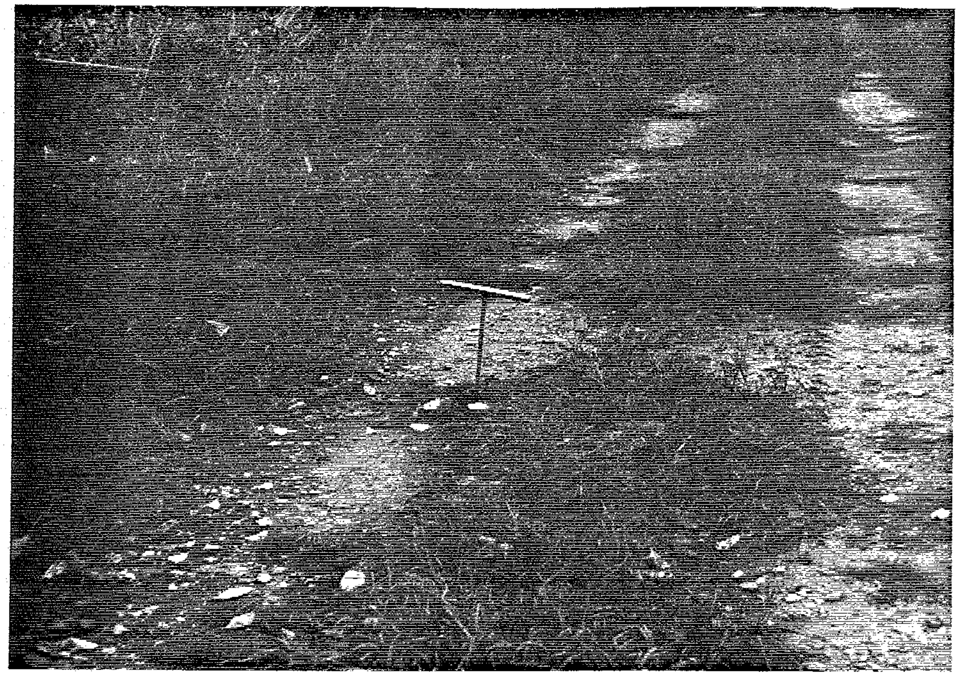
The terraces shown in this photograph are bedrock covered with a veneer of sorted sediment (St. 173).

At the base of the valley shown above there is a trough in the bedrock filled with rhythmites (St. 174).



At the crest of the valley are crevasses oriented 065° filled with greater than 1.10 m of unsorted sediment (ST. 175).

High-lighted ridge is an ancient shoreline (St. 176) composed of sorted sediment consisting of fining upward cycles at elevation 99 m (325') ASL.



At the crest of the valley are crevasses oriented 125° filled with greater than 1.10 m of unsorted sediment (St. 177).

A pop-up at Station 184 oriented approximately 125°. A well developed till abuts and covers this feature.

STATION NUMBER: 201 -210 **UTM:** E 33270 N 46225 (St. 210)
TOWNSHIP: S. Marysb. **CON.** C **LOT:** -
ELEVATION: 91 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology north of Royal Street within Concession C.

Observations:

The northern portion of this area consists of a series of linear ridges at elevations 91 m, 94 m and 96 m ASL (300, 310 and 315 feet). The ridges at the higher elevations (St. 201 and 204) are composed of fining upward cycles of clast supported fine to coarse gravel and plane bedded or planar cross-bedded medium to fine sand.

In contrast to the ridges at higher elevations, the ridges at lower elevations (St. 202, 203, 208a and 210) have distinct lateral transitions. At their highest point, the ridges are composed of fining upward cycles of clast supported fine gravel and plane bedded to cross-laminated fine sand. As the height of the ridge decreases, these cycles grade into fining upward cycles of planar cross-bedded fine to medium sand and cross laminated fine sand.

