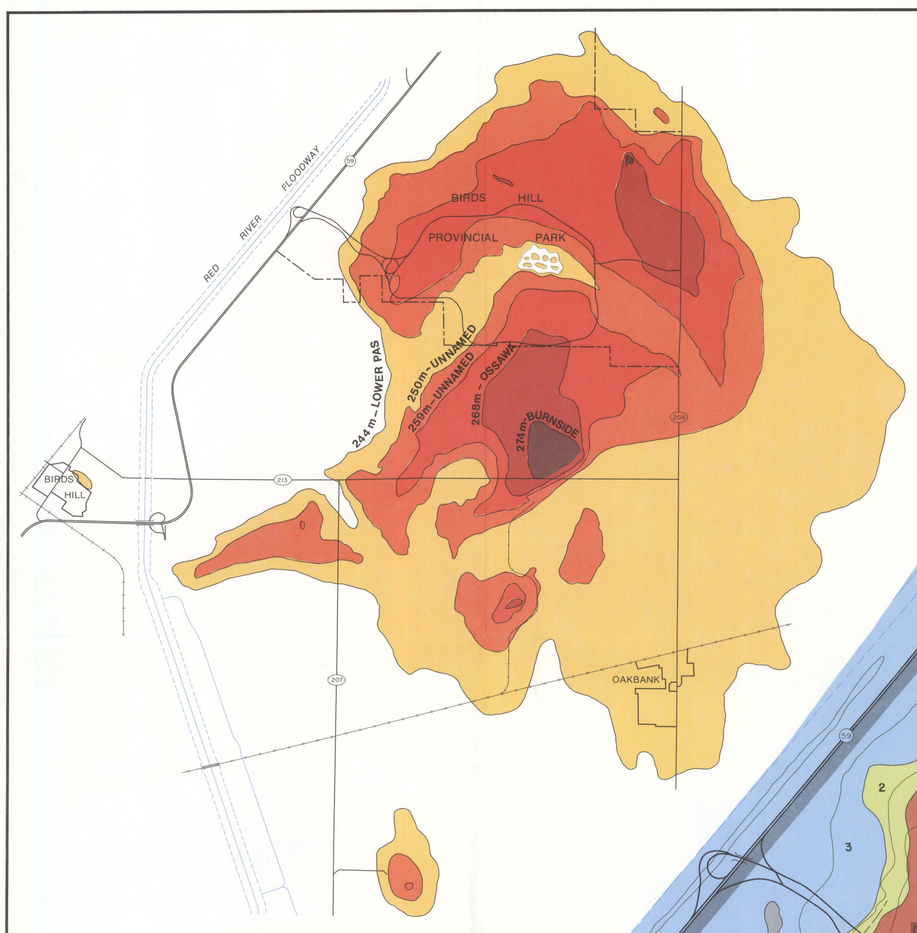
MAP AR84-5

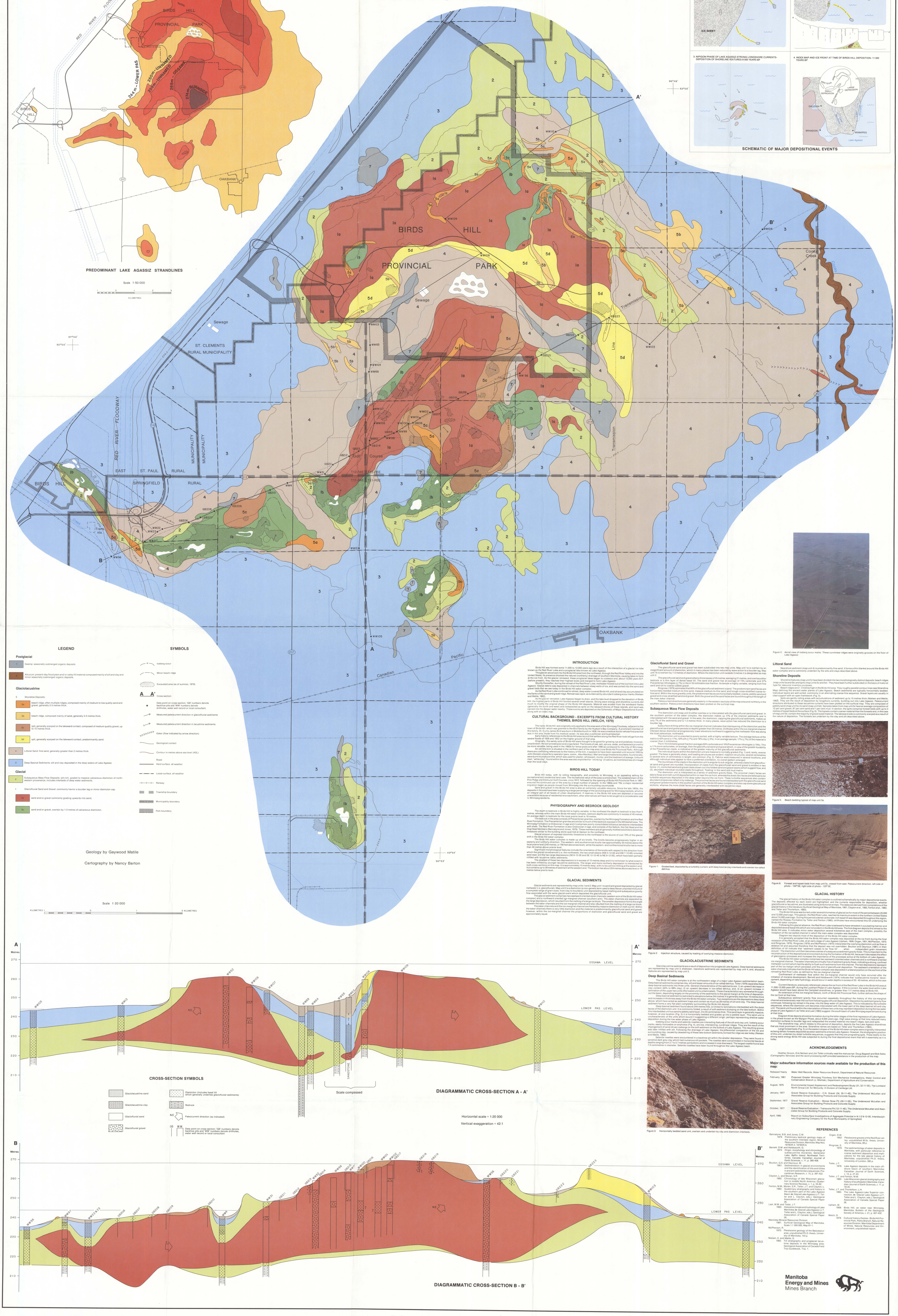
QUATERNARY GEOLOGY MAP OF THE BIRDS HILL AREA



PREDOMINANT LAKE AGASSIZ STRANDLINES

Scale 1:50 000

KILOMETRES

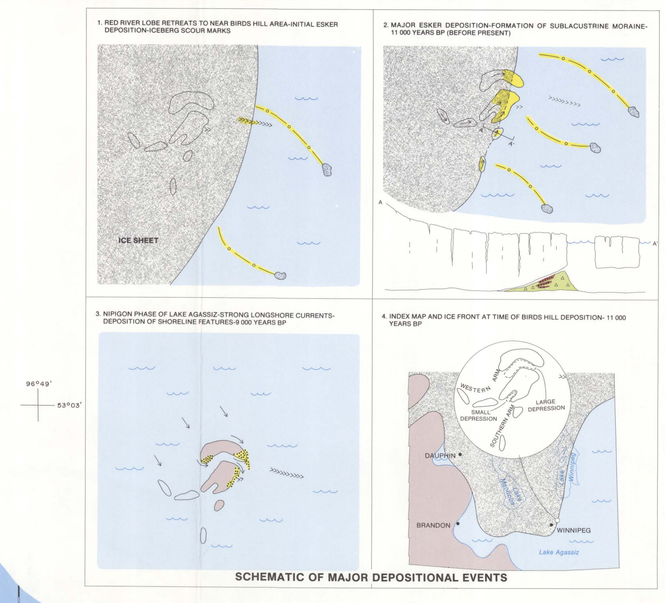


Geology by Gaywood Matile

Cartography by Nancy Barton

Scale 1:20 000

KILOMETRES 1 0 1 2 KILOMETRES



SCHEMATIC OF MAJOR DEPOSITIONAL EVENTS

LEGEND

Postglacial

7 Swamp: seasonally submerged organic deposits

6 Alluvium: present-day flood plain and/or valley fill material composed mainly of silt and clay and minor seasonally submerged organic deposits.

Glaciolacustrine

5 Shoreline Deposits:

5a beach ridge, often multiple ridges, composed mainly of medium to low quality sand and gravel, generally 2-3 metres thick.

5b beach ridge, composed mainly of sand, generally 2-3 metres thick.

5c spit, generally scarped on the lakeward contact, composed of medium quality gravel, up to 15 metres thick.

5d spit, generally scarped on the lakeward contact, predominantly sand.

4 Littoral Sand: fine sand, generally greater than 2 metres thick.

3 Deep Basinal Sediments: silt and clay deposited in the deep waters of Lake Agassiz.

Glacial

2 Subaqueous Mass Flow Deposits: silt-rich, graded to massive calcareous diamicton of north-western provenance, includes interbeds of deep water sediments.

1 Glaciofluvial Sand and Gravel: commonly having a boulder lag or minor diamicton cap.

