QUATERNARY GEOLOGY OF BLUEGOOSE PRAIRIE, BAFFIN ISLAND, NUNAVUT

by

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ABSTRACT

The surficial geology and glacial history of Bluegoose Prairie (NTS 36H/1-8) are described, and the first surficial geology map of the area is presented. Four phases of ice flow occurred in Bluegoose Prairie since the Last Glacial Maximum. Collapse of the Foxe Dome ca. 6.2 - 6.5 ^{14}C ka BP initiated deglaciation of Foxe Basin. Deglaciation of Bluegoose Prairie and subsequent isostatic rebound were rapid, as evidenced by a relative sea level curve constructed using marine mollusc ^{14}C ages. Diverse macrofossil assemblages show deglacial climate was as warmer or warmer than today. Contemporaneous pairs of terrestrial and marine macrofossils allow for the measurement of deglacial marine reservoir age for Bluegoose Prairie. This new value of 985 ± 10 ^{14}C years, 265 ^{14}C years older than previously thought, can be applied to deglacial marine ^{14}C ages in Foxe Basin and Hudson Strait. Application of this value allows more accurate palaeogeographic reconstructions.

Keywords:

Quaternary geology; surficial geology; Laurentide Ice Sheet; Foxe Basin; radiocarbon; marine reservoir age; palaeoenvironment; relative sea level; glacial history; marine limit

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Alice Telka of Paleotec Services prepared and documented all of the radiocarbon samples in immaculate fashion, and spent endless hours cataloguing the terrestrial macrofossil assemblages. I am grateful for your effort and your attention to detail. Celine Gilbert from the C-NGO was the cartographer for the map, thank you for your hard work. Able assistance in the field was provided by Michelle Trommelen, Sam Kelley, and Olivia Brown. Doug Hodgson and John Gosse provided invaluable advice, both in and out of the field.

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CHAPTER 1: INTRODUCTION

Introduction

The glacial history of Foxe Peninsula, southwest Baffin Island, is an important component of reconstructions for the northern Laurentide Ice Sheet. Foxe Peninsula was between Foxe Dome, the ice dispersal centre for the Baffin Sector, and the Hudson Strait Ice Stream. Bluegoose Prairie, the low relief northeast portion of Foxe Peninsula and the site of this study, lies on the southeast coast of Foxe Basin, an area with a paucity of dates to constrain deglaciation.

This thesis is the result of work done as part of the Southwest Baffin Integrated Geoscience (SWBIG) Project, a large-scale joint geological mapping venture between the Geological Survey of Canada and the Canada-Nunavut Geoscience Office. The SWBIG project studied the geology of Foxe Peninsula, southwest Baffin Island. The surficial geology component of the SWBIG project covers six 1:250 000 map areas, one of which is the south half of Bluegoose River (NTS 36H), the site for this project. Bluegoose River (South) is referred to as Bluegoose Prairie throughout this thesis, to differentiate it from Bluegoose River, the entirety of NTS 36H.

The timing of ice flow and deglaciation in Bluegoose Prairie has important implications for interpreting glacier dynamics in other parts of the ice sheet. Bluegoose Prairie contained some of the last remnants of the Laurentide Ice Sheet. Despite the significance of its location, its glacial history has not been studied in detail, and no surficial geology maps have been published for the area. This thesis presents data and interpretations on the Quaternary geology and glacial history of Bluegoose Prairie that answer questions relating to the distribution of surficial materials, the ice flow history, the age of deglaciation, relative sea level history and the environments during deglaciation.

Methods

Specific methods for each component of this study are explained in detail in the following chapters. Described here is an overview of the two seasons of fieldwork. The first field season took place in the summer of 2006. The SWBIG project was based out of two base camps: Mingo Lake in July and Tellik Bay in August (Fig 1.1). Fieldwork in Bluegoose Prairie occurred in July using helicopter transport to travel from Mingo Lake each day. Sixteen traverses were conducted in Bluegoose Prairie in July 2006, and observations at 175 stations were recorded. One additional field day in August was spent in Bluegoose Prairie, from the Tellik Bay base camp, to study in more detail sites noted to be of particular interest. The purpose of the first field season was to gain as much coverage of the area as possible, while ground-truthing surficial material types and gathering marine molluscs for radiocarbon dating.

The second field season occurred in late June and early July of 2007. My thesis supervisor and I spent two weeks conducting traverses by all terrain vehicle, spending one week based out of each of two camps (Fig 1.2). We conducted a more detailed study of a smaller geographic area than during the previous season. Ten traverses were conducted, and observations at 32 stations were recorded. The purpose of the second field season was to find stratigraphic sections that contained additional marine and terrestrial organics.

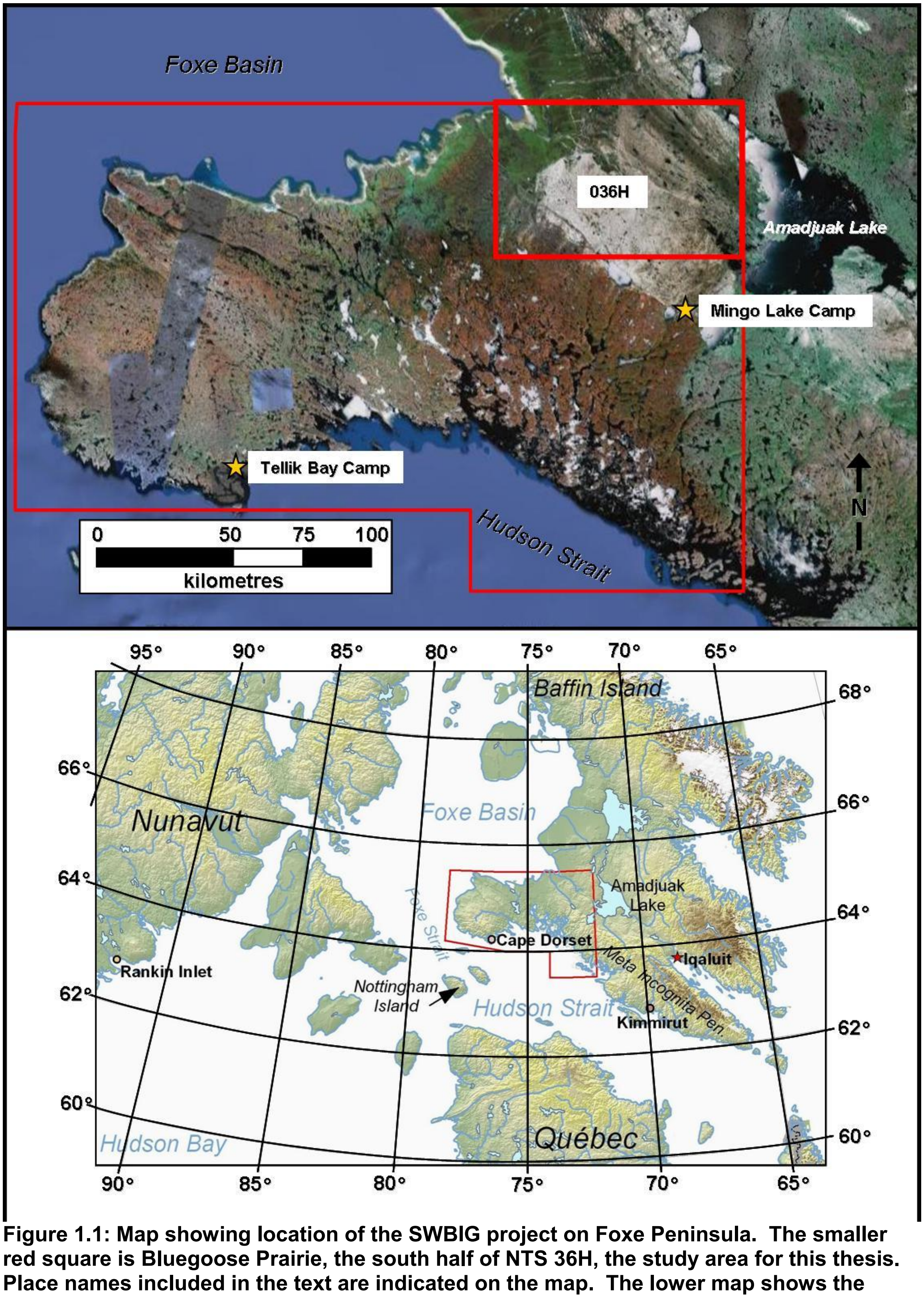


Figure 1.1: Map showing location of the SWBIG project on Foxe Peninsula. The smaller red square is Bluegoose Prairie, the south half of NTS 36H, the study area for this thesis. Place names included in the text are indicated on the map. The lower map shows the location of Foxe Peninsula, on southwest Baffin Island, in regional context (from Utting et al. 2007). Upper map is from Google Earth.

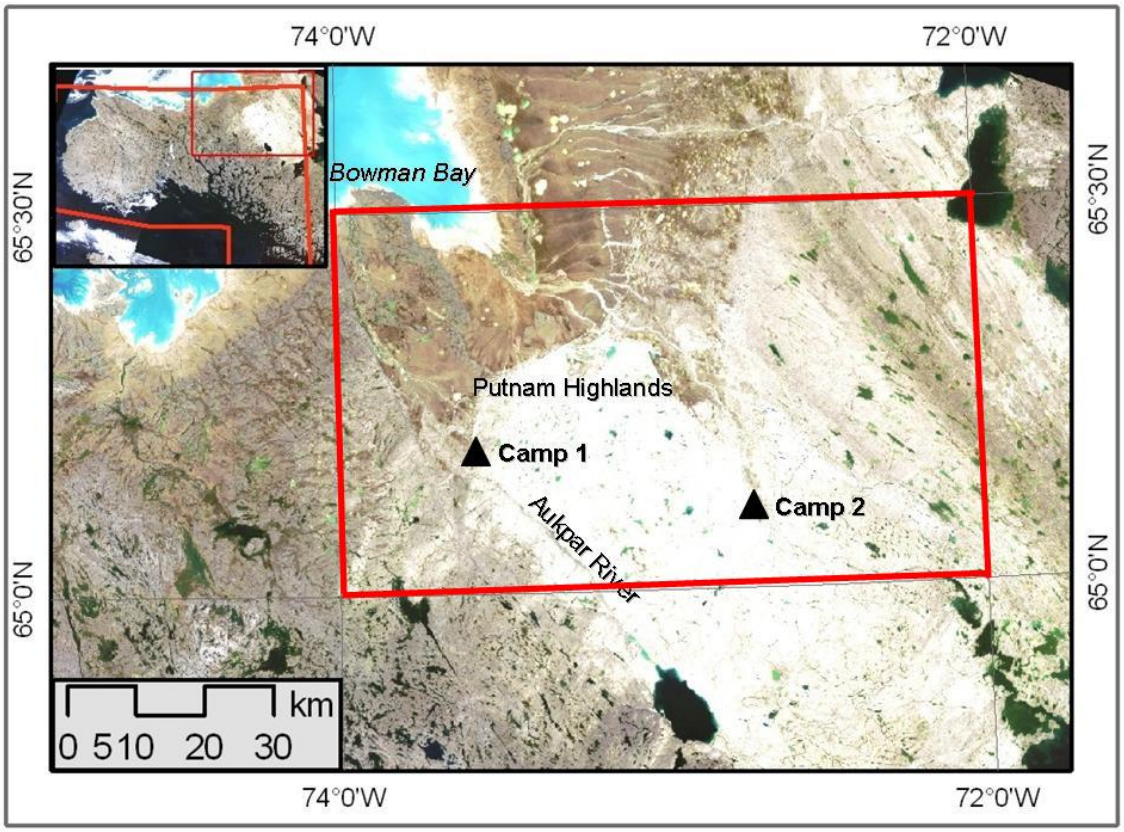


Figure 1.2: A Landsat 7 satellite image of Bluegoose Prairie, showing the locations of the two base camps used in the 2007 field season, and place names given in the text. Inset map shows the location of Bluegoose Prairie relative to the SWBIG project area (modified from Utting et al. 2007).

Physiography and Climate

The Bluegoose Prairie region is located in the northeast corner of Foxe Peninsula on Baffin Island, Nunavut, Canada (Fig 1.1). The study site is the south half of map sheet NTS 36H, Bluegoose River (Fig 1.2). The area is characterized by low relief and is part of the Foxe Basin lowlands (Bird 1967). The northwest corner of the map area is the modern coastline of Foxe Basin. Hudson Strait lies south of Foxe Peninsula (Fig 1.1). The closest community is Cape Dorset, which is on the southwest tip of Foxe Peninsula, west of the study area; Iqaluit and Kimmirut are southeast of the field area (Fig 1.1). Rivers in the area, the largest of which is the Aukpar River, drain northwest into Bowman Bay, Foxe Basin (Fig 1.2). Low-lying areas close to the coast are saturated, making summer travel difficult. The only notable topographic feature is a long limestone scarp, the edge of the Putnam Highlands, which has a relief of up to120 m and marks the boundary of the coastal flats. Raised beaches composed of coarse limestone gravel are common in the low-lying coastal areas.

Bluegoose Prairie is part of the low arctic bioclimatic zone (Jacobs et al. 1997). The closest modern climate data is available from a weather station at the southeast corner of Amadjuak Lake, ~110 km southeast of Bluegoose Prairie (Jacobs et al. 1997), and from weather stations at Iqaluit, NU and Cape Dorset, NU. The region experience cold winters, with a February mean temperature of -27 °C, and mild summers, with a July mean temperature of 7 °C. Mean annual precipitation is 400mm, over half of which falls as snow. More detail on the local climate is provided in Chapter 4.

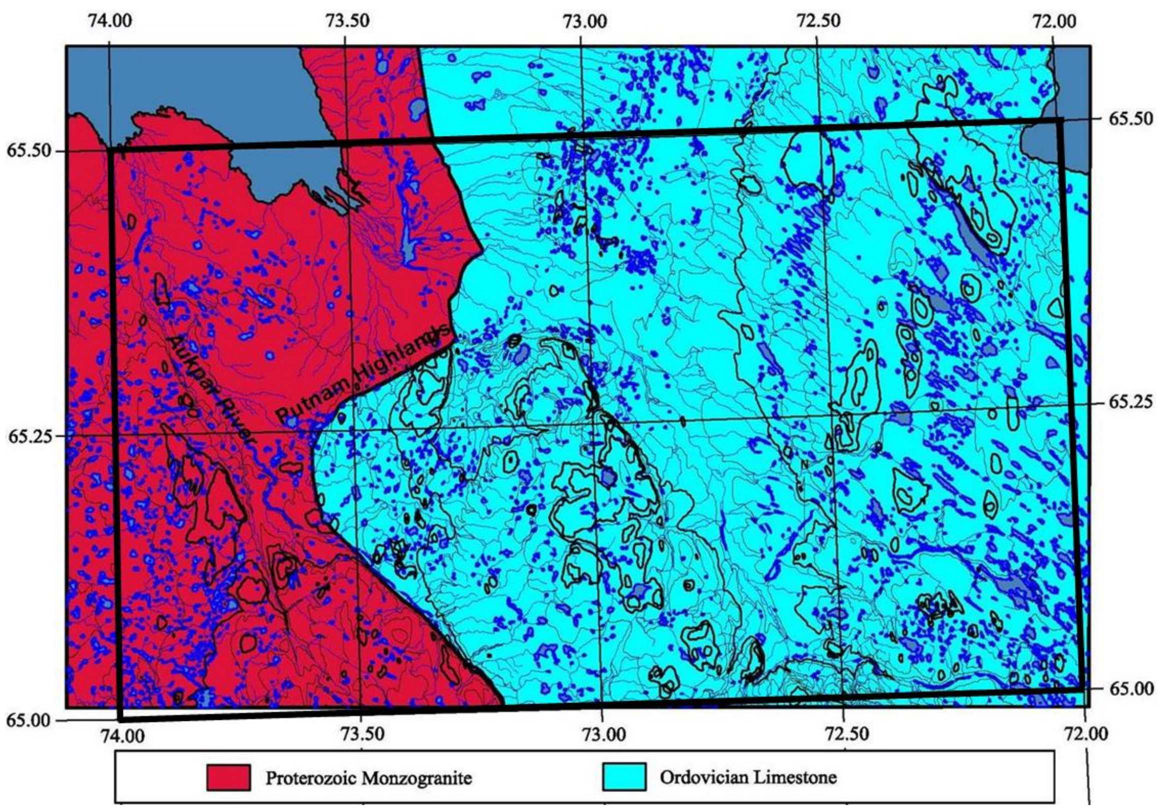


Figure 1.3: General bedrock map showing distribution of Proterozoic monzogranite and Ordovician limestone bedrock (modified from St-Onge et al. 2007). Erosional remnants of limestone described in text are too small to be seen at map scale.