All the ridges composed of sorted sediment formed against rises in the bedrock surface. However, the rises do not consist of a series of steps. Rather the bedrock surface appears to consist of a series of asymmetrical waves which increase in amplitude towards the north. For example, both of the ridges at Stations 202 and 210 abut rises in the bedrock surface. However, separating these bedrock rises is a trough greater than 1.0 m deep filled with medium to coarse sand. This trough can be traced eastward to Station 219. The bedrock surface in this area is also waved.

At the base of all the hills composed of sorted sediment is an area consisting of saturated, rhythmically bedded silts and clays. A watering hole had been excavated for the cattle (St. 205) and the owner of the property indicated that there was up to 5.0 m of sediment overlying the bedrock in this area. A single silt and clay couplet ranged in thickness from 40 mm to 80 mm. Interbedded with these couplets are 20 mm to 70 mm thick layers of medium to coarse sand. These sand layers appear to thin southward, away from the ridges composed of sorted sediment.

The area consisting of rhythmites of silt and clay abruptly terminates against a lineament oriented approximately 060° (St. 207 and 209). On the north side of this lineament the sediment is greater than 5.0 m deep. The water which was on the surface in this area was flowing southward through small drainage channels. This flowing water disappeared along the edge of the lineament (St 209). On the south side of the lineament, 0.10 to 0.20 m of unsorted sediment overlies the rock. Because the overburden is thin south of the 060° lineament, the fractures and lineaments in the bedrock can be distinguished.

Two linear depressions are located south of the area consisting of rhythmites (St. 206). The largest depression is oriented 025° and can be traced westward to Station 89. This linear depression consists of a series of depressions, each greater than 2.0 m deep and 1.00 m wide joined by a 0.20 wide depression. It is filled with clasts up to 0.80 m in diameter and unsorted sediment consisting of clayey-silt. This linear depression terminates on the eastern side of the area against a lineament oriented approximately 125°. This lineament, which is filled with boulders and unsorted clayey-silt, can be traced northwestward to Station 171.

Surrounding these lineaments are Type A waves oriented 060° and 125°. Adjacent to the depressions the waves oriented 125° change to 148°. At the crest of the waves, 0.10 to 0.25 m of unsorted sandy-silt overlies bedrock. However, there is greater than 1.10 m of sediment in the troughs, and this sediment fines downward to rhythmites of silt and clay. This suggests that troughs are located over fractures in the bedrock surface (joints).

The bedrock surface drops abruptly 1.50 m towards the south in the southeastern corner of this area (Station 208b). Type A waves, oriented approximately 148°, were observed on the higher north side of this east/west rise.

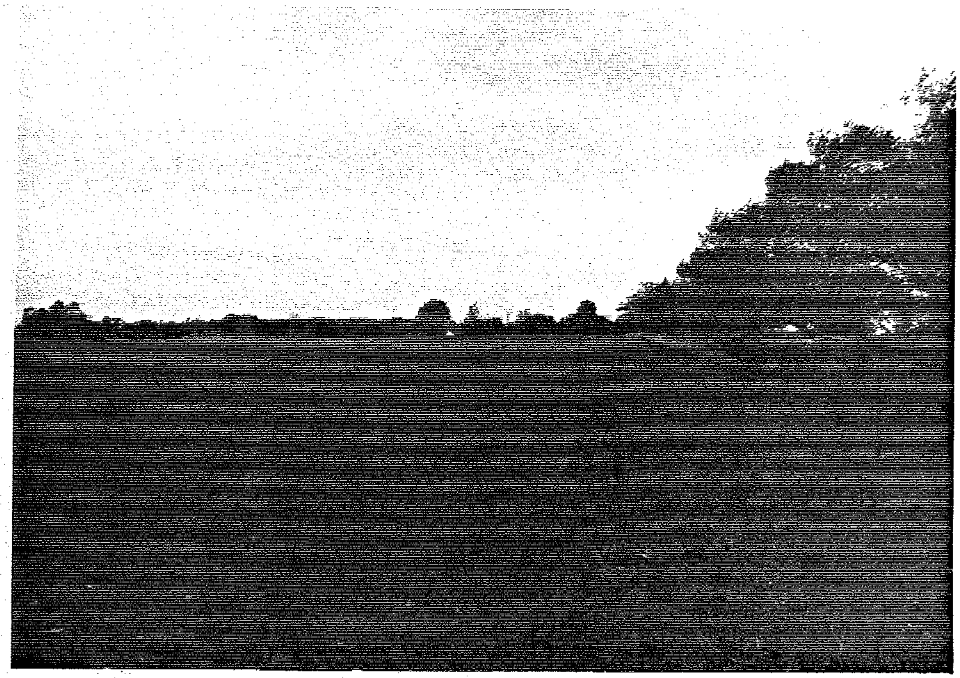
<u>Comment</u>:

The linear ridges (St. 201, 202, 203, 204, 208a and 210) are ancient shoreline deposits of either the Belleville Phase or the Sidney Phase of Lake Iroquois. These shorelines are at elevations higher than attributed for the Belleville Phase in the area. The levels for this lake stage in the area are unknown. The lake was on the southern side of the valley when the shoreline formed.

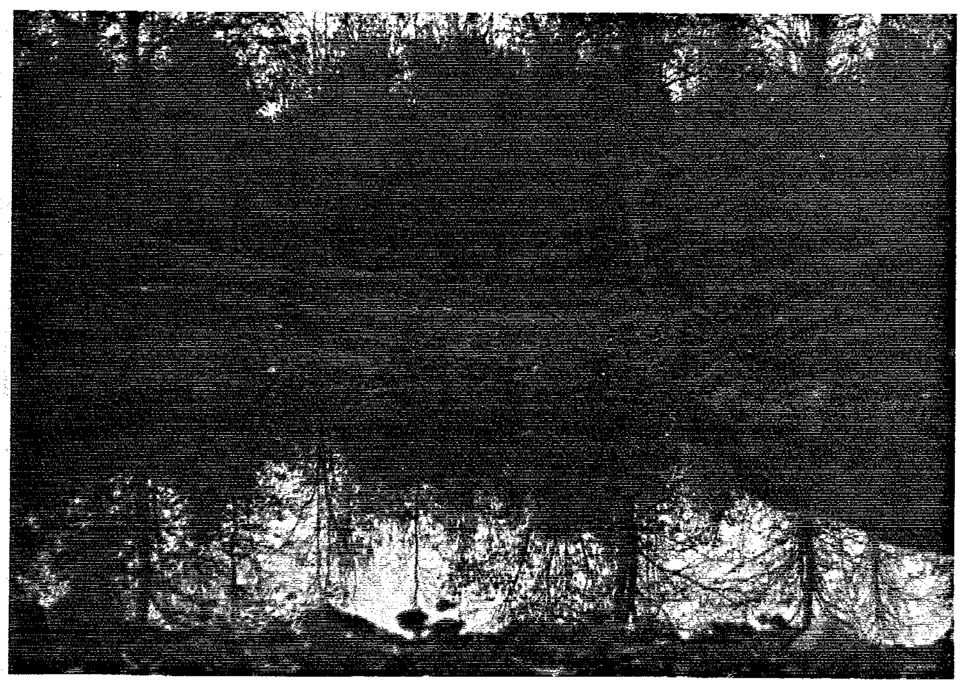
The rhythmites are probably sediment deposited in a basin in the offshore zone of the shoreline described above. The 20 to 70 mm beds consisting of medium to coarse sand that is interbedded with the rhythmites are probable debris flow deposits. These debris flows were probable induced by cyclical loading by waves.

It is not known whether the waved topography was caused by seismic activity or by abrasion during glacial periods.