1a sand and/or gravel commonly grading upwards into sand;

1b sand and/or gravel, overlain by 1-3 metres of calcareous diamicton.

SYMBOLS

Iceberg scour

Minor beach ridge

Excavated area (as of summer, 1979)

A A' Cross-section

Data point on cross-section; 'GB' numbers denote backhoe pits and 'WW' numbers denote drillholes, water well record or local consultant.

Measured paleocurrent direction in glaciofluvial sediments

Measured paleocurrent direction in lacustrine sediments

Esker (flow indicated by arrow direction)

Geological contact

Contour in metres above sea level (ASL)

Road:

Hard surface, all weather

Loose surface, all weather

Railway

Township boundary

Municipality boundary

Park boundary

INTRODUCTION

Birds Hill was formed some 11,000 to 12,000 years ago as a result of the interaction of a glacial ice lobe known as the Red River Lobe and a proglacial lake known as Lake Agassiz.

This glacier advanced into the Birds Hill area from the northwest, through the Red River Valley and into the United States. Its presence blocked the natural (northerly) drainage of southern Manitoba, causing lakes to form at the ice front. As the glacier retreated, these proglacial lakes began to coalesce and, about 13,000 years B.P. (before present), they reached their highest levels and merged to form Lake Agassiz.

Shortly thereafter, during the retreat of the Red River Lobe, meltwater flowed out of the ice front into Lake Agassiz. Glacial debris was deposited in channels between steep walls of ice, and was sorted into the sand and gravel beds that we see today in the Birds Hill esker complex.

As the Red River Lobe continued to retreat, deep water covered Birds Hill, and silt and clay accumulated on the flanks of the sand and gravel ridge. Retreat was rapid, as evidenced by abundant iceberg scour marks (Nielsen and Matile, 1982).

As the glacier retreated, Lake Agassiz began to drain, and the lake level dropped to the elevation of Birds Hill: the highest parts of Birds Hill formed several small islands. Strong wave energy and shoreline currents did much to modify the original shape of the Birds Hill deposits. Material was eroded from the windward flanks (generally the north and west) and redeposited as spits on the leeward shores of these islands, and sand was carried into the deeper water nearby. These events are depicted on the Schematic of Major Depositional Events, along with an index map.

CULTURAL BACKGROUND - EXCERPTS FROM CULTURAL HISTORY THEMES, BIRDS HILL (WELCH, 1979)

The name, Birds Hill, was originally only applied to the area west of the Winnipeg Floodway, adjacent to the town of Birds Hill, which was granted to the Bird family by the Hudson's Bay Company. A prominent member of this family, Dr. Curtis James Bird was born in Middlechurch in 1838. He was a medical doctor whose first practice was in the area. Aside from his medical career, he was also a politician and businessman.