Bedrock Geology

Bluegoose Prairie is within the Canadian Shield. The bedrock of the area can be divided into two general types (Fig 1.3): Ordovician limestone and Proterozoic monzogranite (St-Onge et al. 2007). Most of the area is underlain by fossiliferous Ordovician limestone, a continuation of rocks flooring Foxe Basin (Wheeler et al. 1996). The west side of the map area is primarily Proterozoic granitic rocks of the Churchill Province (St-Onge et al. 2007) and the contact between the two rock types is commonly a normal fault, which runs parallel to the Aukpar River and then curves eastward as the north-facing scarp of the Putnam Highlands (St-Onge et al. 2007). Isolated erosional remnants of limestone bedrock persist in the southwest corner of the map area, overlying granite. These limestone relicts are evidence that the limestone cover used to be more extensive and has subsequently been eroded.

Previous Work

Regional Glacial History

The Baffin Sector of the Laurentide Ice Sheet covered Bluegoose Prairie at its maximum ice extent during the local last glacial maximum (LLGM), ca. 26.5 to 19 ka cal bp (22 to 16 ka ^{14}C BP)(Clark et al. 2009). This is time period is very similar to the global last glacial maximum (LGM) from 26.5 to 18 ka cal bp (22 to 15 ka ^{14}C BP), as measured by global sea level lowstand. During the LLGM, Foxe Dome was the main centre of ice dispersal for the Baffin Sector, and several ice divides radiated from this dome (Dyke and Prest 1987; Fig 1.4a). The main Foxe Ice Divide ran north-south down the centre of Foxe Basin, separating eastward flow across Baffin Island from westward flow across Melville Peninsula. This ice divide lay west of the study area. Amadjuak Ice Divide radiated southeast from the Foxe Dome, lying northwest of the study area. This ice divide separated ice flowing into Cumberland Sound, off the east coast of Baffin Island, from ice flowing into Hudson Strait, the body of water between Baffin Island and Ungava Peninsula. Abundant evidence supports the presence of a large ice stream in Hudson Strait, funnelling ice down the strait from west to east (Laymon 1992). Reconstructions of the Laurentide Ice Sheet show that during LLGM, ice on eastern Foxe Peninsula flowed southwest away from Amadjuak Ice Divide, and then funnelled south into the Hudson Strait Ice Stream (Dyke and Prest 1987).

Deglaciation of Hudson Strait began ca. 9.0 ^{14}C ka BP (Dyke et al. 2003b), causing the shutdown of the Hudson Strait ice stream (Dyke and Prest 1987). Incursion of the sea into Hudson Bay occurred ca. 7.8 ^{14}C ka BP (Dyke et al. 2003b). This allowed the drainage of Glacial Lake Agassiz by 7.7 ^{14}C ka BP, resulting in the 8.2 cal ka bp cooling event (Clarke et al. 2004). The southwest tip of Foxe Peninsula deglaciated ca. 7.3-7.5 ^{14}C ka BP (Dyke et al. 2003b; Fig 1.4b). Marine limit on southwest Foxe Peninsula is ~170 m above modern sea level (asl), declining to the east (Dyke and Prest 1987). Ice persisted in Foxe Basin after deglaciation of Hudson Bay due to its grounded core and the high ground along 80% of its perimeter, protecting it from marine incursion (Dyke and Prest 1987). Eventually, ice calving along the southern margin of Foxe Basin caused drawdown of Foxe Dome, resulting in its collapse between 7.0 to 6.5 ^{14}C ka BP (Dyke et al. 2003b). Collapse of Foxe Dome caused the major ice divide to shift east onto Baffin Island, resulting in west to northwest flow across the study area (Dyke and Prest 1987, Fig 1.4c). The collapse of Foxe Dome allowed marine incursion of Foxe Basin flooding low-lying central Foxe Peninsula. Groundfast ice on southwest Baffin Island retreated steadily, with some of the final remnants lingering near Amadjuak Lake before melting away.

Dyke (2004) states that in North America, “the ages of deglaciation are now reasonably well established in most coastal areas, the west coast of Hudson Bay and eastern Foxe Basin being exceptions”. Bluegoose Prairie lies on the southeast coast of Foxe Basin and ages from this thesis will be a significant contribution to determining the age of deglaciation in this relatively unstudied area.

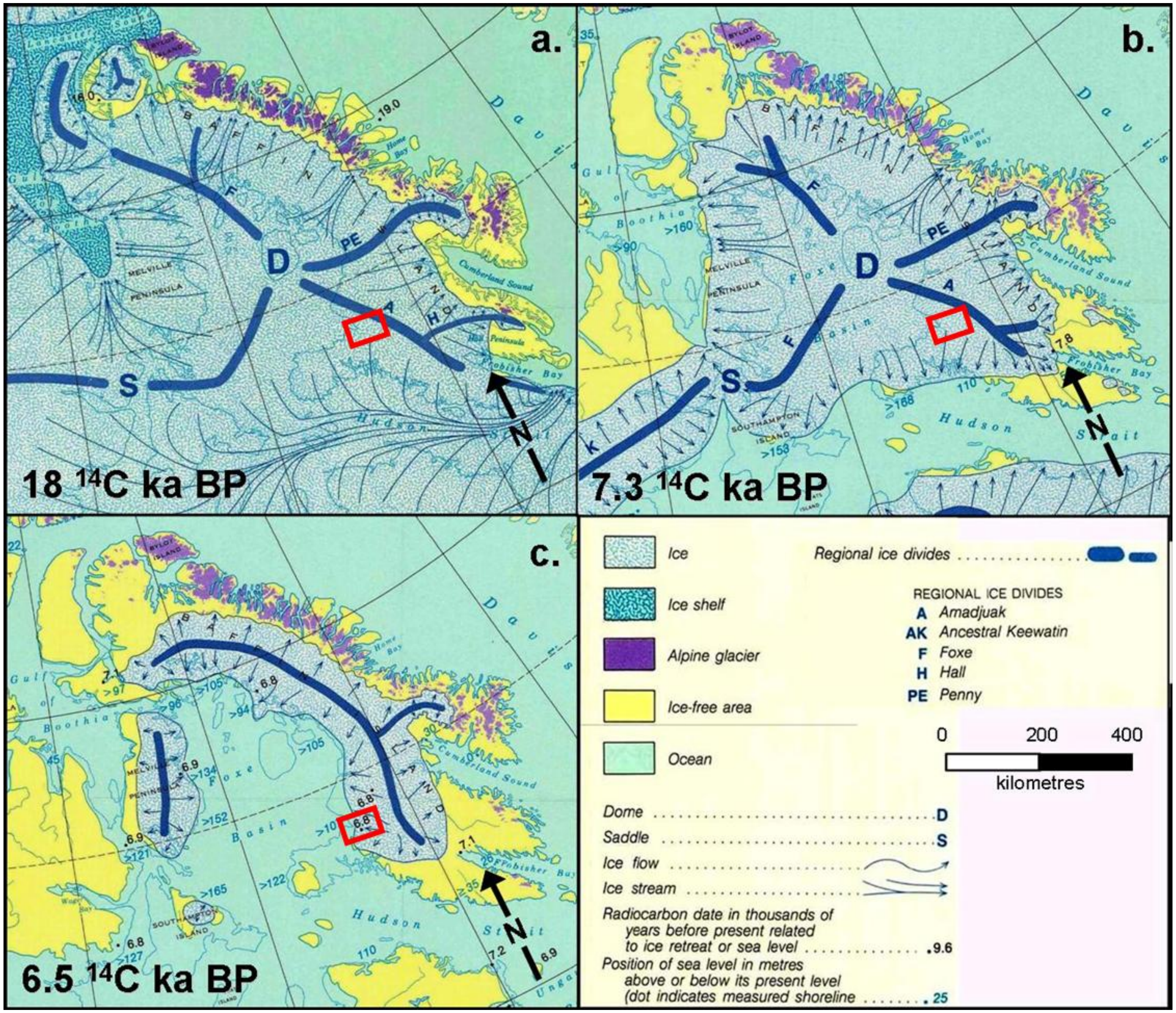


Figure 1.4: Reconstruction of the Baffin Sector of the Laurentide Ice Sheet, showing major ice dispersal centers and ice flow patterns. a) At 18 ^{14}C ka, Foxe Dome is centered directly over Foxe Basin, with Foxe Ice Divide extending south, and Amadjuak Ice Divide extending southeast. The Hudson Strait Ice Stream is visible south of Baffin Island. b) By 7.3 ^{14}C ka BP, Hudson Strait and Hudson Bay have deglaciated, as has the southwest tip of Foxe Peninsula. Ice over Foxe Basin still maintains near-maximum configuration. c) By 6.5 ^{14}C ka BP, Foxe Dome collapses and the ice divide migrates over Baffin Island, shifting ice flow. Central Foxe Peninsula is submerged below high sea levels. (Figure adapted from Dyke and Prest 1987, dates from Dyke 2003b which has slightly different ice margins.)

Quaternary Geology of Bluegoose Prairie

Prior to this study, no detailed fieldwork had been done to study the Quaternary geology of Bluegoose Prairie, and no surficial geology map of the area had been published. Surficial geology maps have been published for nearby areas, and the glacial history of adjoining Meta Incognita Peninsula is known in more detail (Hodgson 2005).

Gould (1928) performed a brief survey of the coastal area, and named Bluegoose Prairie and Putnam Highlands. Blake (1966) conducted some reconnaissance fieldwork and obtained the only previous radiocarbon samples on Putnam Highland. Two bulk marine mollusc samples from within 9 m of marine limit (~107m asl) produced ages of 6830 ± 150 ^{14}C yrs BP (GSC 465) and 6590 ± 140 ^{14}C yrs BP (GSC 553), providing minimum ages for deglaciation of southeast Foxe Basin. A bulk organic sample from the bottom of a bog on a small island in southeast Amadjuak Lake dates to 4460 ± 140 ^{14}C yrs BP (Blake 1966), providing a minimum age for deglaciation for the last remnant of Laurentide ice to melt from southwest Baffin Island. The accuracy of these three ^{14}C ages is uncertain. The exact nature of the material dated from the bog bottom sample is unknown, and contamination and potential hard water effects are difficult to quantify. The species of molluscs included in the two bulk marine samples is also unknown, so there is a possibility of bottom feeding species, e.g., *Portlandia arctica*, being included, which could result in an age that is too old.

Blake produced an unpublished map of prominent landforms in the area from aerial photographs. He interpreted westward ice flow west of Putnam Highland from tails of till extending west from limestone outliers and highly smoothed and plucked Precambrian outcrops. He also noted an absence of limestone erratics on the east side of Amadjuak Lake, suggesting no eastward ice flow across the lake had occurred.

Two surficial geology papers have been produced from the SWBIG project so far. Utting et al. (2007) describe five phases of ice flow for Foxe Peninsula, including a brief discussion of glaciation in Bluegoose Prairie. A till geochemistry study (Utting and Brown 2007) identifies two types of till, which can be distinguished based on geochemical composition of the silt and clay fraction. Limestone derived till has high calcium and relatively low iron, magnesium, and sodium content. Proterozoic bedrock derived till has high iron and relatively low calcium content. Light coloured till plumes in the west side of Bluegoose Prairie that are visible on satellite images are also identified in field observations of erratics, and on plots of calcium and iron from till geochemistry. The length of these till plumes indicates glacial transport of materials up to 20 km to the southwest from Ordovician bedrock. Chapter 2 discusses in further detail the pattern of ice flow and descriptions of the two distinct till units.

Scope and Purpose of Study

This project was undertaken to examine the glacial history of an area that until now was relatively unstudied. This thesis presents results from the first detailed fieldwork conducted in Bluegoose Prairie, and addresses the following questions:

1. What is the distribution of surficial materials in Bluegoose Prairie?

A surficial geology map for the south half of NTS 36H has been produced and is included in the rear pocket. A digital copy of this map is also included in the CD of appendices. A description and interpretation of the map is provided in Chapter 2.

2. What were the patterns of glaciation and deglaciation in Bluegoose Prairie?

Chapter 2 also describes changes in ice flow patterns and ice margins in Bluegoose Prairie from LLGM to deglaciation.

3. When did deglaciation of Foxe Basin and Bluegoose Prairie occur, and what was the environment associated with deglaciation?

Radiocarbon ages are presented in Chapter 3 that provide timing of deglaciation. Chapter 3 also includes a relative sea level curve and a reconstruction of palaeoenvironment immediately following deglaciation.

4. What was regional reservoir age for Foxe Basin during deglaciation?

Chapter 4 presents a new deglacial reservoir age for Foxe Basin, as well as a reinterpretation of regional glacial history, including the 8.2 cal ka bp event, based on this new reservoir age.

The results of work conducted in Bluegoose Prairie will be useful to numerous stakeholders. The surficial geology map has been published as a Geological Survey of Canada Open File, and is publicly available for use by local Inuit prospectors, mineral exploration companies, Quaternary geologists, and other scientists. Interpretation of the glacial history will be significant for reconstruction of the geometry, ice flow, and deglaciation of the Baffin Sector of the Laurentide Ice Sheet. Radiocarbon measurements on marine and terrestrial material from Bluegoose Prairie provide the first deglacial reservoir ages for Foxe Basin and potentially impact the reconstruction of glacial chronology in the region.

CHAPTER 2: RESERVOIR AGE[1]

Introduction

Radiocarbon (^{14}C) concentrations differ between the atmosphere and the ocean. Carbon has a longer residence time in oceans than in the atmosphere, allowing more time for ^{14}C to decay before the carbon is ingested by living organisms. Thus, ocean-dwelling organisms, such as molluscs, which incorporate marine bicarbonate into their shells, have lower ^{14}C concentrations than concurrently growing terrestrial organisms. This "reservoir effect" imparts anomalously old ^{14}C ages to marine organisms compared to terrestrial organisms that lived at the same time. The difference between the ^{14}C ages of a marine organism and a contemporaneous terrestrial organism is known as marine reservoir age. Modern[2] mean global marine reservoir age is ~400 ^{14}C years; it is known that this value has changed over time (Stuiver and Braziunas 1993).

Regional reservoir age differences occur in ocean basins due to ocean current regime, ocean-atmosphere exchange, and oceanic mixing processes. The difference between regional reservoir age and the model global marine reservoir age is defined as ΔR (Stuiver and Braziunas 1993). Spatial and temporal comparisons are often made using ΔR values instead of reservoir ages, and ΔR values are used to calibrate marine ^{14}C ages to calendar years (Stuiver et al. 2005). Studies using marine ^{14}C ages often make the assumption that ΔR has remained constant over time, and therefore apply modern ΔR values to older material. Modern regional reservoir ages have been measured by ^{14}C dating molluscs of known age that were collected live before 1955, prior to atmospheric nuclear bomb testing that artificially elevated global ^{14}C levels (e.g., Mangerud and Gulliksen 1975; Ingram and Southon 1996; McNeely et al. 2006). Measuring

[1] A version of this chapter has been published as a paper (Vickers et al. 2010).

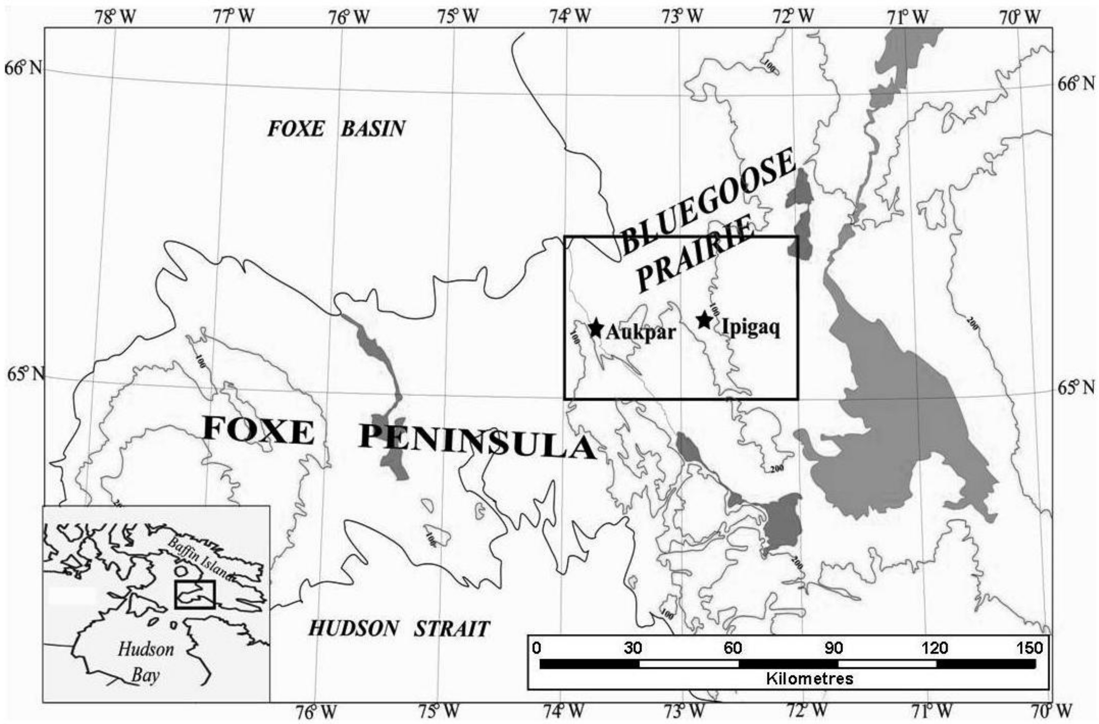
[2] In this chapter, the term "modern" refers to reservoir age measured on known-age molluscs that lived before 1955, prior to nuclear bomb testing.