Diagram and/or Picture:

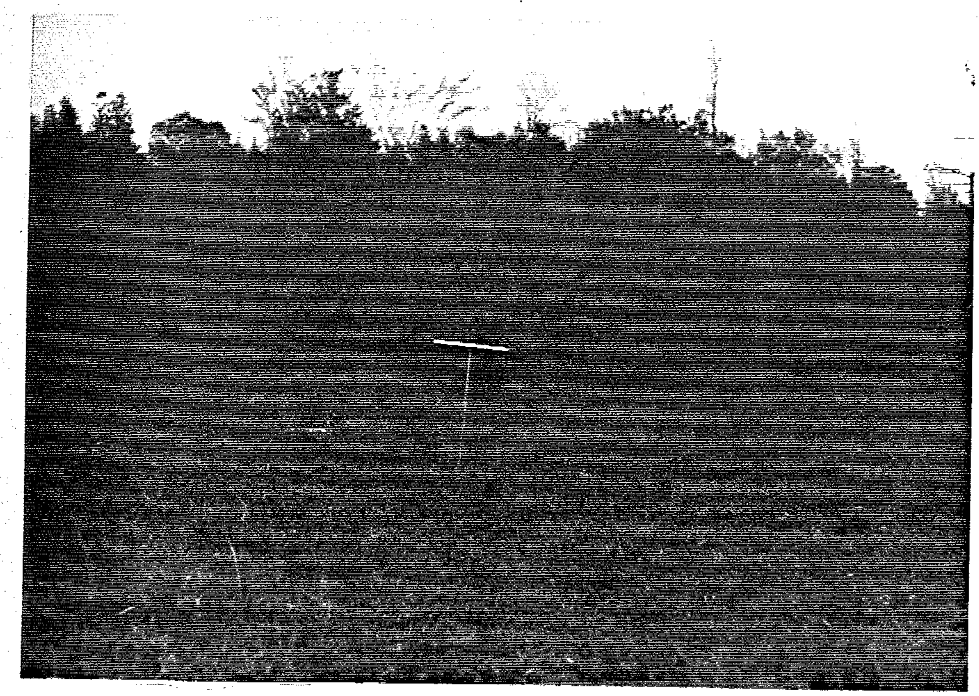


The hills in the background are ancient shorelines (St. 204) composed of sorted sediment consisting of fining upward cycles at elevation 94 m (310') ASL.



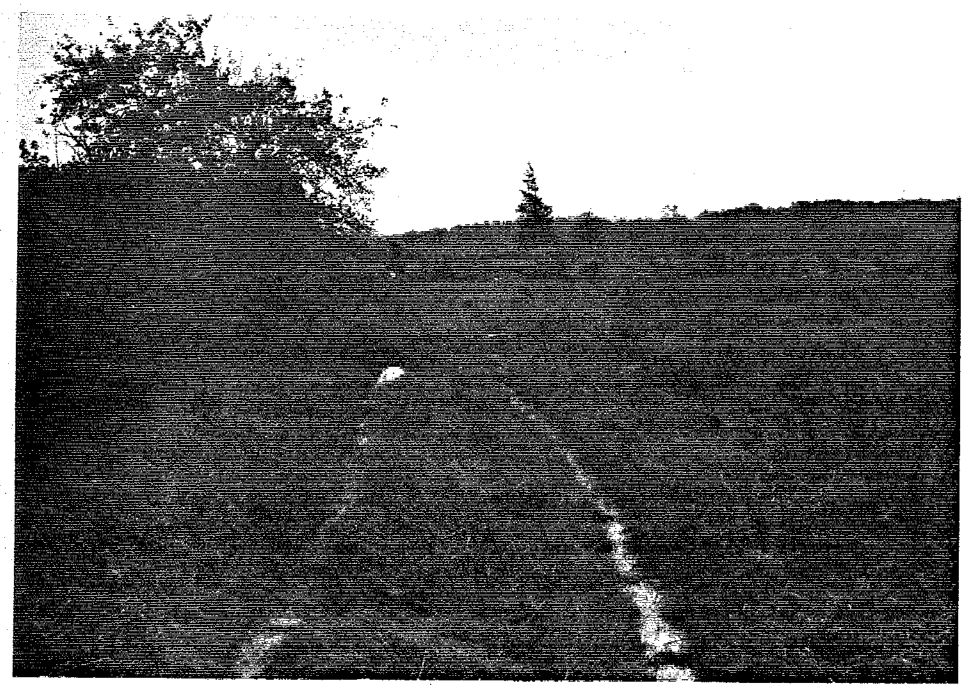
At the base of the shorelines is a basin filled with rhythmites of silt and clay (St. 205).