Early historic references to the Birds Hill area record that settlers along the Red River took refuge from the severe floods of 1826 and 1852 on the higher ground of that area.

Originally, the sandy soils of Birds Hill were thought to be good for growing rye and potatoes; however, once broken, the soil proved poor and crops failed. The forests of oak, ash, spruce, cedar, and tamarack proved to be more valuable, being used in the 1860s for fence posts and after 1890 as cordwood for the City of Winnipeg.

An old lime kiln is situated in the northern part of the map area (now Birds Hill Provincial Park). Although there are conflicting references to the history of the kiln, it appears to have been operated until around 1930 by John Donald, a local ferry operator (pers. comm., Alex MacKay). Marl and large limestone boulders, found locally, were burnt to produce lime, which was used for plaster, whitewash, mortar, and the treatment of sewage. Unburnt marl, "white clay", found within the area was also exploited for "chinking" of cabins, as it exhibited less shrinkage than the local clays.

BIRDS HILL TODAY

Birds Hill today, with its rolling topography, and proximity to Winnipeg, is an appealing setting for recreational and residential land uses. The recreational value of the area is entrenched. The establishment of the Pine Ridge and Elmhurst Golf Courses, circa 1912, followed by the opening of Birds Hill Provincial Park in 1967 ensured the continued use of the area by a large number of people. In the 1960s and '70s, a major residential migration began as people moved from Winnipeg into the surrounding countryside.

Sand and gravel in the Birds Hill area is also an extremely valuable resource. Since the late 1800s, the deposits in the area have been supplying a large percentage of the sand and gravel for Winnipeg markets, which is an integral part of all facets of urban development. If reserves in the Birds Hill area are depleted or become unavailable because of residential encroachment, other alternatives will have to be sought at a considerable cost to Winnipeg residents.

PHYSIOGRAPHY AND BEDROCK GEOLOGY

The depth to bedrock in Birds Hill is highly variable. In the northeast the depth to bedrock is less than 5 metres, whereas within the main Birds Hill esker complex, bedrock depths are commonly in excess of 40 metres. An average depth to bedrock for the local prairie level is 18 metres.

The bedrock in the area consists of Precambrian granites, overlain by the Winnipeg Formation and the Red River Formation. The Precambrian granites are similar to much of the bedrock exposed in the Whiteshell area. The Winnipeg Formation is Ordovician in age and it comprises poorly consolidated siliceous sandstone interbedded with shale. The Red River Formation is also Ordovician in age, and consists of the Selkirk, the Cat Head and the Dog Head Members (Bannatyne and Jones, 1979). These members are all generally mottled dolomite to dolomitic limestone similar to the building stone quarried at Garson to the northeast.

Glacial erosion of exposed dolomitic limestone to the northwest is the source of over 70% of the glacial drift in the Birds Hill esker complex.

The Birds Hill esker complex is made up of six knolls. The knolls become progressively higher in an easterly and northerly direction. The western- and southernmost knolls rise approximately 20 metres above the local prairie level (240 metres, or 790 feet above sea level), while the eastern- and northernmost knolls rise to more than 40 metres above prairie level.

Significant morphological features include the orientation of the knolls with respect to the direction from which the glacial ice advanced (i.e. the northwest); the two small eskers (NW 4-12-5E and SW 7-12-6E) oriented west-east; and the two large depressions (SE 6-12-5E and SE 12-12-4E to NE 9-12-5E), which have been partially infilled with lacustrine (lake) sediments.

The smallest of these two depressions is in excess of 15 metres deep and it is not known to what extent it has been infilled by younger lacustrine sediments. The larger and more northerly depression is intersected by both cross-sections on this map. It is approximately 15 metres deep, with no lacustrine infilling at the eastern end, but contains up to 29 metres of sediment at the western end. The bottom lies about 224 metres above sea level or 16 metres below prairie level.