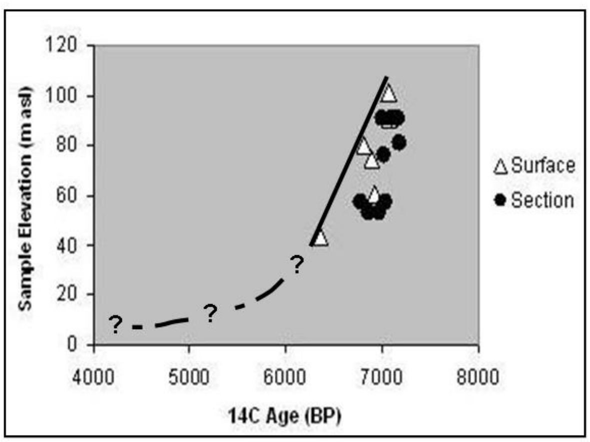
past reservoir age is more difficult. Such studies have been done using a variety of methods, including the comparison of marine mollusc ^{14}C ages to known-age tephras (e.g., Bondevik et al. 2001; Eiriksson et al. 2004) and the construction of correlations between climatic events in marine cores and terrestrial records (e.g., Bjorck et al. 2003). Perhaps the most direct method is to compare ^{14}C ages of marine and terrestrial macrofossils that were deposited contemporaneously in the same stratigraphic unit (e.g., Bard et al. 1994; Kovanen and Easterbrook 2002; Southon and Fedje 2003).

In this chapter, we calculate marine reservoir age for the Foxe Basin during deglaciation of the Laurentide Ice Sheet using paired samples of marine molluscs (*Mya truncata* and *Hiatella arctica*) and willow (*Salix* sp.). We compare these values to modern values, and discuss the implications of this work to palaeogeographic reconstructions. In order to maintain consistency with other sources, we use both reservoir age and ΔR in these comparisons. As this chapter is published as a journal paper, there will be some repetition of methods and results included in other chapters.

Study Area and Context

The Foxe Peninsula branches off the southeast corner of Baffin Island, Nunavut, and separates Foxe Basin from Hudson Strait (Fig 2.1). Marine limit varies from less than 100 m asl in Bluegoose Prairie to almost 200 m asl along the southwest coastline of the peninsula. During the last glaciation, Foxe Peninsula was covered by ice from the Foxe Dome of the Laurentide Ice Sheet. Deglaciation of Foxe Basin and Hudson Strait is marked by ice contact marine deposits, and postglacial emergence of Foxe Peninsula is recorded in flights of raised beaches (Utting et al. 2007). Radiocarbon dating of marine molluscs found in these raised marine deposits is the method most widely used to date deglacial events in the Arctic, where there is commonly a paucity of dateable terrestrial organic material.





UCIAMS #	Elevation (m. asl)	Location	^{14}C Age (^{14}C yr BP)	Error (+/-)
33279	101	Surface	7070	20
33280	91	Surface	7065	20
33282	81	Section	7185	20
33281	80	Surface	6810	25
40424	76	Section	7020	20
40421	75	Section	6895	20
33283	73	Section	7155	25
48456	73	Section	7005	20
71228	73	Section	7090	15
33278	61	Surface	6925	20
40422	57	Section	6770	20
40423	57	Section	7025	20
40418	53	Section	6975	20
40419	53	Section	6855	25
48247	43	Surface	6350	20

Figure 2.1: Study area location, showing the two stratigraphic locations described in the text and in Fig 2.2. The 100 m contour line approximates marine limit for Bluegoose Prairie. The relative sea level curve is constructed from conventional ^{14}C ages on molluscs collected in Bluegoose Prairie.

Methods

Paired marine bivalves and terrestrial macrofossils were collected in two sections in stream cuts with surfaces ~15 m below marine limit (Fig 2.1). Pairs were collected where careful site inspection revealed no evidence of slumping or other disturbance; bedding was sub-horizontal and continuous. Samples for ^{14}C dating were selected based on strict criteria to ensure that minimal reworking had occurred. Individual molluscs were selected with intact periostracum and articulated valves. Sediment infilling the shells was the same colour and texture as the surrounding material. *M. truncata* and *H. arctica* were chosen for dating because they are suspension feeders and therefore limit the risk of incorporation of old carbon from the substrate. Terrestrial macrofossils were selected from bulk samples collected from the same unit as the molluscs, or in one case the overlying unit. The delicate nature of the *Salix* leaves, twigs, and seed catkin selected for dating indicates short transport distance from the shore, and eliminates the chance of "old" heartwood being dated. The abundance of terrestrial material and quality of preservation makes it unlikely to be reworked from older sediments.

Mollusc identification was done using Dyke et al. (1996) and consultation with R. Hetherington (personal communication, 2008). The shells were cleaned and ground down to the inner nacre. Portions of the hinge segment of each shell were selected for AMS dating. Bulk organic samples were sieved using a 0.425 mm screen and examined under a microscope to isolate macrofossils. Identification of terrestrial macrofossils was done using taxonomic keys and illustrations from Martin and Barkley (1961) and Porsild and Cody (1980).

Prepared samples were sent to W. M. Keck Carbon Cycle Accelerator Mass Spectrometry Laboratory at University of California, Irvine (Southon et al. 2004) for AMS dating. Radiocarbon ages are reported using the conventions of Stuiver and Polach (1977).

Calibration of ^{14}C ages was done using the CALIB Radiocarbon Calibration Program, version 6.0 (Stuiver et al. 2005; accessed 15/01/2010).

Regional reservoir age was calculated according to procedure outlined by Stuiver and Braziunas (1993), using the Marine04 (Hughen et al. 2004) and IntCal04 (Reimer et al. 2004) calibration curves.

Results

Section Descriptions

Marine limit in Bluegoose Prairie ranges from 90 to 120 m asl, based on the elevation of the highest raised beaches or highest marine sediments, measured using GPS and digital altimeter. Postglacial uplift was rapid, as shown by the sharp initial drop in relative sea level (Fig 2.1). The tops of both sections are ~15 m below marine limit, and therefore were likely deposited 100 to 200 years after deglaciation of southeastern Foxe Basin and the northern shore of Foxe Peninsula, based on the relative sea level curve for Bluegoose Prairie (Fig 2.1).

Aukpar section is on the east side of the Aukpar River and the top is 81 ± 5 m asl (Fig 2.1). Marine limit in this area is 95 ± 5 m asl. The section consists of four units (Fig 2.2) and is 7.5 m high. Unit One is fissile clayey silt that includes dropstones and some organics. Mollusc genera found in the unit include *H. arctica, M. truncata,* and *Clinocardium ciliatum*. Unit Two is horizontally stratified sand and silt, including dark beds of organics. Dipping beds of sand make up Unit Three. The final unit consists of massive gravel that unconformably overlies the rest of the section.

The Aukpar section is interpreted as a delta. Unit One is offshore marine sediment that contains both ice-rafted dropstones and terrestrial material from a nearby shoreline. Unit Two comprises bottom sets, overlain by the foreset beds of Unit Three, and the gravel topsets of Unit Four.

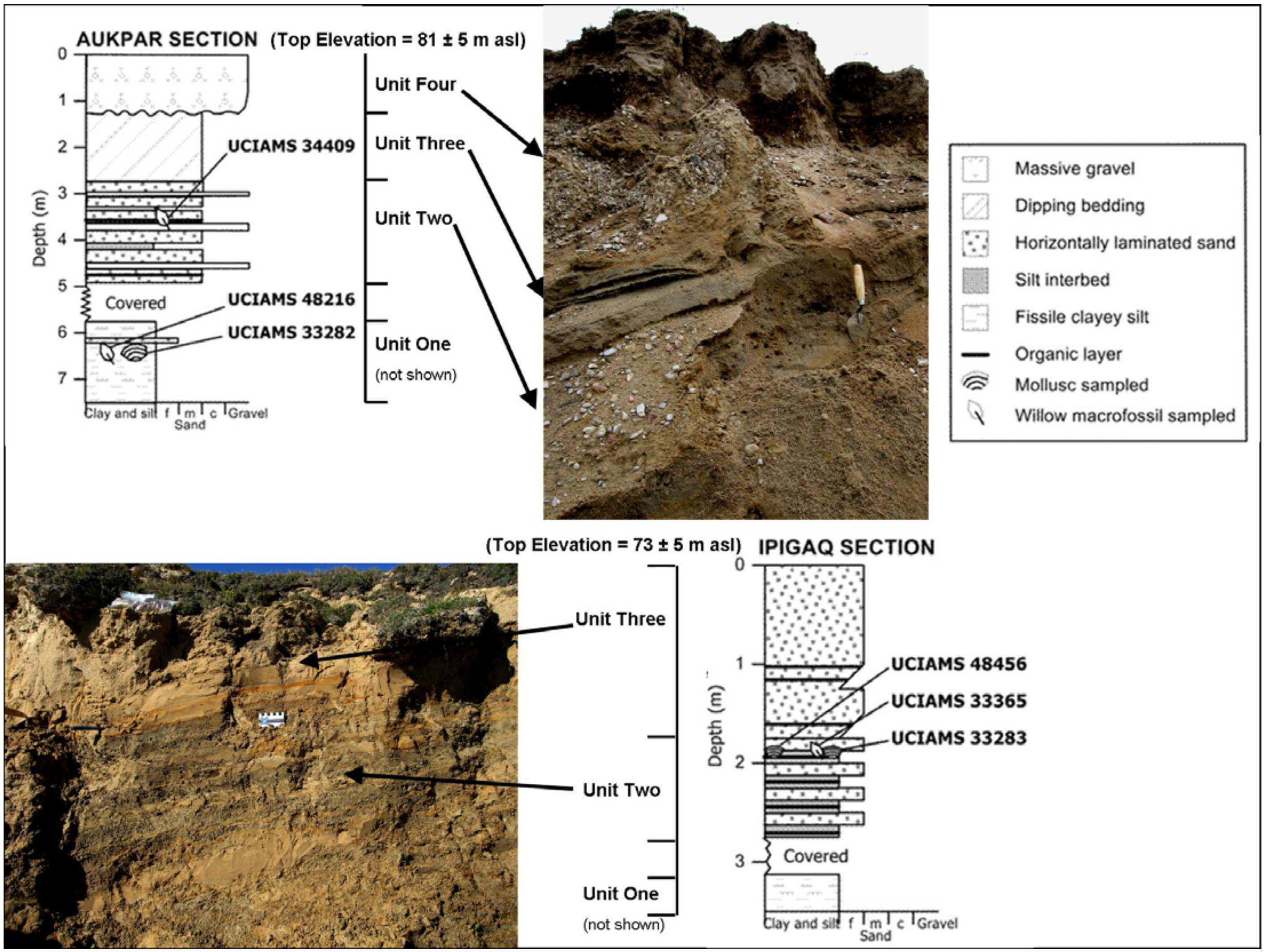


Figure 2.2: Stratigraphic logs and photos for the two sections described in the text, showing major units and locations of samples taken for ^{14}C dating.

Ipigaq is an exposure on a stream east of Aukpar (Fig 2.1). Marine limit in the area is 90 ± 5 m asl. The section is 3.7 m high and the top is 73 ± 5 m asl. It consists of three units (Fig 2.2). Unit One is 1.5 m of fissile clayey silt. Unit Two is a shell-rich, terrestrial organic-bearing package of horizontally bedded sand. Mollusc genera include *Hiatella* and *Mya*. The top unit consists of well sorted, laminated sand. Ipigaq is interpreted as a regressional sequence of marine sediments. The clayey material of Unit One was deposited farthest off shore, and Units Two and Three were deposited as relative sea level dropped.

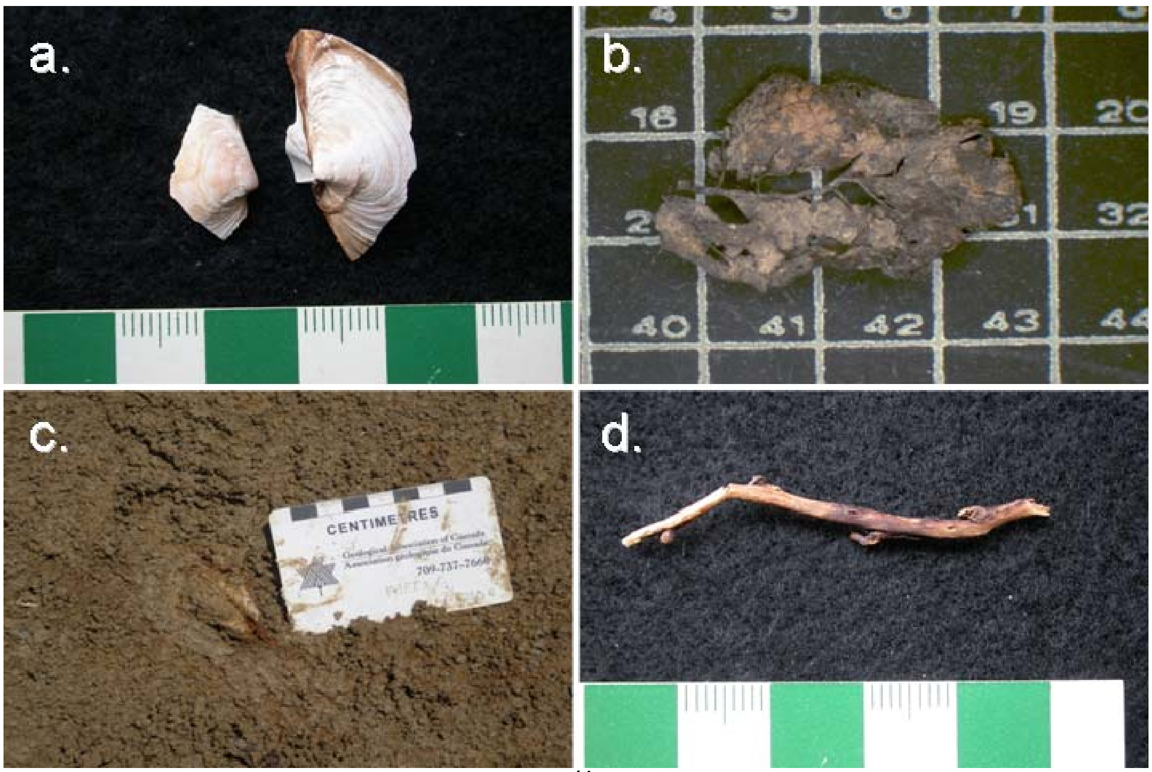


Figure 2.3: Photographs of samples used for ^{14}C dating. a) The hinge of a *Mya* shell (UCIAMS 33282) from Aukpar, showing traces of periostracum. The shell was fractured as part of preparation for AMS dating. b) A *Salix* (willow) leaf (UCIAMS 48216) from Aukpar. For scale, background lines are 4 mm x 4 mm. c) An articulated *Mya* shell (UCIAMS 33283) found *in situ* in Ipigaq, before removal. d) A *Salix* (willow) twig (UCIAMS 33365) from Ipigaq.

Samples were dated from each of these two sections (Fig 2.2; Fig 2.3; Table 2.1). An individual bivalve (UCIAMS 33282) was collected from Unit One at Aukpar. Two bulk organic samples were collected, one from Unit One and one from Unit Two. Two *Salix* leaves (UCIAMS 48216) were dated from the Unit One bulk sample. One *Salix* leaf (UCIAMS 34409) was dated from Unit Two. ^{14}C ages of UCIAMS 48216 and UCIAMS 34409 are equal within error, indicating rapid deposition. We therefore consider UCIAMS 34409 suitable for measuring reservoir age.All samples from Ipigaq were collected in Unit Two. A mollusc (UCIAMS 33283) and *Salix* twig (UCIAMS 33365) were found within 1 cm of each other. A second mollusc (UCIAMS 48456) was collected from the same stratigraphic level. Two molluscs (UCIAMS 71228 and 71229) and a *Salix* seed catkin (UCIAMS 71218) were selected from a bulk sample from the same unit.

Radiocarbon Ages and Reservoir Calculations

Sample ages (Table 2.1) are thought to closely correspond to deposition age of the units. Sample UCIAMS 71229 is significantly older than the other molluscs in Ipigaq section, nine standard deviations (σ) away from the next oldest shell, and pre-dates the age of regional deglaciation, therefore it has not been used to calculate reservoir age. This anomalously old age is likely due to contamination of the shell by older carbon. Sample UCIAMS 48456 is younger than other mollusc samples from Ipigaq, but is within three σ, so is included in the calculations. All other mollusc samples are concordant within one to two σ. Terrestrial samples UCIAMS 33365 and UCIAMS 71218 from Ipigaq differ by 130 ^{14}C years, which is within 3σ. The fact that deglaciation only occurred 100-200 years earlier (Fig 2.1) reduces the effect of reworking of older material on the calculation of deglacial reservoir age.