A linear depression filled with boulders and unsorted sediment oriented approximately 060° (St. 206).



A linear depression filled with boulders and unsorted sediment oriented approximately 125° (St. 206).

A crevasse in the bedrock surface oriented 060° (St. 207). On either side of the probe the bedorck is covered by < 0.12 m of sediment. The probe could have been put in ground for full metre.



The rhythmites of silt and clay are found in a basin bordered by bedrock. The water seen in the tire ruts abruptly disappears along the lineament oriented 060° in background (St. 209).

STATION NUMBER: 215 - 222 and 231 UTM: E 33260 N 46292 (St. 218)

TOWNSHIP: S. Marysb. CON. D LOT:

ELEVATION: 97 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology 3 km west of South Bay.

Observations:

Three ponds have been excavated in this area (Stations 215 and 218). These ponds, are located approximately at elevation 98 m (320') ASL. They were excavated in sediment consisting of saturated, rhythmically bedded silts and clays similar to the sediment at Station 231. The owner of one of the ponds indicated that there was up to 5.0 m of sediment overlying the bedrock in this area. A single silt and clay couplet ranged in thickness from 40 mm to 80 mm. Interbedded with these couplets are 20 mm to 70 mm thick layers of medium to coarse sand. These sand layers appear to thin southward.

The rhythmites of silt and clay appear to have been deposited in a basin. This is because the bedrock on the northern and southern sides of the area is much closer to the surface. On the southern side of the area which is composed of rhythmites there are a series of hills approximately 1.20 m high oriented approximately 270°. Adjacent to the area where the rhythmites were deposited the hills consist, in descending order, 0.15 m of rhythmites and 0.80 m of unsorted sediment composed of clayey-silt and fine gravel (St. 216). Farther south (St. 217) the hills are predominantly composed of clayey-silt and fine gravel. In the troughs at the base of the hills there is less than 0.20 of sediment overlying the bedrock surface.

East of the area where the rhythmites were deposited and along the north to south oriented road, the bedrock surface appears to be terraced (St. 219). However, the rises do not consist of a series of steps. Rather the bedrock surface appears to consist of a series of asymmetrical waves which increase in amplitude towards the north. A sorted ridge consisting of fining upward cycles of medium to fine gravel and medium sand is found at the crest of the hill. This ridge is at approximately elevation 101 m (330') ASL.

Separating the bedrock rises is a trough which is greater than 1.0 m. This trough is filled with medium to coarse sand. This trough can be traced westward to Stations 202 and 210. The bedrock surface in this area is also waved.

Not only do the joints widen near the margins of the trough, they also appear to change orientation. For example, on the southern side of the trough the joints are generally oriented 065° and 125°. The joints oriented 065° appear to be wider than the 125° ones. However, on the northern margin of the trough the joints are oriented 060° and 148°. The joints oriented 148° are greater than 0.20 m wide. This orientation changes near the crest of the hill where the joints are oriented 040° and 125°.