GLACIAL SEDIMENTS

Glacial sediments are represented by map units 1 and 2. Map unit 1 is sand and gravel deposited by glacial meltwater (i.e. glaciofluvial). Map unit 2 is a diamicton (a non-genetic term used to describe an unsorted mixture of a complete range of grain sizes, from clay to boulders) until deposited by basal melting and subaqueous gravity flow associated with the same glacial event which deposited the glaciofluvial unit.

The glacial sediment comprises two eastward oriented esker channels (western arm of the Birds Hill esker complex) and a northward oriented ice-marginal channel (southern arm). The esker channels are separated by the large depression, which resulted from the melting of a large ice block. The smaller depression forms the angle between the esker channels and the ice-marginal channel and also resulted from the melting of a large ice block.

The esker channels and the ice-marginal channel are flanked by massive diamicton or melt-out till. Within the esker channels there is very little diamicton and the material is predominantly glaciofluvial sand and gravel; however, within the ice-marginal channel the proportions of diamicton and glaciofluvial sand and gravel are approximately equal.

Glaciofluvial Sand and Gravel

The glaciofluvial sand and gravel has been subdivided into two map units. Map unit 1a is overlain by an insignificant amount of diamicton, which in many places has been reduced by wave action to a boulder lag. Map unit 1b is overlain by 1-3 metres of diamicton. Where the diamicton unit exceeds 3 metres it is designated as map unit 2.

The glaciofluvial sand and gravel attains thicknesses of 45 metres, averaging 21 metres, and overlies either bedrock or a thin layer of dense basal till. The sand and gravel has an average of 73% carbonate and 27% Precambrian lithologies (± 7%) in the 4-16 millimetre size fraction. Its texture is highly variable, ranging from fine sand and silt to coarse cobble gravel.

Ringrose (1979) estimated that 60% of the glaciofluvial sediment is sand. The predominant sand facies are horizontally bedded medium-to-fine sand, massive medium-to-fine sand, and trough cross-stratified coarse-to-fine sand. Within the more gravelly units, the predominant facies are horizontally bedded, coarse, pebbly sand and gravel and cross-stratified sand and gravel. Both the gravel and the sand facies are found throughout the length of the main esker channel.

Paleocurrent directions are generally easterly in the western sections of the map area and northerly in the southern section. Paleocurrent directions have been plotted on the surficial map.

Subaqueous Mass Flow Deposits

The diamicton unit (map unit 2) either overlies or is intercalated with the glaciofluvial sand and gravel. In the southern portion of the esker complex, the diamicton makes up 47% of the channel sediments and is intercalated with the sand and gravel. In the west, the diamicton, capping the glaciofluvial sediments, makes up only 7% of the sediments and is 1-3 metres thick. In many places, wave action has reduced the diamicton to a boulder lag.

Subsurface drilling within the ice-marginal channel indicates that interlayering of the diamicton and the glaciofluvial sand and gravel persists to depths greater than 20 metres. Drillholes within the ice-marginal channel intersect dense diamicton at progressively lower elevations northward suggesting that meltwater flow was along the local paleoslope, northward.

The diamicton unit is unsorted to poorly sorted, with a highly variable texture. The average texture of the matrix is 42% sand (± 11%), 42% silt (± 7%) and 16% clay (± 5%). In an average sample, 17% (± 7%) of the material is coarser than 2 millimetres.

The 4-16 millimetre gravel fraction averages 84% carbonate and 16% Precambrian lithologies (± 10%). This is 11% more carbonates, on average, than the glaciofluvial sand and gravel which, in view of the greater durability of the Precambrian clasts, is indicative of the greater maturity of the glaciofluvial sediments.

The individual layers within the diamicton unit are massive to normally graded (Fig. 1) and, rarely, reverse graded. The base is generally sharp, and loading structures are evident. Injection structures, several centimetres to several tens of centimetres in length, are common (Fig. 2). Fabrics were measured in several locations, and although individual sites appear to have a preferred orientation, no overall pattern emerged.