Deglacial reservoir ages are calculated as the difference between ^{14}C age of each marine sample and ^{14}C age of each terrestrial sample within the same section (Table 2.2). Eight reservoir ages range from 845 ± 30 to 1125 ± 30 ^{14}C years, giving a mean reservoir age of 985 ± 10 ^{14}C years. This value is a measure of maximum reservoir age, as there is a possibility the marine material has been reworked. We use this value for further calculations in this paper.

Table 2.1: Samples used to measure deglacial marine reservoir age for Foxe Basin.

UCIAMS#	Section	Lat	Long	Elev[1] (m.asl)	Type	Species	$\delta^{13}C$[2] (‰vPDB)	^{14}C Age[3] (BP)	R-Corrected[4] ^{14}C Age (BP)
33282	Aukpar	65.148	73.703	81	Marine	*Mya truncata*	0.9	7185 ± 20	6200 ± 20
34409	Aukpar	65.148	73.708	81	Terrestrial	*Salix* sp. (leaf)	-27.3	6190 ± 20	n/a
48216	Aukpar	65.148	73.308	81	Terrestrial	*Salix* sp. (leaf)	-26.0	6165 ± 20	n/a
33283	Ipigaq	65.207	72.725	73	Marine	*Mya truncata*	2.5	7155 ± 25	6170 ± 25
48456	Ipigaq	65.207	72.725	73	Marine	*Mya truncata*	1.9	7005 ± 20	6020 ± 20
33365	Ipigaq	65.207	72.725	73	Terrestrial	*Salix* sp. (twig)	-27.0	6160 ± 20	n/a
71218	Ipigaq	65.207	72.725	73	Terrestrial	*Salix* sp. (catkin)	Unrecorded*	6030 ± 25	n/a
71228	Ipigaq	65.207	72.725	73	Marine	*Hiatella arctica*	0.3	7090 ± 15	6105 ± 20
71229	Ipigaq	65.207	72.725	73	Marine	*Mya truncata*	1.3	7540 ± 20	6555 ± 20

[1]Elevation in metres above modern sea level, error is ± 5 m. Measured using GPS.

[2]Reported according to standards outlined by Stuiver and Polach (1977).

[3]Conventional ^{14}C age, as defined by Stuiver and Polach (1977). Error is reported as 1 σ.

[4]Reservoir-corrected ^{14}C age = marine ^{14}C age – reservoir age, (Stuiver and Polach, 1977). Reservoir age used is 985 ± 10 ^{14}C years (see Table 2 and main text).

* Sample was too small to measure $\delta^{13}C$.

Table 2.2: Reservoir age and ∆R calculations. Each marine sample is compared to each terrestrial sample from the same section.

Section	Marine UCIAMS#	$\delta^{13}C$ (‰ vPDB)	Marine ^{14}C Age (BP)	Terrestrial UCIAMS#	$\delta^{13}C$ (‰ vPDB)	Terrestrial ^{14}C Age (BP)	Reservoir Age[1] (^{14}C yrs)	Calendar Age[2] (cal bp)	Model Marine Age[3] (^{14}C BP)	∆R[4] (^{14}C yrs)
Aukpar	33282	0.9	7185 ± 20	34409	-27.3	6190 ± 20	995 ± 30	7165 - 7005	6580 ± 50	605 ± 55
Aukpar	33282	0.9	7185 ± 20	48216	-26.0	6165 ± 20	1020 ± 30	7160 - 7000	6570 ± 50	615 ± 55
Ipigaq	33283	2.5	7155 ± 25	33365	-27.0	6160 ± 20	995 ± 30	7160 - 6990	6565 ± 55	590 ± 60
Ipigaq	48456	1.9	7005 ± 20	33365	-27.0	6160 ± 20	845 ± 30	7160 - 6990	6565 ± 55	440 ± 60
Ipigaq	33283	2.5	7155 ± 25	71218	-	6030 ± 25	1125 ± 35	6945 - 6795	6390 ± 50	765 ± 55
Ipigaq	48456	1.9	7005 ± 20	71218	-	6030 ± 25	975 ± 30	6945 - 6795	6390 ± 50	615 ± 55
Ipigaq	71228	0.3	7090 ± 15	33365	-27.0	6160 ± 20	930 ± 25	7160 - 6990	6565 ± 55	525 ± 55
Ipigaq	71228	0.3	7090 ± 15	71218	-	6030 ± 25	1060 ± 30	6945 - 6795	6390 ± 50	700 ± 50

[1]Reservoir Age (BP) = Marine ^{14}C Age – Terrestrial ^{14}C Age (Stuiver and Braziunas, 1993).

[2]Calibration done for terrestrial samples using the program Calib 6.0 (Stuiver et al. 2005, accessed 15/01/2010) and the calibration curve IntCal04 (Reimer et al. 2004). Calibrated age is reported as the calendar year range within 2σ (95.4% of area enclosed).

[3]From Marine04 (Hughen et al., 2004).

[4]∆R = (measured) Marine ^{14}C Age – Model Marine ^{14}C Age (Stuiver and Braziunas, 1993).

See notes associated with Table 2.1 for further details.

In order to make direct comparisons to other studies, ∆R was also calculated for each pair (Table 2.2), following the procedure of Stuiver and Braziunas (1993), and using the Intcal04 (Reimer et al., 2004a) and Marine04 (Hughen et al., 2004) calibration curves. Excluding UCIAMS 71229 gives a range of ∆R values from 440 ± 60 to 765 ± 55 ^{14}C years. A mean maximum ∆R of 615 ± 15 ^{14}C years is obtained from these values.

Comparison of Deglacial Reservoir Age to Modern Reservoir Age

Molluscs collected from ice marginal deposits in Bluegoose Prairie were living there at the time of deglaciation of Foxe Basin (Fig 2.4). Radiocarbon ages on these molluscs give a minimum age of deglaciation of Bluegoose Prairie, which corresponds to the collapse of the Foxe Dome and marine incursion of Foxe Basin.

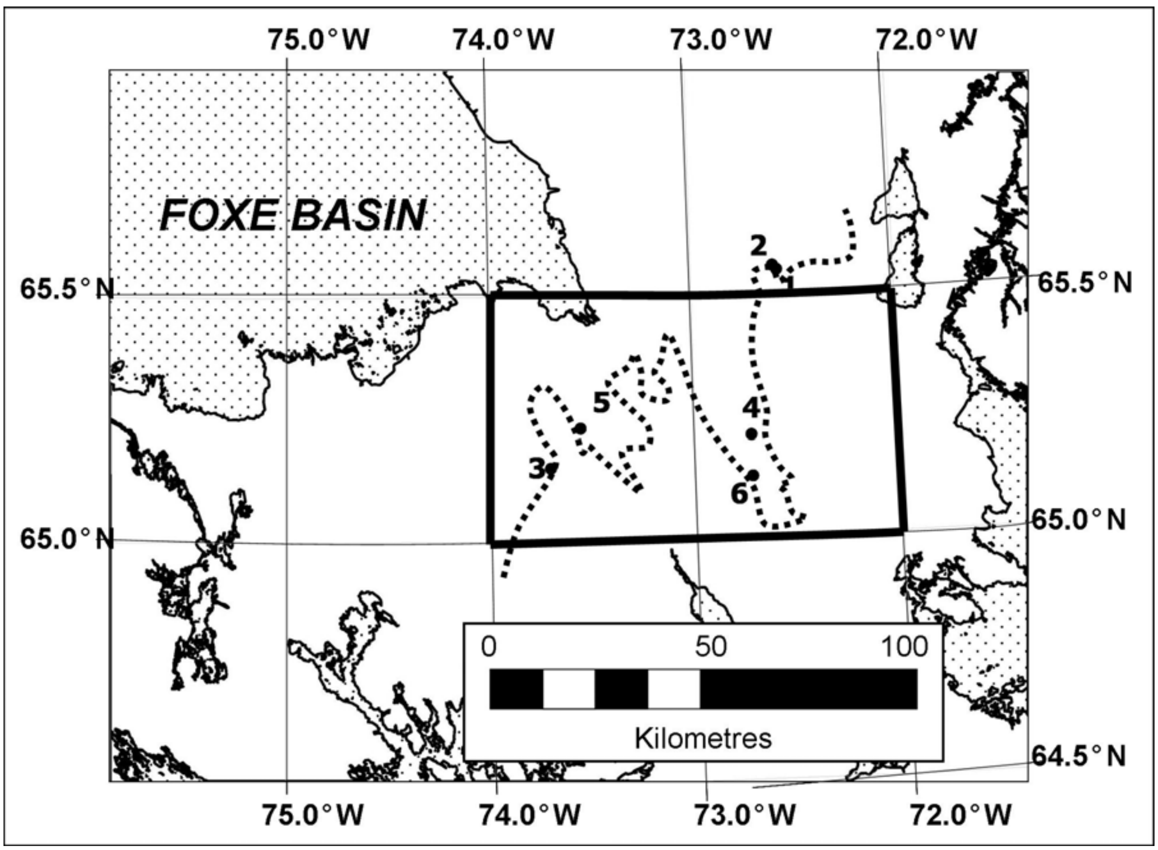


Figure 2.4: Locations of molluscs collected near marine limit in Bluegoose Prairie. Sample information is shown in Table 2.3. Dotted line shows approximate location of marine limit.

Modern reservoir ages for Foxe Basin are reported by McNeely et al. (2006), who radiocarbon dated an extensive collection of pre-bomb molluscs of known age (Fig 2.5). Measurements on *Portlandia arctica* were removed from the data set as these deposit-feeding organisms have been documented to give anomalously large reservoir ages (Forman and Polyak, 1997; McNeely et al., 2006). We compare the results of correcting Bluegoose Prairie marine ^{14}C ages using our deglacial reservoir values vs. modern reservoir values (Table 2.3). Two methods are used, the calculation of reservoir-corrected ages (^{14}C BP) using reservoir age and the calibration to calendar years (cal bp) using ΔR.

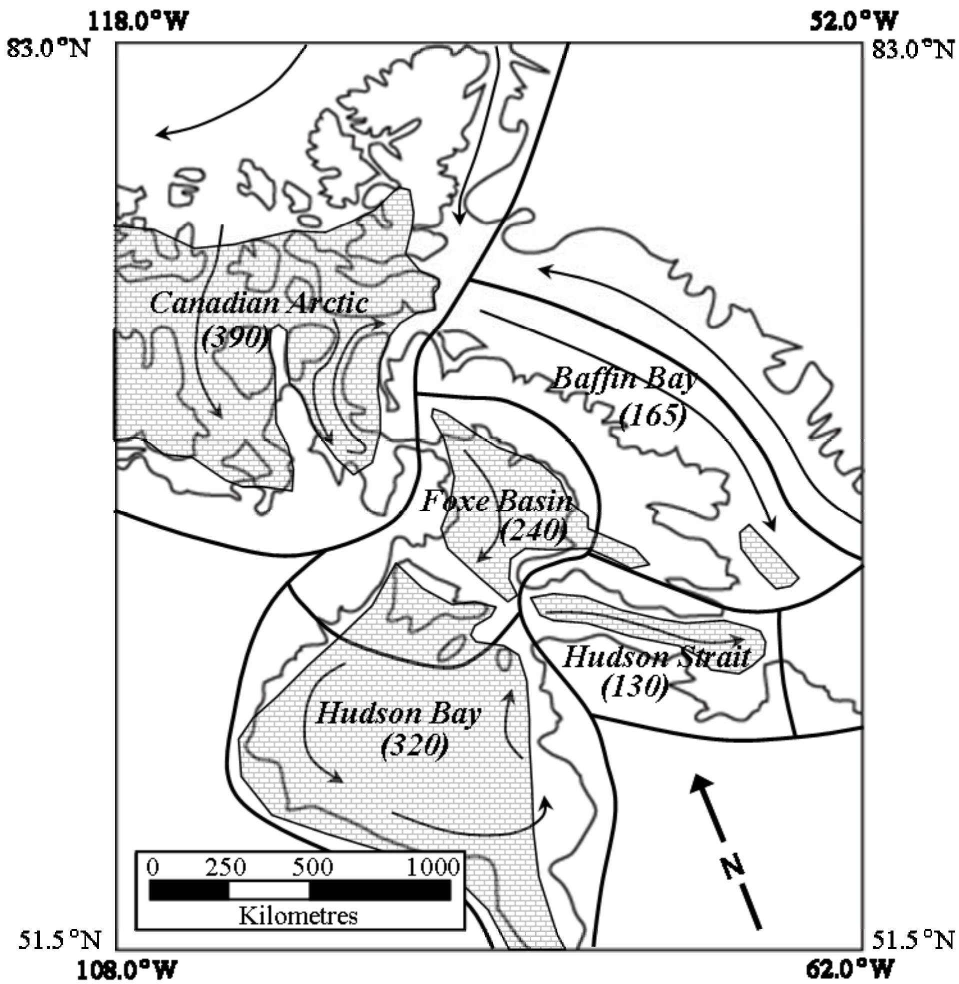


Figure 2.5: Ocean current regimes in the Eastern Canadian Arctic (revised from McNeely et al. 2006). Numbers in parentheses are average modern ΔR values (McNeely et al. 2006). Brick pattern represents areas of limestone bedrock (Wheeler et al. 1996).

Table 2.3: Bluegoose Prairie ^{14}C ages. Reservoir-corrected ^{14}C age (BP) is calculated using modern reservoir age of 720 ± 15 ^{14}C years (McNeely et al., 2006) and deglacial reservoir age of 985 ± 10 ^{14}C years (this paper) for comparison. Calendar age (cal bp) is calculated using modern ΔR of 240 ± 15 ^{14}C years (McNeely et al., 2006) and deglacial ΔR of 615 ± 20 ^{14}C years (this paper) for comparison. In both cases, ages calculated using modern reservoir values are significantly older.

Map[1] #	UCIAMS #	Lat	Long	Elev. (m.asl)	Genus	$\delta^{13}C$ (‰ vPDB)	^{14}C Age (BP)	R-corrected ^{14}C Age (BP) *R = 720 ± 15 ^{14}C yrs	Calendar Age (cal bp) *ΔR = 240 ± 15 ^{14}C yrs	R-corrected ^{14}C Age (BP) ⁺R = 985 ± 10 ^{14}C yrs	Calendar Age (cal bp) ⁺ΔR = 615 ± 20 ^{14}C yrs
1	33279	65.543	72.574	91	*Mya*	3.4	7070 ± 20	6350 ± 25	7415 - 7285	6085 ± 20	7060 - 6850
2	33280	65.552	72.594	73	*Hiatella*	1.2	7065 ± 20	6345 ± 25	7410 - 7280	6080 ± 20	7048 - 6840
3	33282	65.148	73.708	81	*Mya*	0.9	7185 ± 20	6465 ± 25	7515 - 7400	6200 ± 20	7180 - 6985
4	33283	65.207	72.725	73	*Mya*	2.5	7155 ± 25	6435 ± 30	7500 - 7360	6170 ± 25	7150 - 6955
5	40421	65.228	73.559	75	*Mya*	1.9	6895 ± 20	6175 ± 25	7260 - 7135	5910 ± 20	6825 - 6650
6	40424	65.123	72.724	76	*Mya*	1.8	7020 ± 20	6300 ± 25	7385 - 7245	6035 ± 20	6975 - 6785

[1]Refers to numbered sites on Fig 2.5

*McNeely et al., 2006.

⁺This paper.

See notes associated with Tables 2.1and 2.2 for further details.

The new data for the region indicates that reconstructions of events based on marine ^{14}C ages will be ~1000 ^{14}C years too old unless corrected for reservoir age. The modern reservoir correction for Foxe Basin is 720 ± 60 ^{14}C years (McNeely et al. 2006). Our data indicates that using the modern reservoir correction on deglacial ages results in reservoir-corrected marine radiocarbon ages that are still too old. If modern reservoir age is used to correct deglacial marine ^{14}C ages on Foxe Peninsula, it leads to the interpretation that Bluegoose Prairie deglaciated ca. 6.5 ka ^{14}C BP (7.4 ka cal bp). Using the deglacial reservoir age of 985 ± 10 ^{14}C years yields an age that is ~ 300 ^{14}C years younger: 6.2 ka ^{14}C BP (7.0 ka cal bp). The deglacial reservoir age for Foxe Basin is more accurate because it is specific to the time being evaluated.

We have calculated the weighted mean of the modern ΔR values (McNeely et al. 2006) to be 240 ± 50 ^{14}C years. Ages calibrated using deglacial ΔR = 615 ± 20 ^{14}C years are 350 to 450 calendar years younger than when calibrated using modern ΔR (Table 2.3). Ages calibrated using modern ΔR give a minimum age of deglaciation of Foxe Basin of ca. 7.5 ka cal bp. Calibrating the same ages using deglacial ΔR indicate that eastern Foxe Basin was open by ca. 7.1 ka cal bp. Constraining of early Holocene events can require century-scale precision; in these cases, the change in ΔR since deglaciation is significant. Use of deglacial ΔR is necessary for comparison of deglaciation at this site with other regions.