A lineament oriented approximately 125o crosses the north to south oriented road near the base of the hill (St. 220). The 0.40 m of unsorted sediment overlying the bedrock surface was excavated (ditch) adjacent to the road and it appears that the surface has buckled. The bedrock surface on the western side of this buckle appears to be higher. A crevasse greater than 1.0 m deep and filled with unsorted clayey-silt is on the eastern side of this feature.

Type B waves were observed on either side of the lineament (St. 221, 222). At the crest of these waves there is up to 0.70 m of unsorted sediment consisting of sandy-silt. These waves are oriented approximately 060°.

Striations and grooves were observed on the bedrock surface (St. 221) south of the lineament along the side of the road. The grooves are oriented approximately 258° and the striae are oriented approximately 253°. The striations and grooves do not appear to change direction or structure on either side of the Type B waves.

<u>Comment</u>:

The linear ridge (St. 219) is ancient shoreline deposit of either the Belleville Phase or the Sidney Phase of Lake Iroquois. This shoreline is at an elevation higher than attributed for the Belleville Phase in the area. This suggests that the beach may have formed during the Sidney Stage. The levels for this lake stage in the area are unknown.

The rhythmites are probably sediment deposited in a basin in the offshore zone. The elevation of this zone is much higher than the beaches of the Belleville stage of Lake Iroquois was in this area. Therefore, this sediment was probably deposited at an earlier time (the Sidney Stage). Alternatively, there has been major uplift after the beach developed.

It is not known whether the waved topography was caused by seismic activity or by abrasion during glacial periods. However, the change in the joint orientation and width suggests that the waves were caused by seismic activity.

Diagram and/or Picture:

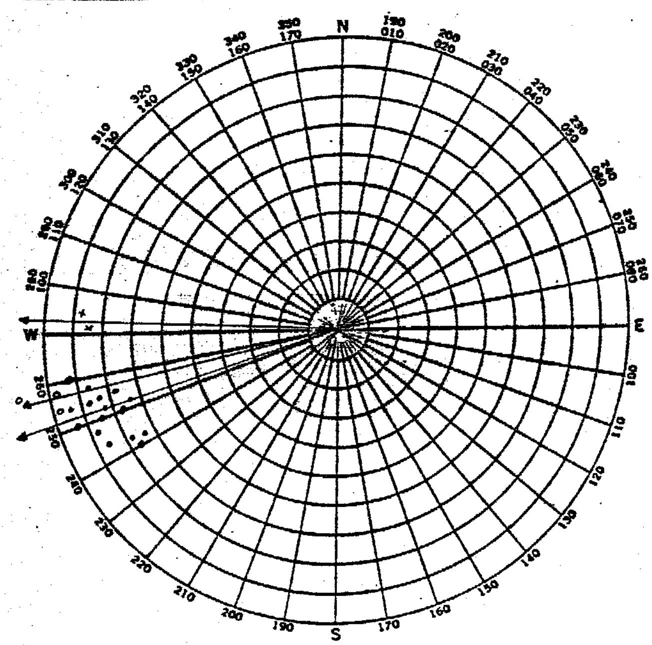
STRIATIONS PROJECT

Station 221 **Date** 30/10/87 **Personnel** G. A. Gorrell

No. of striations: 20

Location:

- · direction 1
- × direction 2
- ∘ p—forms, sichelwannen or cavettos



Stream-lined mound of unsorted sediment (St. 217).

A lineament oriented 125° covered with unsorted sediment (St. 220).

STATION NUMBER: 223 - 227 UTM: E 33350 N 46230 (St. 224)
TOWNSHIP: S. Marysb. CON. D LOT: -
ELEVATION: 91 metres above sealevel

Brief Description of Morphology:

These Stations describe the sediment and morphology 2 km west of South Bay.

Observations:

A series of lineaments cross this area. The largest one is a positive linear feature (St. 224) and is oriented approximately 125°. It is up to 1.8 m high and 12 m wide.