The roundness of the clasts in the diamicton unit is angular to sub-angular, whereas clasts from glaciofluvial sand and gravel are rounded. Incorporation of clasts from the glaciofluvial sand and gravel is evident in two forms: (1), contorted sand and gravel clasts drawn out into folded sand and gravel seams which suggest flow; and (2), abundant individual rounded clasts throughout, 'floating' in the sand and mud matrix.

The diamicton unit is interpreted as a series of sediment gravity flows. The proximal (near) facies are debris flows and melt-out till deposited within or near the ice front, whereas the distal (far) facies are believed to be turbidite sequences deposited in the deep water beyond the ice front. These turbidite sequences also contain abundant dropstones rafted in by icebergs. The proximal facies are found interbedded with the glaciofluvial sand and gravel (predominantly in the southern portion of the Birds Hill esker complex) and also cap some glaciofluvial sections, whereas the more distal facies are generally interbedded with lacustrine clays.

Figure 1: Graded bed, deposited by a turbidity current, with deep basinal clay interbeds and coarser ice-rafted detritus.

Figure 2: Injection structure, caused by loading of overlying massive diamicton.

GLACIOLACUSTRINE SEDIMENTS

Glaciolacustrine sediments are a result of deposition into proglacial Lake Agassiz. Deep basinal sediments are represented by map unit 3; shallower, nearshore sediments are represented by map unit 4; and, shoreline features are represented by map unit 5.

Deep Basinal Sediments

The Birds Hill esker complex is at the northeastern edge of a major Lake Agassiz sedimentation basin. Deep basinal sediments comprise clay, silt and lesser amounts of ice-rafted detritus. Teller (1976) separates these deep basinal sediments into three units. General characteristics of the sediments are: 1) an upward decrease in clay content (82% to 69% clay); 2) an upward decrease in ice-rafted detritus; and, 3) an upward increase in lamination of the upper two units (the lowest unit is unlaminated). These characteristics vary somewhat throughout the basin, depending largely on the proximity of the sediments to the glacial margin at the time of deposition.

Deep basinal sediment is restricted to elevations below 244 metres. It is generally less than 10 metres thick and increases in thickness away from the Birds Hill esker complex. Two exceptions are the depressions described above, which have acted as sediment traps and contain as much as 29 metres of silt and clay. The deep basinal sediment forms a very flat plain completely surrounding the Birds Hill deposit.

Deep basinal sediment found above 244 metres ASL is limited to laminations interbedded with the distal facies of the diamicton unit. It is commonly folded, a result of soft-sediment slumping on the lake bottom. Within this interbedded unit is a sand to pebbly sand layer, 3 to 50 centimetres thick. This sand layer is generally massive, however, at one location (Fig. 3) it is horizontally bedded and grades up into a pebble layer. This sand unit is uncharacteristic of the units which bound it suggesting a different origin, perhaps representing shallow water deposition during the low water phase of Lake Agassiz.

Iceberg scour marks and selenite rosettes are interesting features of the silt and clay unit. Iceberg scour marks, easily noticeable on airphotos (Fig. 4), are low, intersecting, curvilinear ridges. They are the result of the impingement of wind-driven icebergs on the soft sediment on the bottom of Lake Agassiz. The resulting groove was later infilled with silt. Following the drainage of Lake Agassiz, the differential compaction of the silt and surrounding clay, caused by dewatering of these lake bottom sediments, formed the ridge we see today (Nielsen and Matile, 1982).

Selenite rosettes were encountered in a backhoe pit within the smaller depression. They were found in sensitive dark grey clay which had numerous silt pockets. The rosettes were concentrated in horizontal bands at depths ranging from 2.7 to 5.7 metres (pit bottom) and increased in size downward. The largest rosette found was 7.6 centimetres in diameter. Selenite rosettes have been found throughout the Lake Agassiz basin.

Figure 3: Horizontally bedded sand unit, overlain and underlain by clay and diamicton interbeds.

Figure 4: Aerial view of iceberg scour marks. These curvilinear ridges were originally grooves on the floor of Lake Agassiz

Littoral Sand

Nearshore sediment (map unit 4) is predominantly fine sand. It forms a thin blanket around the Birds Hill esker complex and is commonly underlain by the silts and clays described above.