Discussion

In Foxe Basin, deglacial reservoir ages are significantly different from modern reservoir ages, indicating that ΔR has changed. Changes in ΔR over time have been observed in the North Atlantic (Bard et al. 1994) and the northeast Pacific (Kovanen and Easterbrook 2002), but this is the first study to measure deglacial ΔR in the Canadian Arctic.

Possible Reasons for Temporal Variations in Regional Reservoir Age

There are a number of conditions that may increase reservoir age:

1. Feeding habits of molluscs sampled. Infaunal species (e.g., *Portlandia arctica*) incorporate ^{14}C -depleted carbon from pore water in the substrate, as well as carbon from sea water, and therefore should not be used for reservoir studies (Forman and Polyak 1997; McNeely et al. 2006). *Mya* and *Hiatella* are used for reservoir age measurements in this study because they are epifaunal suspension feeders that build shell carbonate in equilibrium with the surrounding ocean water (Mook 1971).
2. Incorporation of old carbon from the Palaeozoic limestone that floors Foxe Basin (Trettin 1975). Old carbon could also have been brought in during deglaciation by melt water flowing across limestone-derived till on Foxe Peninsula (Forman and Polyak 1997; Barber et al. 1999) (Fig 2.5).
3. Ocean circulation patterns may have been different during deglaciation (Dyke et al. 1996), resulting in variation in the upwelling of ^{14}C -depleted deep waters and affecting carbon transport. These effects on reservoir age have been observed in the Pacific Ocean (Ingram and Southon 1996; Kovanen and Easterbrook 2002) and also likely apply to the Arctic. Bard et al. (1994) proposed that reduced advection of surface waters to the North Atlantic during the Younger Dryas could have changed ocean currents. It is possible that the same process could have occurred during the lesser cooling event at 8.2 ka cal bp, discussed below.

Implications for Palaeogeomorphic Reconstructions: 8.2 ka cal bp Event

The causes for increased reservoir age that apply to Foxe Basin probably also affected reservoir age in adjacent parts of the Arctic, including Hudson Strait and Hudson Bay (Fig 2.5). The most likely cause for the change in regional reservoir age is changing ocean circulation, which would affect the entire area. Other areas floored by carbonates (Laymon 1992; Wheeler et al. 1996), or with water input from areas covered in carbonate-rich till, may also have experienced higher reservoir ages during deglaciation, although the effects of substrate on ^{14}C concentrations are reduced by the selection of suspension feeders for dating. A high ΔR relative to modern values in Foxe Basin implies that ΔR in the rest of the eastern Canadian Arctic was also likely higher during deglaciation, the magnitude of which is unclear.

The middle section of Foxe Peninsula is less than 60 m asl. During deglaciation, when sea levels were 100 -200 m higher than today, this middle portion of land was under water (Dyke et al. 2003b), creating a shallow channel between Foxe Basin and Hudson Strait. This connection of the two now-separate water bodies is further reason to expect that deglacial reservoir ages in Hudson Strait may also have been elevated relative to present values, as the two would have shared some exchange of marine waters.

We use the 8.2 ka cal bp cold event as an example to demonstrate the difference in calculating calendar age using deglacial reservoir values vs. modern reservoir values in palaeogeographic reconstructions. A cooling period was recorded in Greenland ice cores beginning ca. 8300 cal bp (7500 ^{14}C BP) and ending ca. 8140 cal bp (7300 ^{14}C BP) (Alley et al. 1997; Rasmussen et al 2007). One proposed trigger for this cooling period is a change in thermohaline circulation caused by outflow of massive volumes of fresh water through Hudson Strait from Glacial Lake Agassiz, when the ice dam in Hudson Bay failed (Barber et al. 1999; Klitgaard-Kristensen et al. 1998, Teller et al. 2002). This hypothesis requires deglaciation of Hudson Bay and Hudson Strait by 8.3 ka cal bp (ca. 7.5 ka ^{14}C BP).

Table 2.4: Hudson Strait ^{14}C ages from previous work, compiled in Dyke et al. (2003b). Reservoir-corrected ^{14}C age (BP) is calculated using a reservoir age of 540 ± 10 ^{14}C years (Dyke et al., 2003b) and deglacial reservoir age of 985 ± 10 ^{14}C years (this paper) for comparison. Calibration to calendar years is done to allow correlation to the 8.2 ka cal bp event (see discussion).

Map[1] #	Lab Code	Lat	Long	Elev[2] (masl)	Material	^{14}C age (BP)	R-Corrected ^{14}C Age (BP) *R = 540 ± 10 ^{14}C yrs	R-Corrected ^{14}C Age (BP) $^{+}$R = 985 ± 10 ^{14}C yrs	Calendar Age (cal bp) $^{+}\Delta$R = 615 ± 20 ^{14}C yrs	Reference
1	CAMS-22023	62.621	-71.595	-108	forams, ostracods	8990 ± 50	8450 ± 50	8005 ± 50	9125 - 8760	Manley & Jennings, 1996
2	AA-10251	62.968	-69.788	35	*H.arctica*	8445 ± 55	7905 ± 55	7460 ± 55	8400 - 8170	Manley, 1996
3	AA-10649	62.233	-68.233	16	*M.truncata*	8045 ± 60	7505 ± 60	7060 ± 60	8015 - 7740	Manley & Jennings, 1996
4	CAMS-29558	61.208	-70.450	?	forams	8450 ± 50	7910 ± 50	7465 ± 50	8395 - 8175	MacLean et al., 2001
5	AA-10656	63.050	-74.304	-389	forams	8920 ± 65	8380 ± 65	7935 ± 65	9025 - 8620	Manley & Jennings, 1996
6	GSC-672	62.200	-75.633	99	*H.arctica, M.truncata*	8370 ± 250[3]	7830 ± 250	7385 ± 250	8840 - 7690	Matthews, 1967
7	GX-9996	63.583	-77.233	114	shells	8250 ± 290	7710 ± 290	7265 ± 290	8760 - 7515	Stravers et al., 1992
8	AA-12885	63.046	-81.988	-212	forams	8530 ± 60	7990 ± 60	7545 ± 60	8530 - 8240	Manley & Jennings, 1996

[1]Refers to numbered sites on Fig 2.6.
[2]Negative values are depths below modern sea level, for marine core samples.
[3]Error for GSC-672 is 2 σ.

*Dyke et al., 2003b.
$^{+}$This paper.
See notes associated with Tables 2.1 and 2.2 for further details.

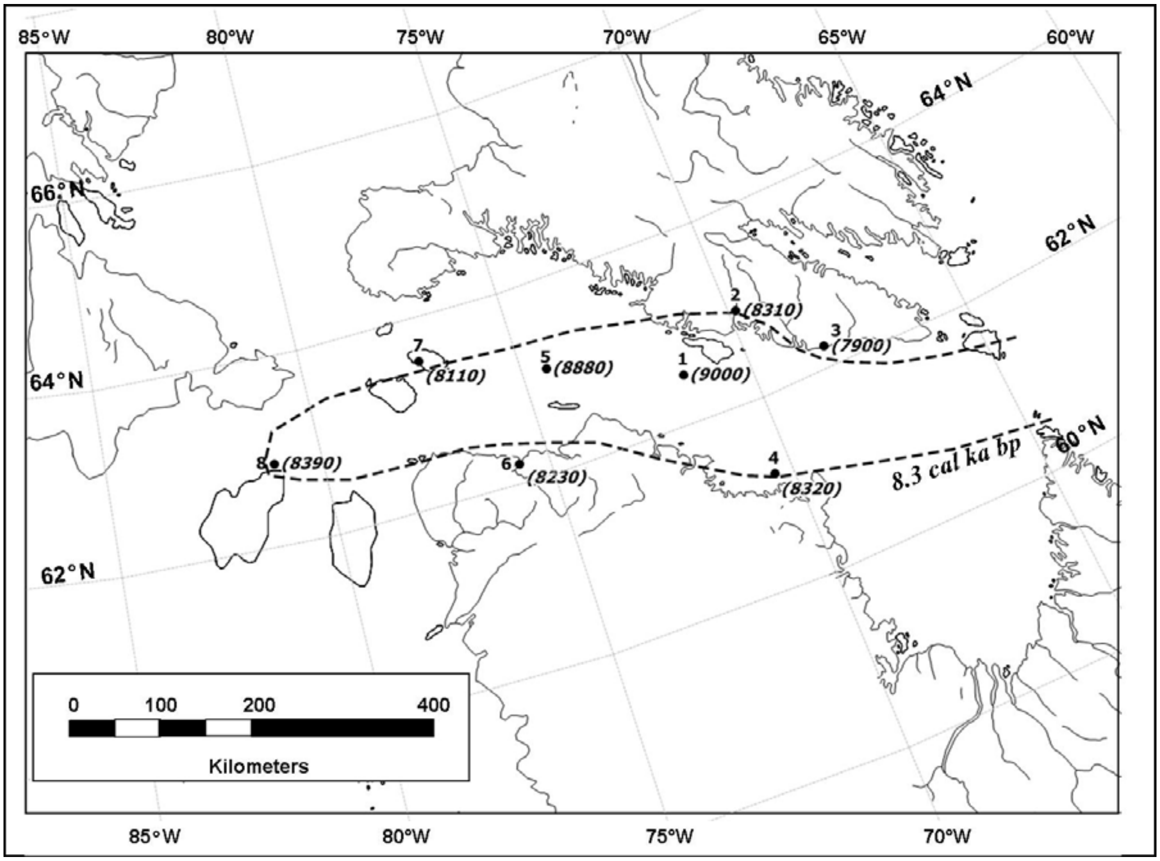


Figure 2.6: Locations of Hudson Strait samples from Table 2.4 (Dyke et al. 2003b). Numbers in parentheses are median calendar ages (cal bp), calibrated using deglacial ΔR of 615 ± 20 ^{14}C years. Dashed line shows approximate extent of open water at 8.3 cal ka bp (modified from Dyke et al. 2003b).

Marine samples providing minimum deglacial ages from Hudson Strait have previously been used to constrain the maximum age of drainage of Glacial Lake Agassiz through Hudson Bay and Hudson Strait, using ΔR values of 85 to 310 ^{14}C years (Barber et al. 1999). Previous studies (e.g., Dyke et al. 2003b) place the opening of Hudson Strait at ca. 8.8 ka cal bp (8.0 ka ^{14}C BP), 500 years before the onset of cooling at 8.3 ka cal bp. We again compare the use of modern reservoir age (Dyke et al. 2003b) to deglacial reservoir age. The deglacial reservoir age of 985 ± 10 ^{14}C years obtained from Foxe Basin is applied to Hudson Strait for this comparison, due to the lack of available deglacial reservoir measurements from Hudson Strait. Application of the deglacial reservoir age to a selection of samples from previous studies (Table 2.4) constrains the final opening of Hudson Strait to ca. 8.3 ka cal bp (7.5 ka ^{14}C BP)

(Fig 2.6), concurrent with the onset of the 8.2 ka cal bp event. If the final drainage of Glacial Lake Agassiz was responsible for the 8.2 ka cal bp event, this implies that deglaciation of Hudson Bay was very rapid after the opening of Hudson Strait or that drainage was initially subglacial. This example serves to demonstrate the difference in palaeogeographic reconstructions made by applying deglacial reservoir age instead of modern reservoir age. Accurate reconstruction of the timing of the drainage of Glacial Lake Agassiz requires measurement of deglacial reservoir age in Hudson Strait.

Conclusion

Marine organics, mainly molluscs, are commonly the only material available for ^{14}C dating in the Arctic, due to the abundance of raised marine landforms and the paucity of terrestrial organics associated with deglaciation. The correlation of marine ^{14}C ages with dates obtained by other dating methods, for example, terrestrial ^{14}C, cosmogenic nuclide, or optical luminescence, requires that they be calibrated to calendar years. Because reservoir age is time and location dependent, it is necessary to use a ΔR value that is temporally and spatially accurate. Studies that measure modern reservoir age are valuable for recent events, but are inappropriate for use with older ages. Our study shows that ΔR for Foxe Basin has changed since deglaciation. If our ages are correct and applicable to a wider area, a reconfiguration of palaeogeographic reconstructions associated with deglaciation is required. In the absence of suitable material for measuring reservoir age, we recommend that a reservoir age of 985 ± 10 ^{14}C years be applied to deglacial marine samples in Foxe Basin. More research is required on reservoir ages during deglaciation. Precise reconstruction of glacial events requires the measurement of local deglacial reservoir age whenever possible.

CHAPTER 3: SURFICIAL GEOLOGY MAPPING AND GLACIAL HISTORY

Introduction

As part of the South West Baffin Integrated Geoscience Project, one of the primary objectives of this masters' project was to publish a surficial geology map in support of a regional compilation. The map "Surficial Geology of Bluegoose River (South)" was completed following the standards used by the Geological Survey of Canada at a scale of 1:100 000. It covers the southern half of NTS 36H. The map is included in the rear pocket and in CD form with this thesis. It is also available as Open File 6176 through Natural Resources Canada's MIRAGE (gdr.nrcan.gc.ca/mirage) and GeoPub (www.geopub.nrcan.gc.ca) websites. This chapter describes in detail the production and interpretation of the map, and describes the glacial history of Bluegoose Prairie over the last 18 ka ^{14}C years.

Methods

Field preparation involved studying air photos of the area. Bluegoose River South (NTS 36H/1-8), referred to as Bluegoose Prairie, is covered by 147 black and white vertical 1:60 000 scale air photos. These air photos were used to identify landforms, surficial geology, and common landscape types, and to plan field traverses and identify potential sections.

The objective of the first season of fieldwork in 2006 was to gain comprehensive coverage of the map area. Ground-truthing was done via helicopter and foot traverses, focusing on describing characteristic surficial materials and examining unusual landforms and ground cover previously identified in air photos. Stratigraphy was described for all sections found, and marine and terrestrial material was collected for radiocarbon dating. Information for 184 stations was recorded on a Dell Axim personal digital assistant (PDA), using ESRI's ArcPad program and the Geological Survey of Canada's GanFeld application (Buller 2007). Elevation at every station was measured using a Garmin GPS and at least two handheld altimeters. The altimeters were reset at base camp each morning and each evening, and elevations were corrected for pressure change each day. Altimeters were also zeroed at modern high tide level when possible. Error in elevation measurements is ±5 m. Azimuth was measured for striations and streamlined landforms. A regional till sampling survey was also conducted during the first field season, in conjunction with this project (Utting and Brown 2007).

Information was collected for 32 stations during the second field season in 2007. The fieldwork focused on collecting more detailed sea level and palaeoenvironment data, utilizing all terrain vehicles for travel within a 10 km radius from two base camps.

Once fieldwork was complete, station data were transferred to air photos. Stereo pairs of air photos were used in combination with field data and ground photographs to plot surficial geology polygon boundaries, landforms, and symbols. Only polygons >600 m diameter were mapped, which is equivalent to >1 cm diameter on the air photos and 0.6 cm on the map. Polygons smaller than this would be too small easily distinguish on the map. The use of colour LandSat 7 images assisted in distinguishing between limestone- and Proterozoic-derived till, differences that were more subtle on the black and white air photos. Once mapping was complete, the photos were sent to the Canada-Nunavut Geoscience Office for digitization and cartography by C. Gilbert. Formatting and publication of the final map was completed at the Geological Survey of Canada. The final product is the 1:100 000 map (Vickers et al. 2011).

Legend

Map Units

Map units used in Bluegoose Prairie were adapted from legends for other surficial geology maps for southern Baffin Island (Hodgson 2003b) to maintain consistency across the area. As is standard for surficial geology maps, map units have two-part labels: an uppercase letter(s) indicating surficial material type and genesis, and a lower case letter(s) indicating surface expression and/or category; composite polygons were not used. The main control is surficial material genesis. Surficial materials are non-lithified, unconsolidated sediments (Howes and Kenk 1997). They are classified based on mode of transport and environment of deposition. Surficial materials are generally listed in order of increasing age. Units are further subdivided based on surface expression, which describes the three-dimensional form or shape of the land surface, or the thickness of the surficial materials (Howes and Kenk 1997) (Table 3.1). In cases where more than one material type or surface expression exists within the same polygon, the label indicates only the most dominant material and surface expression. Polygon boundaries are either solid, indicating a known boundary, dashed, indicating an approximate boundary (known within 500 m), or dotted, indicating an inferred boundary.

Table 3.1: Surface expressions used in the map and their descriptions.