The aspect of this feature changes three times. Near the Wildlife area (St. 227) the feature is a linear depression. In this area it is approximately 0.30 m wide and filled with unsorted clayey-silt and clasts up to 0.40 m in diameter. The aspect of this feature changes again north of the road where it crosses an east/west rise (St. 223). It remains a positive linear feature until it crosses a linear depression (St. 226) upon which it changes to a linear depression (St. 225).

In contrast to many of the linear depressions in the study area, the linear depression at Station 226 is filled medium to coarse sand. The thickness of this sediment is greater than 1.10 m. When this depression was probed the water in the depression flowed to the surface.

Where the feature is a positive linear feature it is covered, at its crest and western side, with sorted sediment consisting of fining upward cycles of fine to medium gravel and medium to fine sand (St. 224). The feature at this location is located approximately at elevation 91 m (300') ASL. Type A waves oriented 060° are found on the eastern and western side of the feature in this area.

Parallel with the largest lineament is another linear depression (St. 227). This depression can be traced southeastward to Stations 123 and 129. Similar to the large depression it is filled with unsorted clayey-silt and clasts up to 0.40 m. Two old wells are located on this lineament.

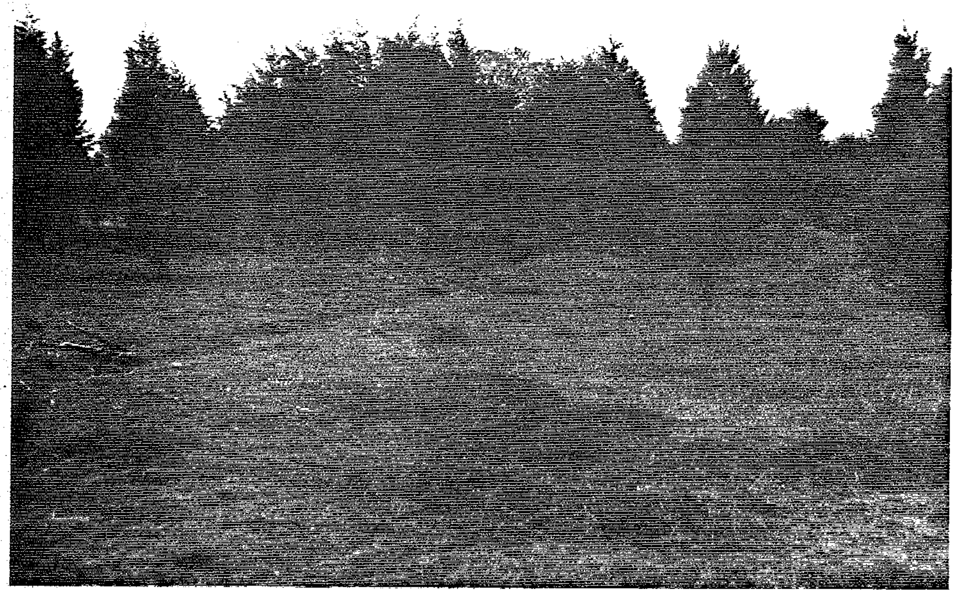
Comment:

It appears that the positive linear feature (Stations 224) is a pop-up similar to those described by White *et al.* (1974). The unsorted sediment abutting and overlying the feature may be a till suggesting that the feature formed preglacially or during the glacial period. The unsorted sediment in the linear depressions (St. 225 and 227) support this, for this material was probably deposited when the ice covered the area. This is discussed further in the report.

The sorted sediment which abuts the feature on the western side is probably an ancient shoreline of either the Belleville Phase or the Sidney Phase of Lake Iroquois. Since the sediment has developed upon the feature it indicates that the feature had popped prior to the area being covered by the lake.

Diagram and/or Picture:

A linear depression filled with unsorted sediment and boulders (St. 223).



The linear depression shown above changes aspect at a east/west rise to a positive feature. This feature is covered with sorted sediment (St. 224). Adjacent to the feature are Type A waves.