Shoreline Deposits

Shoreline features (map unit 5) have been divided into two morphologically distinct deposits: beach ridges (map units 5a and 5b) and spits (map units 5c and 5d). They have been further subdivided on the basis of material type for resource inventory purposes.

Beach ridges are 2-3 metres high in the Birds Hill area. They roughly parallel contour lines (see Strandline Map) defining the ancient water planes of Lake Agassiz. Beach sediments are typically horizontally bedded. Individual layers are well sorted, commonly in an alternating coarse-fine sequence. Gravel layers are usually in clast support with an open framework (Fig. 5).

Spits are gently rolling areas with accumulations of sediment up to 15 metres thick (Nielsen and Matile, 1982). They are the result of deposition by longshore currents, building out into Lake Agassiz. Paleocurrent directions attributed to these longshore currents have been plotted on the surficial map. They are composed of pebbly sand (map unit 5c) to sand (map unit 5d). Samples taken from map unit 5c have an average composition of 12 per cent gravel, 87 per cent sand and 1 per cent mud. In section, the spits comprise foreset beds with up to 2 metres of topset beds at the surface (Fig. 6). The topsets contain coarser material than the foresets and, in the case of map unit 5d, contain the majority of gravel-sized material. The lakeward side is commonly scarped as a result of the nature of deposition. The foresets are underlain by the clay and silt described above.

Figure 5: Beach bedding typical of map unit 5a.

Figure 6: Foreset and topset beds from map unit 5c, viewed from east. Paleocurrent direction: left side of photo - 150° SE; right side of photo - 120° SE.

GLACIAL HISTORY

The glacial history of the Birds Hill esker complex is outlined schematically by major depositional events. The deposits affected by each event are highlighted, and the currents responsible for deposition, whether glaciofluvial or lacustrine, are illustrated using directional arrows. The dates are derived from compilations of the glacial history in the literature (Surficial Geological Map of Manitoba, 1981, Clayton et al., 1982, Fenton et al., 1983, and Teller and Thorleifson, 1983).

The Birds Hill area was buried under several kilometres of glacial ice for most of the period between 20,000 and 12,000 years ago. This glacier, the Red River Lobe, reached its maximum extent in the northern United States about 14,000 years ago. During this period a dense carbonate-rich basal till was deposited throughout the region, named the Roseau Formation by Teller and Fenton (1980); drillholes have encountered this till underlying the Birds Hill esker complex.

Following this glacial advance, the Red River Lobe is believed to have retreated in a pulsating manner and deposited several basal tills which are not evident in the Birds Hill area. The first diagram depicts this retreat to the Birds Hill area. It indicates minor esker deposition several kilometres east of the main complex, possibly the inception of the ice-walled channel in which the main esker complex was deposited.

Diagram two depicts most of the deposition of the Birds Hill esker complex.

It is generally accepted that the Birds Hill esker complex was deposited at the ice front during the final recession of the Red River Lobe, at an early stage of Lake Agassiz (Upham, 1909; Organ, 1951; McPherson, 1970; and Ringrose, 1979). Ringrose (1979) and McPherson (1970) interpreted the overlying diamicton unit as flow or ablation till and assumed therefore that the deposit was not overridden. Boulton and Deynoux (1981) in their definition of till indicate that "sediment ceases to be 'flow till' . . . when . . . independent grain movement occurs". The diamicton unit then becomes a series of subaqueous sediment gravity flows. This is important to the reconstruction of the depositional environment during the formation of Birds Hill, because it decreases the effect of glaciogenic processes and increases the importance of the processes active at the bottom of Lake Agassiz.

The Birds Hill esker complex comprises two eastward oriented esker channels and a northward oriented ice-marginal channel. The esker channels are virtually free of sediment gravity flows, indicating a strong, confined meltwater current which had the ability to flush such sediments from the channel. The two depressions represent part of the ice margin which persisted until the end of glaciofluvial deposition. The eastward orientation of the esker channels indicates that the Birds Hill esker complex was deposited in a lateral position on the ice front of the retreating Red River Lobe, as defined by the ice-marginal channel.