Symbol	**Name**	**Description**
pt	plain/terrace (outwash)	even surfaces or fans with slope <15°, may have stepped topography
r	ridge	elongate rises and/or hills, slope >15°
d	delta	landform deposited by a river discharging into the sea, commonly a nearly flat, triangular or fan-shaped surface
b	blanket	surface reflects, but smoothes out, underlying bedrock topography, material thickness >1m, continuous cover
v	veneer	surface reflects underlying bedrock topography, material thickness <1m, commonly discontinuous cover
h	hummocks	non-linear rises and hollows

Bedrock (R)

The bedrock in Bluegoose River can be divided into two types: Proterozoic granites and gneisses, and a fossiliferous, fissile, Ordovician limestone (Fig 3.1). Most of the bedrock exposed at the surface is Proterozoic rock, particularly where water has washed away the overlying material. Exposed limestone is rare, except along the steep limestone scarp of the Putnam Highlands. In some cases, bedrock is overlain by a veneer of unconsolidated materials (e.g.,, till, glaciomarine deposits) that covers less than 40% of the surface. As bedrock is the one map unit that is not composed of unconsolidated materials, it is not given a surface expression. The limestone is horizontally planar to gently dipping, and the Proterozoic bedrock is ridged to undulating with local smoothing and plucking by glacial erosion.

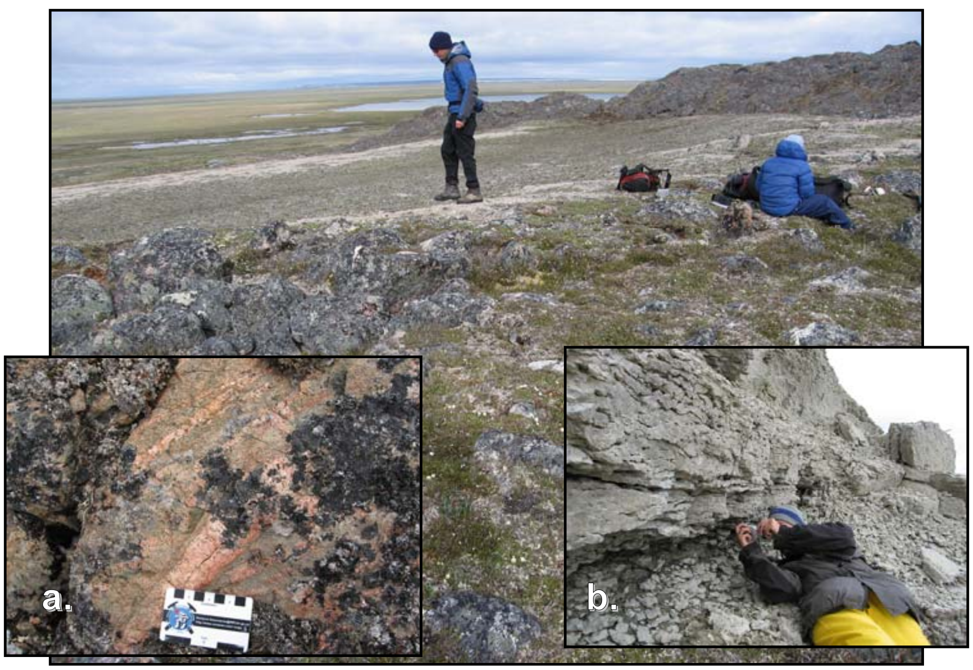


Figure 3.1: Landscape marked as R (bedrock), with insets showing close ups of (a) Proterozoic granitic bedrock and (b) limestone bedrock.

Till (Tv/Tv^L, Tb/Tb^L, Th/Th^L)

Till is defined as “sediment that has been transported and deposited by or from glacier ice” (Dreimanis 1988). It is the most extensive sediment type throughout Bluegoose Prairie, especially above marine limit. Two types of till are present, with compact to loose consolidation. Till below marine limit is commonly washed, with fines removed. Periglacial features are ubiquitous in till, and include sorted circles (Fig 3.2c), solifluction lobes, and mud boils (Fig 3.2d). This reworking in the active layer destroys any primary sedimentary structures in the till. Till with clay to fine silt limestone matrix may contain ice wedge polygons.

The two types of till are differentiated on the basis of bedrock source material. Proterozoic rock-derived till appears darker coloured on aerial photographs, and brown on satellite imagery. It is identified with the label “T” and solid colouring on the map. This till is matrix-supported, and has a tan, silt to fine sand matrix. Clasts are subrounded to subangular and range from 8-30%, with a mode of 15-20%. The modal clast size is 10-20 mm. Clasts are mostly Proterozoic, but up to 40% of the clasts may be limestone.

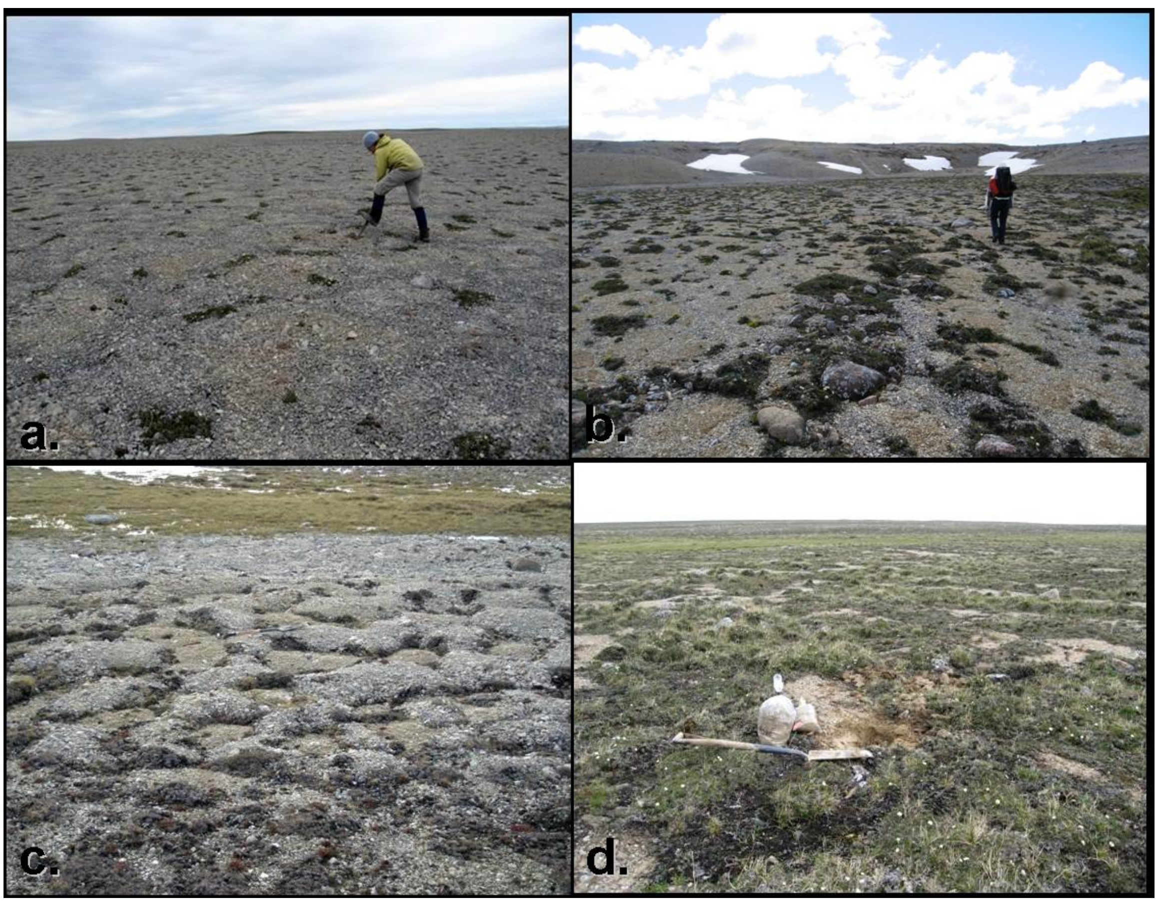


Figure 3.2: Surface expressions and common periglacial features of till. a) Till blanket overlying typical flat-lying limestone bedrock. b) Hummocky limestone till. c) Sorted circles in limestone till. d) Mud boils in limestone till.

Limestone-derived till appears lighter coloured on aerial photographs, and white or pale yellow on satellite imagery. It is identified with the label "T^L" and a brick-patterned fill on the map. This matrix-supported till is finer grained than Proterozoic-derived till, with yellowish-grey, silty-clay to clayey-silt matrix. Limestone clasts are subangular to angular, and range from 2-30%, with a mode of 5-20%. The modal clast size is 5-10 mm. Most clasts appear to be derived from the local limestone, and have undergone very little rounding. The Ordovician limestone has strong bedding and is brittle, breaking easily into sharp fragments instead of rounding. The limestone till contains 0-20% clasts of Proterozoic lithology, which are subrounded.

In both Proterozoic- and limestone-derived till, Proterozoic cobbles and boulders are found on the surface. They are sub-rounded to sub-angular and range in size from 10 – 300 cm. Frost heaving has likely brought many of the cobbles to the surface.

Till thickness ranges from less than 1 m to 5 m, and is most commonly less than 2 m. The thin till is typically flat to rolling, draping the topography of the underlying bedrock (Fig 3.2a). Till less than 1 m thick is classified as till veneer (Tv), while till greater than 1 m thick is characterized as till blanket (Tb). As it is difficult to tell till thickness in the field unless near a stream cut, blankets and veneers are distinguished based on aerial photograph interpretation. Where till cover is discontinuous or the texture, as observed in air photos, of the underlying bedrock is still visible, it is called Tv. Continuous till cover that masks the texture of the underlying bedrock is called Tb. Hummocky till (Th) is mapped where the surface relief is independent of bedrock topography and relief consists of hillocks, ridges and hollows (Fig 3.2b). Hummocky till can include drumlins and moraines, indicated by on-site symbols, while in other areas the pattern of rises and hollows appears chaotic.

Glaciofluvial Deposits (GFr, GFpt)

Glaciofluvial material is deposited by glacial meltwater. These deposits are divided into two categories: outwash (GFpt) and ice-contact deposits (GFr).

GFpt is generally moderate to well sorted and consist of sand to gravel, with common boulders and cobbles. Clasts are sub-rounded to rounded, and the majority of clasts greater than 20 cm diameter are of Proterozoic lithology. These clasts are concentrated in meltwater channels where softer limestone material has eroded away, and are less abundant in outwash fans and ice-contact deposits.

Glaciofluvial outwash deposits (GFpt) include alluvial fans (Fig 3.3) and meltwater channel deposits. Surface expressions include fans, channels, and terraces. These deposits occur commonly at the down-flow end of eskers (see GFr). They have a sand to pebble matrix, and cobble to boulder-sized clasts are rounded. Outwash deposits are 1 to 10 m thick. Below marine limit, glaciofluvial deposits have been redistributed as beaches (see glaciomarine deposits).

Figure 3.3: Large glaciofluvial outwash fan near second 2007 base camp. Fan is cut by a modern stream.

Ice contact glaciofluvial deposits (GFr) are deposited subglacially. These deposits rise above the ground surface and are easily identified in air photo and on foot. Eskers are abundant in the east half of the map sheet. They range in height from 1 to 10 m, and in length from 100 m to greater than 10 km. Smaller eskers are identified with symbols, while a large esker in the southeast is large enough to be a polygon (Fig 3.4). Eskers are typically composed of well-sorted, fine to coarse sand. Cobble to boulder sized rounded clasts are common on the surface. A section cut into the largest esker revealed laminations dipping to the northwest (Fig 3.4b). The sand coarsens upward to gravel. Interbeds of pebble to cobble sized material are present (Fig 3.4c). Ripples are present in some sand beds. The top of the largest esker is kettled (Fig 3.4a). The laminations and ripples indicate the esker flowed northwest. Eskers near marine limit are beaded, with undulating surfaces. Eskers commonly terminate in large fans, classified as GFpt for the map, and represent ice margins.

The ice contact glaciofluvial deposits on Putnam Highland likely formed as ice marginal kames (Dr. Rod Smith pers. comm. 2011). These large landforms have relief of 10 to 50 m (Fig 3.5a) and are large enough to be identified by 20 m interval contours. They are composed of sandy gravel and are moderately to well sorted. Lithology of the gravel is primarily limestone with less than 5% Proterozoic clasts. One mound has a visible 2 m thick band of lighter coloured sediment (Fig 3.5b), dipping away from the ice margin. These landforms mark a palaeo ice margin. Supraglacial streams incised up-dip thrust debris bands near the edge of the glacier, depositing large kames where streams exit the shear vertical face of the glacier margin (Fig 3.5c). Some of the kames have a steep up-ice side, while others are irregular mounds. Kames with steep, ice contact slopes indicate ice flow direction.

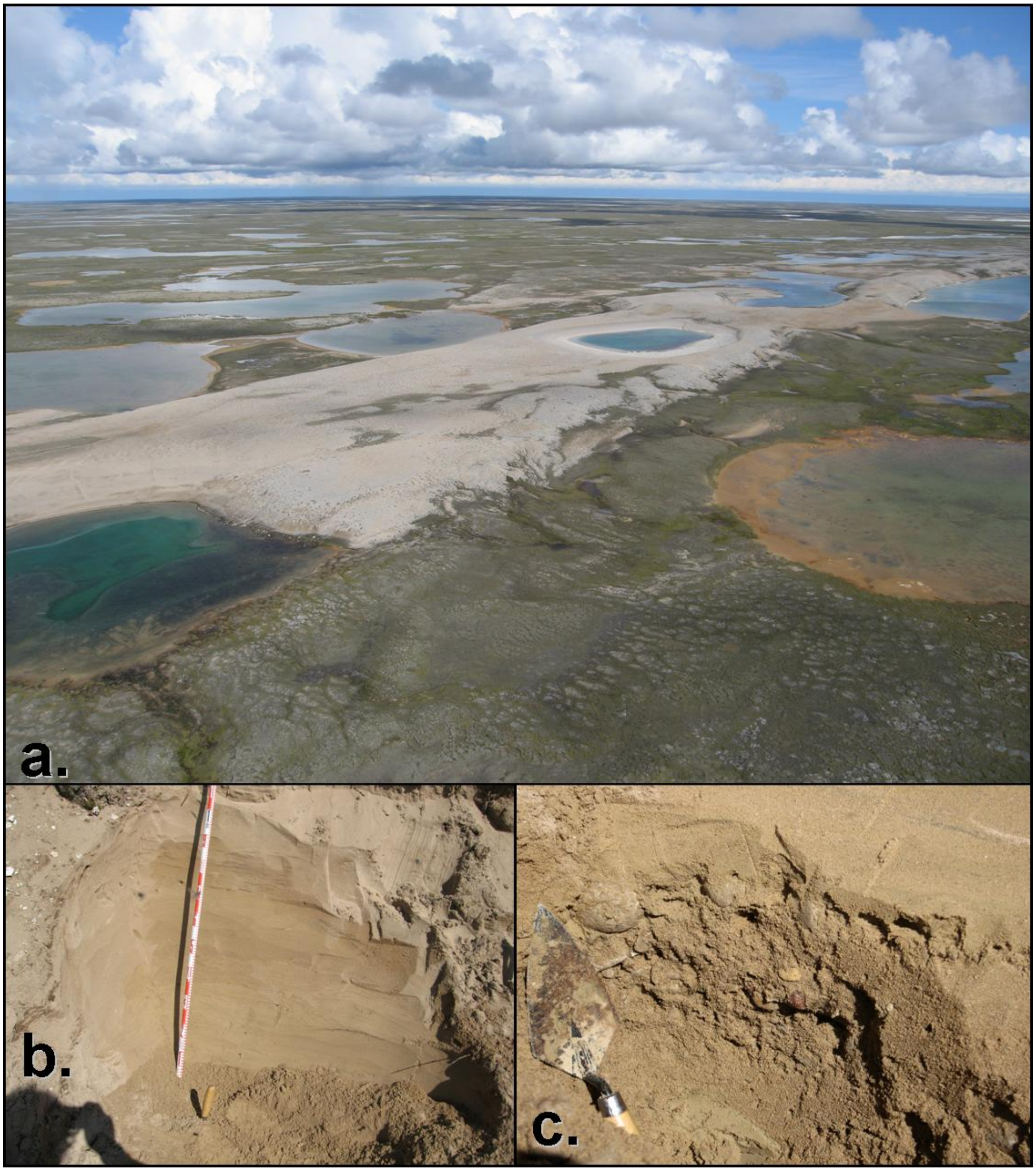


Figure 3.4: Large esker in southwest corner of map area. a) surface is kettled. Esker is ~50 m across at kettle. Pit in this esker shows b) laminated sand and c) pebble layers.