Confinement of meltwater flow within the ice-marginal channel would only have occurred after the initiation of moraine development. Barnett and Holdsworth (1974) indicate that "sublacustrine moraine" development, depending on lake hydrology, would occur in water depths in excess of 30 - 40 metres, which is the case here.

Current literature, previously referenced, places the ice front of the Red River Lobe in the Birds Hill area at 11,000-12,000 years BP; during the Lockhart Phase of Lake Agassiz. If this is correct, the water level within Lake Agassiz would have been above the Campbell strandlines, or greater than 111 metres deep at Birds Hill.

An extension of this ice-marginal feature, north of Birds Hill Provincial Park, further defines the shape of the ice front at that time.

Subaqueous sediment gravity flow occurred repeatedly throughout the history of this ice-marginal channel and extensively near the ice front following glaciofluvial deposition. Deposition by sediment gravity flow continued, following ice retreat in the area, into the deep water of Lake Agassiz. This is indicated by the turbidite sequences, where the diamicton unit becomes intercalated with the lower part of the deep basinal silt and clay unit. The sand unit found within the intercalation of these two units may represent deposition during the low water phase of Lake Agassiz if, as Teller and Last (1983) suggest, the south basin of Lake Winnipeg experienced drying at that time.

Diagram three depicts shoreline formation during the latter stages of the final regression of Lake Agassiz, in the phase known as the Nipigon Phase, about 9,000 years ago. High wave energy at that time reduced many diamicton surfaces to boulder lags and redeposited the eroded material into beach ridges, bars and spits.

The strandline map, which relates to this period of deposition, depicts the five Lake Agassiz strandlines that are most prominent in the area. Strandline names are based on Teller and Thorleifson (1983).

Large foreset beds (Fig. 5) on the eastern slopes of the Birds Hill esker complex were originally interpreted as being deltaic foresets deposited as esker sediments entered Lake Agassiz. However, the stratigraphic position of this unit, underlain by distal turbidite sequences, suggests that they are prograding spits. These testify to the strong wave energy Birds Hill was subjected to during the final depositional event that left it essentially as it is today.

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Major subsurface information sources made available for the production of this map:

Released Yearly	Water Well Records, Water Resources Branch, Department of Natural Resources
February, 1961	Proposed Greater Winnipeg Floodway Soil Mechanics Investigations, Water Control and Conservation Branch (J. Mlishtak), Department of Agriculture and Conservation.
August, 1975	Environmental Impact Assessment and Redevelopment Study (31, 32-11-5E), The Lombard North Group Ltd. for McCurdy: A Division of Canfarge Ltd.
January, 1977	Gravel Reserve Evaluation - C.N. Gravel (34, 35-11-4E), The Underwood McLellan and Associates Group for Building Products and Concrete Supply.
September, 1977	Gravel Reserve Evaluation - Moose Nose Pit (30-11-5E), The Underwood McLellan and Associates Group for Building Products and Concrete Supply.
October, 1977	Gravel Reserve Evaluation - Transcona Pit (12-11-4E), The Underwood McLellan and Associates Group for Building Products and Concrete Supply.
April, 1980	Report on Subsurface Investigations of Aggregate Potential in N 1/2 6-12-5E, Interdisciplinary Engineering Company for the Rural Municipality of Springfield.

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DIAGRAMMATIC CROSS-SECTION A - A'

CROSS-SECTION SYMBOLS

Glaciolacustrine sand

Glaciolacustrine clay

Glaciofluvial sand

Glaciofluvial gravel

Diamicton (Includes basal till which generally underlies glaciofluvial sediments)

Bedrock

NE Paleocurrent direction (as indicated)

GB WW Data point on cross section; 'GB' numbers denote backhoe pits and 'WW' numbers denote drillholes, water well record or local consultant

Horizontal scale = 1:20 000

Vertical exaggeration = 42:1

DIAGRAMMATIC CROSS-SECTION B - B'

Manitoba Energy and Mines
Mines Branch