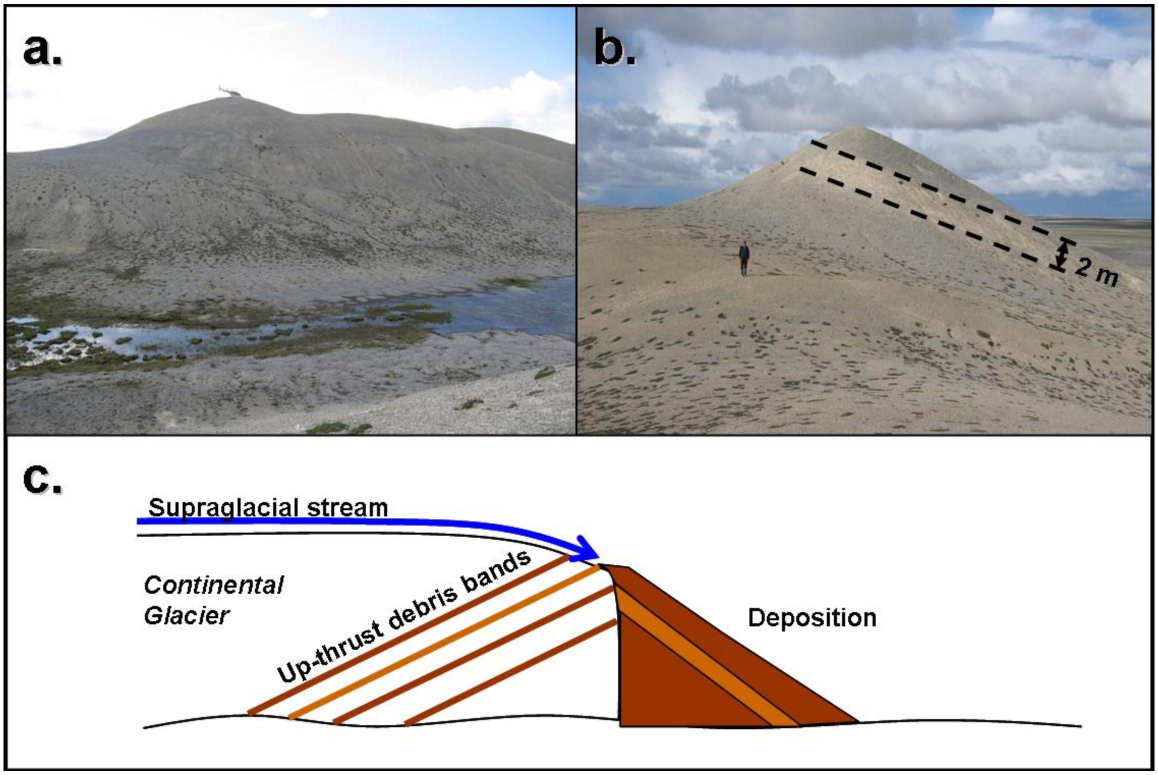


Figure 3.5: Large ice-marginal kames (GFr) on Putnam Highland. a) Landforms are 10-50 m high (helicopter for scale). b) One kame includes a 2 m thick bed of lighter coloured sediment, which marks incision and deposition of a distinct debris band. c) Glaciofluvial deposition at ice margin by supraglacial streams. Once the glacier retreats, deposit is left as isolated mound (kame).

Glaciomarine Deposits (GMr, GMd, GMv, GMb)

All raised marine sediment is referred to as glaciomarine for mapping purposes. The rationale for this generalization is that all of these materials were deposited as the land was rebounding after glacio-isostatic depression. Thus even relatively young marine sediments are considered to be deposited as a consequence of the last glaciation, as they are above modern sea level. Glaciomarine deposits include raised beaches, deltas, estuarine deposits, coastal flats, and marine muds. These deposits are subdivided as described below.

Littoral glaciomarine landforms (GMr) are deposited in the intertidal zone, and include raised beaches, small deltas, spits, and terraces (Fig 3.6). Littoral deposits are gravel or very coarse sand and moderately to well sorted. Clasts are subangular to angular and of mainly local origin. Littoral deposits appear to be glacial sediments that have been reworked by wave action. Relief is typically 1 m, but may be up to 3 m. Most beaches are primarily derived from limestone, but rare Proterozoic pebble beaches were observed. Mollusc valves and fragments are common on limestone beaches above 40 m asl (above sea level) but are rare on beaches composed mainly of Proterozoic-derived sediments, and below 40 m asl. Sections through raised beaches show diffuse grading. Some beaches and terraces have boulder lags on the seaward side, with fines removed. Littoral sediments erosively overly offshore marine sediments, reflecting post-glacial regression.

Figure 3.6: Littoral glaciomarine sediments immediately west of Putnam Highlands. Bowman Bay, and modern sea level, is left of this photograph.

Large glaciomarine deltas are labelled GMd and smaller deltas are identified by an onsite symbol, usually as part of larger GMr complexes. Glaciomarine deltas in Bluegoose River all have surfaces 80 - 90 m asl and were deposited at or near the ice margin. They are commonly associated with either ice contact deposits or the termination of outwash trains and meltwater channels. Stratigraphic sections through deltas show horizontally laminated sand (bottomsets) overlain by foreset dipping bedded sand, capped by gravel lags (topsets). Dropstones are common in the lower sediments.

Glaciomarine mud drapes underlying bedrock, creating large, flat expanses of thin (GMv) and thick (GMb) sediments below marine limit. As described for till, where thickness cannot be directly measured in the field, surface texture, as observed in air photos, is used to distinguish between veneer and blanket. Glaciomarine sediments include weakly stratified clay, silt, and fine sand with dropstones (Fig 3.7).

Typically, fine-grained, horizontally laminated muds are deposited in deeper water and in low energy tidal flats. These fine sediments can be overlain by coarser grained horizontally laminated to diffusely graded sand as sea level drops, as the system transitions from a glaciomarine to a glaciofluvial environment. Ripples and cross-stratification are common in near shore deposits.

Figure 3.7: Section through raised glaciomarine sediments. Distinct horizontal layering is apparent in fine sand to clay-sized sediments. Dropstone is visible near bottom of exposure.

Fluvial Deposits (Fpt)

Fluvial sediments are deposited by postglacial streams and rivers (Fig 3.8). Fluvial deposits above marine limit are limited to modern floodplains, which are incised below the level of glaciofluvial deposition. Below marine limit, fluvial sediments are deposited as floodplains, and as large alluvial fans where modern streams exit incised channels through Putnam Highlands and flow onto the coastal flats. Many fluvial deposits are moderately to well sorted gravel dominated by pebbles and cobbles, while others consist of well sorted sand. Rounded Proterozoic boulders washed out from surrounding sediments are common. Mollusc fragments are also washed from surrounding deposits below marine limit.

Figure 3.8: Modern fluvial sediments deposited by a river southeast of Putnam Highlands, cutting through glaciomarine deposits.

Onsite Symbols

Onsite symbols are used to identify landforms and features that are too small to be represented by polygons, as well as observation sites. The size of point symbols (e.g., relict limestone outcrops, striations) are fixed, and do not represent the relative size of the feature. The lengths of linear symbols (e.g., till lineations, flutes, eskers) vary with the length of the feature represented. In some cases, the symbol may indicate the direction of deposition. Refer to map legend for what each symbol looks like.

Limestone bedrock outcrops (Fig 3.9a,b) are scattered in the southwest portion of the map area and form erosional relicts sitting on top of Proterozoic bedrock. These landforms take the form of hills of frost-shattered limestone. The shape of these hills ranges from conical to elongate. Rare rounded Proterozoic cobbles sit on the surface. Relief of these limestone outcrops range from 5 to 15 m. All of these outcrops are too small to appear on the bedrock map (St-Onge et al. 2007).

Moraines (Fig 3.9c) are deposited along the margin of the ice sheet, and represent a period of stillstand or readvance. Moraines in the area are rounded and subdued, commonly being difficult to identify from the ground. Moraines represent well-defined ice margins. Assumed ice margins are identified by connecting sections of well-defined moraines, or where morainal ridges are subtle, or where the boundary between thicker and thinner till is perpendicular to ice flow. This represents a brief stillstand or readvance, depositing thicker till. The latter instance is common in the east half of the map sheet, where thicker till is up-ice to the southeast.

Till lineations are subglacial depositional landforms that include flutes and till dispersal plumes. Flutes are elongated ridges parallel to ice flow. In Bluegoose Prairie, they are subdued, with relief <1 m and gentle slopes. Till dispersal plumes (Fig 3.9d) are elongated trains of till of a particular composition (either Proterozoic or limestone). Till dispersal plumes are visible on aerial photograph and satellite imagery and are one of the most obvious indicators of ice flow in Bluegoose Prairie. Lengths vary from 100 m to 10 km in the southwest portion of the map area, and to greater than 80 km in the east.

Eskers are subglacial depositional landforms. Symbols are used to identify all esker ridges, even those also denoted by a GFr polygon. Eskers are oriented approximately parallel to ice flow. Flow direction is determined based on a section dug in the largest esker, and on the presence of fans at the terminus of smaller eskers.

Meltwater channels are subglacial or proglacial erosional landforms. Meltwater channels less than ~100 m wide are labelled as minor meltwater channels, while those wider than ~100 m are labelled major meltwater channels. Arrows indicate direction of meltwater flow, where known. Many major meltwater channels are occupied by underfit modern streams and rivers. Deltas that are too small to be mapped as polygons are represented with a symbol.

Beaches are raised marine landforms that mark a stillstand in sea level. Where flights of beaches are present, only representative individual beaches are labelled due to the scale of the map. Beaches are most commonly preserved on slopes of topographic highs.

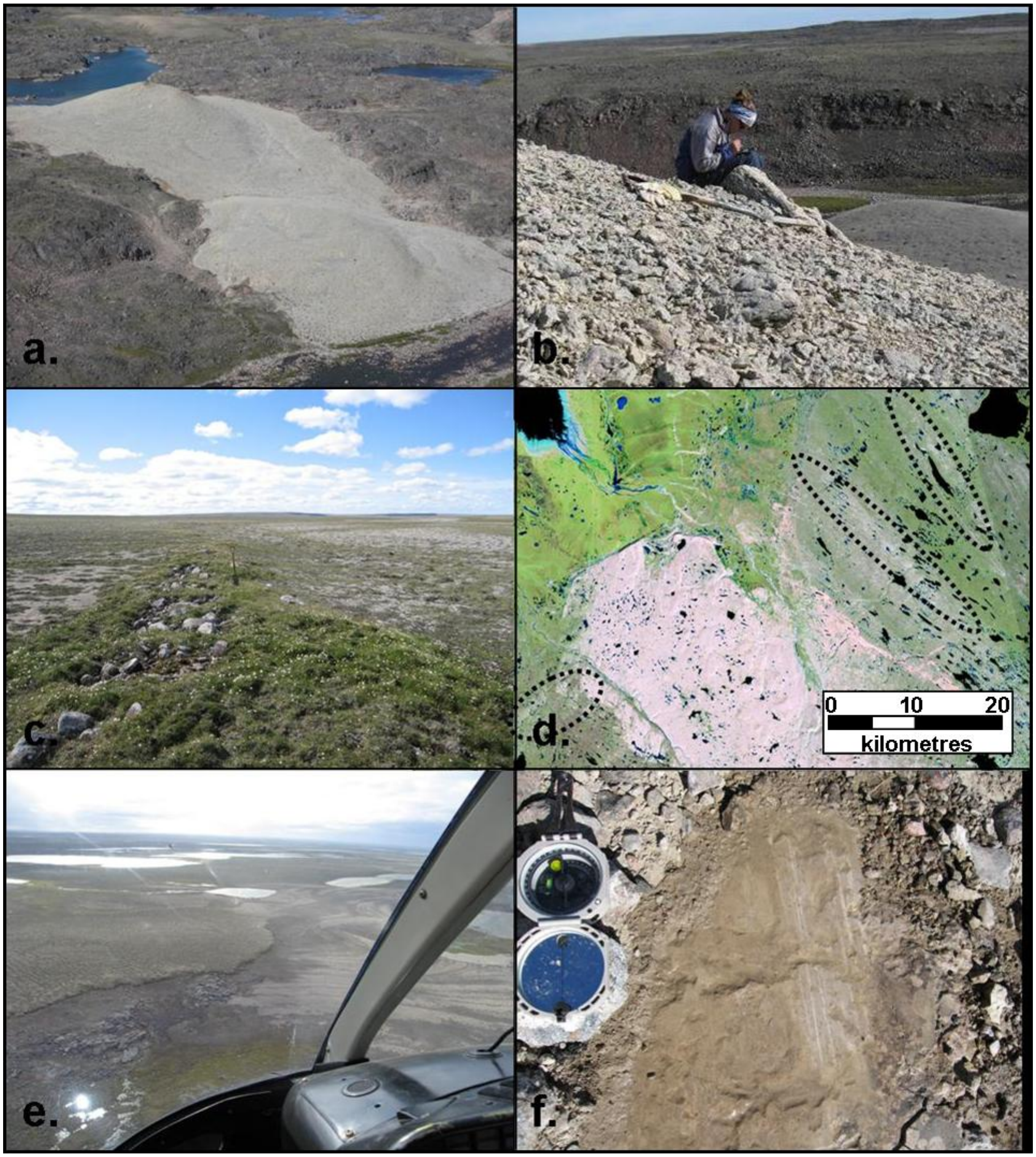


Figure 3.9: Landforms represented by onsite symbols. a) limestone bedrock relict viewed from the air, b) limestone bedrock relict close-up, c) moraine, d) examples of till lineations as seen in satellite imagery (Landsat 7), e) marine trimline: area on right is washed and has marine deposits, area to left is till, f) striations on limestone.

Limit of marine inundation, or marine limit, indicates the maximum extent of the post last glacial sea (Fig 3.9e). In Bluegoose River, marine limit ranges from 80 to 120 m asl and corresponds to the grounded ice margin at the time of deglaciation of Foxe Basin. Marine limit is identified based on highest extent of glaciomarine deposits, or washed till and bedrock. In areas where glaciofluvial or fluvial outwash has removed glaciomarine sediments, interpolated marine limit follows topography between areas of observed marine limit.

Striations were difficult to find in the field due to the abundance of surficial materials. The majority of striations were observed on Proterozoic granite due to its hardness. The limestone bedrock was very soft and commonly frost-shattered or eroded. Striations measured in the field are all bidirectional (Fig 3.9f).

Sites visited in person during the course of this project are also identified with onsite symbols. Numbered fossil localities represent sites where marine mollusc and terrestrial macrofossils were collected and the numbers correspond to ^{14}C ages listed in Table 1 on the map. Ground observations are locations where surficial material characteristics were recorded. Samples of representative surficial deposits were taken at some ground observation sites. Till samples were taken as part of a drift prospecting study (Utting and Brown 2007) during the first field season. Appendix B contains location and date information for each station, and descriptions of surficial materials, samples, and ice flow indicators.

Ice Flow and Deglaciation

Ice flow indicators in Bluegoose Prairie consist of striations, till dispersal plumes, flutes, and eskers (Fig 3.10). Moraine segments mark past ice margins. All of these landforms are used to interpret four phases of ice flow patterns for Bluegoose Prairie (Fig 3.11, 3.12).

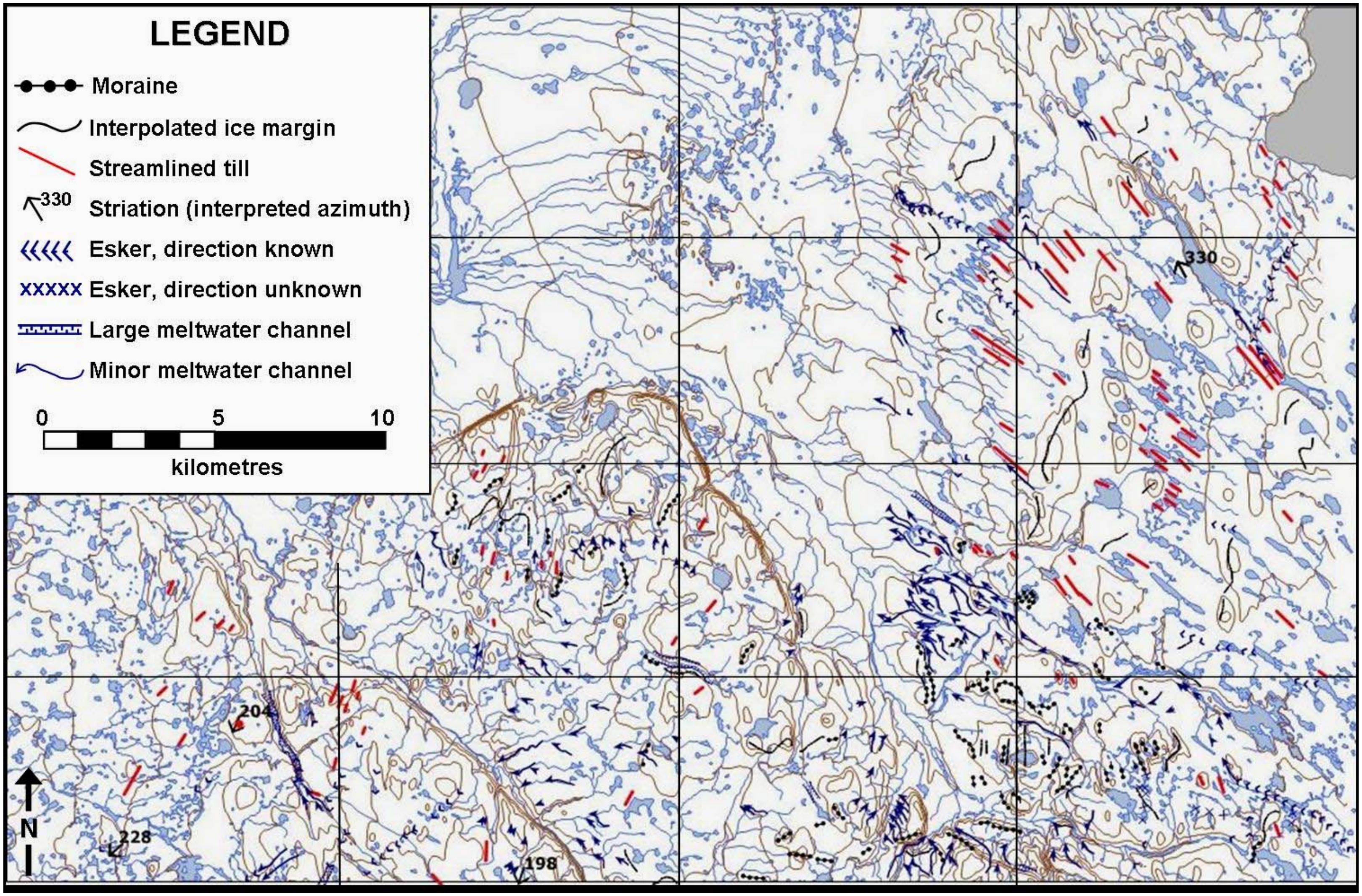


Figure 3.10: Landforms and striations showing ice flow directions in Bluegoose Prairie, as mapped from air photos. All symbols except for striations are representative of the length of the landform. Striations are bidirectional; sense has been inferred from associated landforms.

Phase One ice flow (Fig 3.11a) occurred while Baffin Sector Ice was at its glacial maximum configuration. During that time, ice in Bluegoose Prairie flowed from the Foxe-Amadjuak Divide southwest across the map area, and funnelled into Hudson Strait Ice Stream (Laymon 1992). Evidence of Phase One flow is observed in the southwest corner of the map area, and includes striation measurements ranging from 198° to 228° and dispersal plumes of limestone-derived till that stretch southwest across Proterozoic bedrock. These till dispersal plumes terminate at marine limit, so are interpreted to have been deposited before deglaciation of Foxe Basin. Phase One likely persisted until the collapse of the Foxe Dome ca. 6.2 ka ^{14}C BP (Vickers et al. 2010).

Phase Two ice flow initiated with deglaciation of Foxe Basin, allowing marine incursion of the north coast of Foxe Peninsula (Fig 3.11b). Marine waters penetrated into Bluegoose Prairie along the drainage east of the Putnam Highlands, forming a marine limit at ~110 m asl along the east escarpment (the west side of the open channel). It is difficult to measure the exact sea level along the escarpment as it is a steep cliff. The east side of the open channel (Fig 3.11b) has a marine limit of only 80 m asl. This lower marine limit can only be explained by having grounded ice, blocking marine incursion, and restrained rebound of ~30 m, lasting ~300 to 400 years. As the ice divide shifted onto Baffin Island, ice in the eastern portion of the area continued to flow southwest, and was drawn towards the open channel. West of the channel, ice was also drawn toward the open water, away from a topographic high located in the southwest quadrant of the map area. Phase Two was a transitional phase between ice flow away from Foxe Dome in its full glacial state and ice flow towards Foxe Basin after the collapse of the ice dome. It would have lasted only 100-200 years, based on the relative sea level curve, before establishment of Phase Three when sea level was 90m asl.

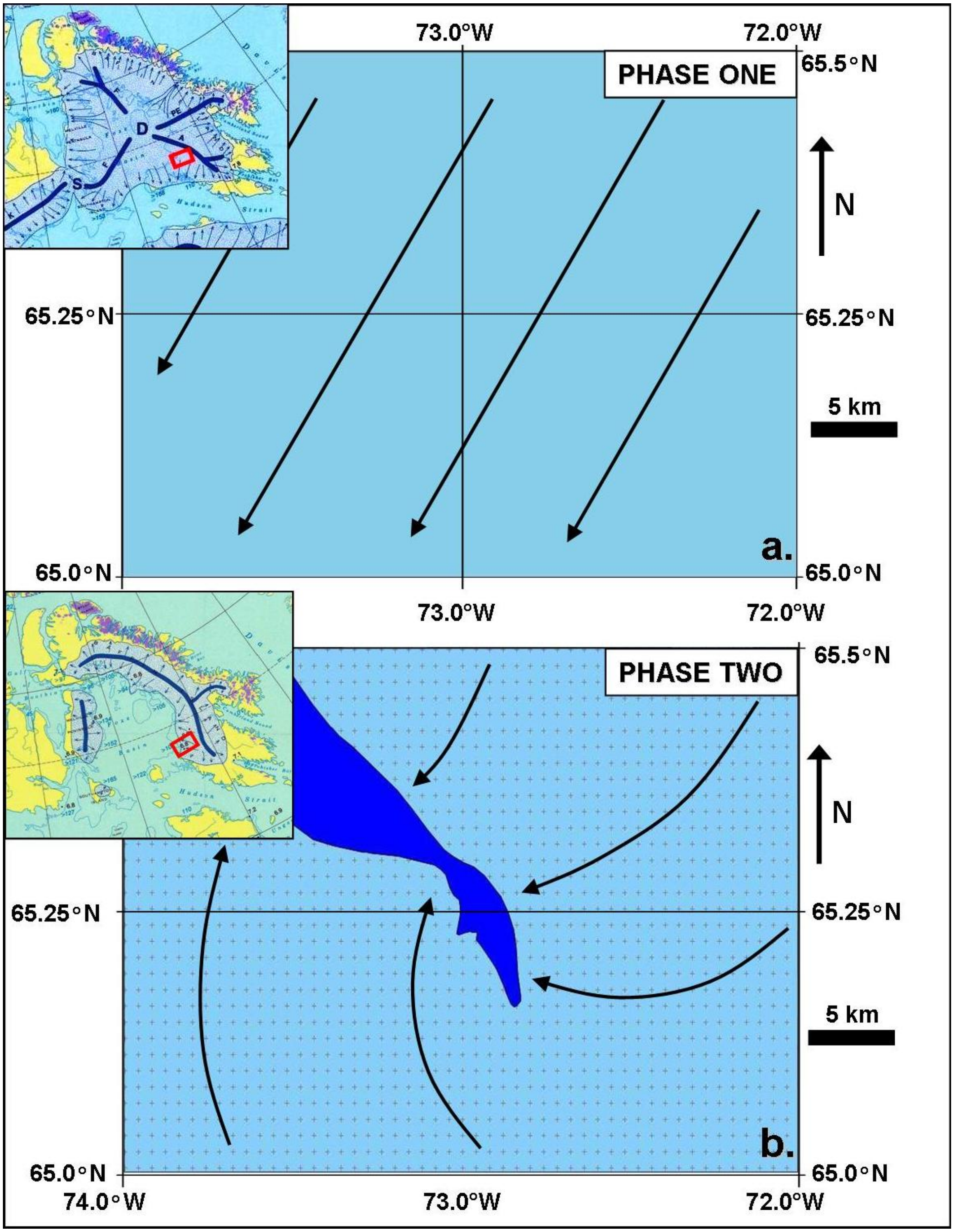


Figure 3.11: Phases of ice flow in Bluegoose Prairie. a) Maximum ice configuration while Foxe Dome ice is still grounded in Foxe Basin. Ice flow is southwest away from Amadjuak Divide. b) With collapse of the Foxe Dome, a channel opens up east of Putnam Highland, pulling flow towards the open water. Flow in southwest corner is still southwest. Large eskers form (dotted lines) in southeast and on Putnam Highland. Inset maps show distribution of Baffin Sector Ice during each phase.

Phase Three ice flow involved two distinct bodies of ice (Fig 3.12a). Glaciomarine deltas (GMd) throughout Bluegoose Prairie were deposited concurrently at an elevation of 80 to 90 m asl. Marine incursion of a second channel to the west caused a lobe of ice centred over the Putnam Highlands to be isolated from the main ice sheet. Ice flowed away from the centre of this isolated lobe, creating a radial pattern of flow in the centre of the map area, as evidenced by the pattern of meltwater channels and glaciofluvial deposits. Large areas of glaciofluvial outwash (GFpt) on Putnam Highlands indicate the presence of high volumes of meltwater, accelerating the downwasting of Bluegoose ice. This meltwater contributed to high sedimentation rates of glaciomarine deposits at the ice margin. The large kames on Putnam Highland were deposited along the western ice margin of Putnam ice, marking a relatively stable ice margin. Active retreat of this ice body left a series of moraine segments along the Putnam Highlands and in the south part of the map sheet.

In the eastern portion of the map sheet, northwest trending flutes and till plumes up to 80 km in length indicate rapid ice flow. This area of streamlined till has sharp margins (only the south margin is in the Bluegoose Prairie map area) that are not associated with any obvious topographic features. Till dispersal trains of similar scale were observed by Dredge (2000) on Melville Peninsula, who interpreted them to be evidence of an ice stream, an area of fast ice flow within a slower moving ice sheet. Rapid flow was facilitated by saturation of the carbonate-rich till beneath the ice, resulting high pore pressure, reducing sediment shear strength and causing deformation of the basal till. Any excess water could act as a glide plane between the ice sheet and its bed, increasing flow further (Dredge 2000). De Angelis and Kleman (2007) mapped an ice stream flowing northwest from Amadjuak Lake, across Bluegoose Prairie, to an active calving margin in Foxe Basin, based on observations from satellite images. Our observations in the field support this interpretation.

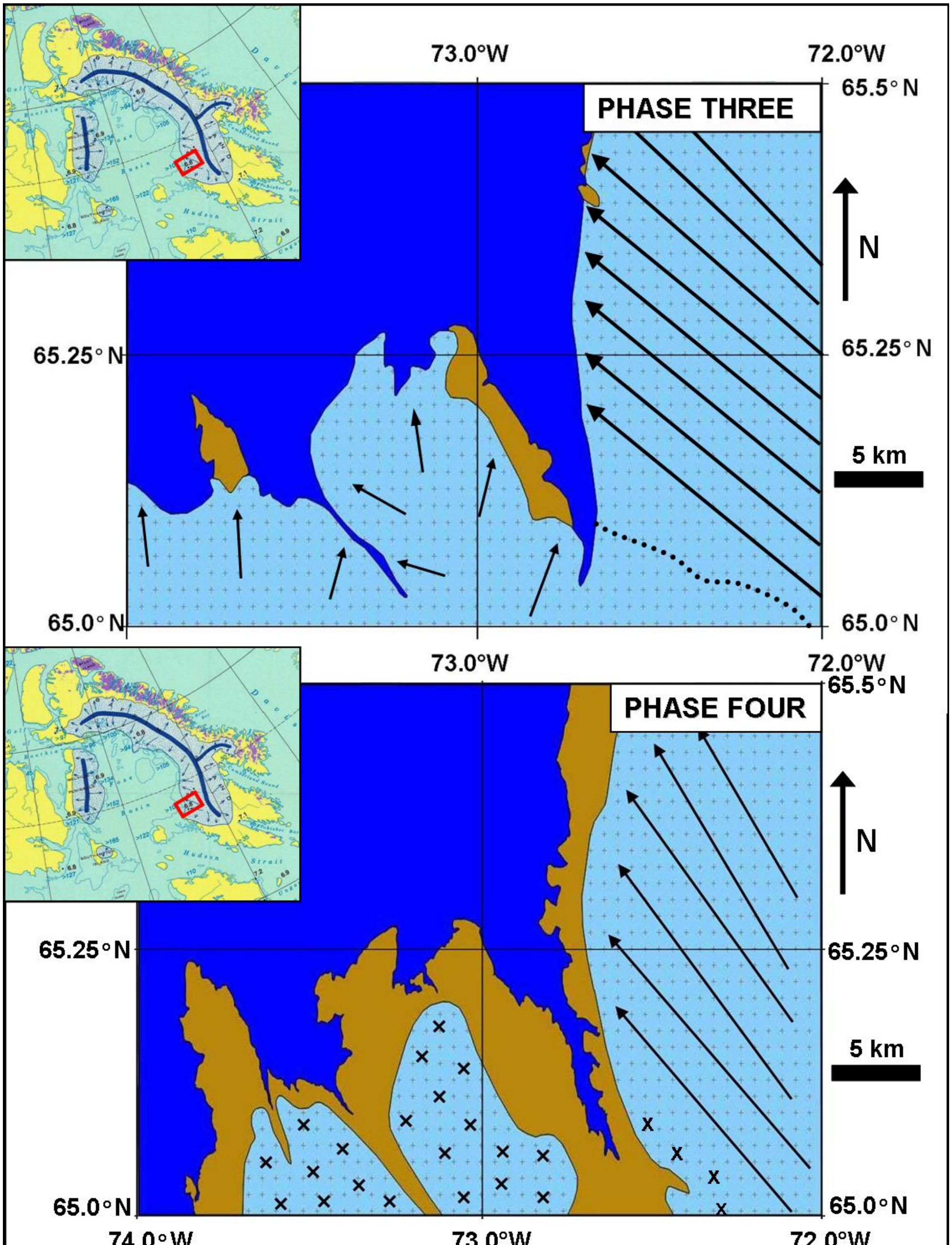


Figure 3.12: Phases of ice flow in Bluegoose Prairie. Phases Three and Four occur as Baffin Island ice retreats, and central Foxe Peninsula is submerged below raised sea levels. a) Marine incursion of a second channel west of Putnam Highland. Putnam ice retreats actively. In the east, ice flows rapidly NW toward a calving margin in Foxe Basin. b) Remaining Putnam Ice stagnates. Ice in east continues to flow NW, while the margin retreats.

The large esker in the southeast corner of the map acted as a conduit for large volumes of subglacial meltwater along the margin of the ice stream. Hummocky till southwest of the till plumes formed as shear moraine along the ice stream, and delineates the boundary between the fast flowing ice and slower ice to the west.

The final phase of ice flow (Fig 3.12b) occurred as the remains of the isolated ice lobe over the Putnam Highlands stagnated, depositing hummocky till. Ice in the southwest corner of the map sheet disappeared, allowing marine inundation to a marine limit of 80 m asl. Ice in the northeast continued to flow northwest, as the ice actively retreated, visible in successive ice margins marked by thick up-ice till and thin down-ice till. The last remnant of Laurentide Ice persisted over Amadjuak Lake, east of Bluegoose Prairie, until finally disappearing sometime before 4.5 ka ^{14}C BP (Blake 1966).

This deglacial history helps to explain the distribution of sediments and landforms in Bluegoose Prairie. The reconstruction of ice flow is important for drift prospecting and palaeogeographic reconstructions of the Baffin Sector of the Laurentide Ice Sheet. Areas of reversing ice flow or large changes in flow direction will confuse the signature from till samples. In addition, areas of limestone derived till could obscure potential mineralized bedrock. The ice flow history presented here should be considered during any mineral exploration in the area.

Conclusion

The map described in this chapter is a useful addition to the Geological Survey of Canada's database. It provides an interpretation of the ice flow history available to the public, mineral exploration companies, and Quaternary scientists.

Below marine limit, glaciomarine sediments are abundant. The soft limestone bedrock that covers most of the map area, combined with the lack of significant relief, results primarily in a flat blanket of till covering most of the area above marine limit. Glaciofluvial sediments are present mainly in the form of eskers and outwash fans.

Till dispersal trains, highlighted in satellite images by the colour difference between darker Proterozoic till and lighter limestone till, are the dominant feature of the map area, giving an indication of dominant ice flow regimes. Other landforms are more subtle, but include flutes, eskers, meltwater channels, and moraines, which all contribute to reconstructing the ice flow history of Bluegoose Prairie. The large relief of the major esker in the southeast and the ice marginal kames on Putnam Prairie indicates that high volumes of sediment and meltwater were present for at least part of deglaciation, or that deglaciation existed for a long time.

The glacial history of the area includes a long period of southwest ice flow across the Bluegoose Prairie, fed by the Foxe-Amadjuak Ice Divide during the LLGM. Once Foxe Basin deglaciated, ice over Bluegoose Prairie was divided into two masses, one flowing radially from the topographic high over Putnam Highlands, and the second flowing rapidly to the northwest across the eastern half of the map area, funnelling ice into Foxe Basin. Final deglaciation occurred with the stagnation of the western ice body, and continued retreat of the eastern ice body.

CHAPTER 4: PALAEOENVIRONMENT AND SEA LEVEL CHANGE

Introduction

This chapter presents an interpretation of the deglacial palaeoenvironment of Bluegoose Prairie. Deglaciation of Arctic Canada occurred during a time of rapid climate change. Reconstructing ecosystems from this period allows us a comparison of deglacial environmental conditions to modern conditions and to examine how climate has changed over time.

Palaeoenvironmental studies can be applied to predict landscape change as a result of future climate change, and the effects these changes will have on ecosystems. A relative sea level curve reconstructs the rate of isostatic rebound and eustatic sea level rise during and after deglaciation of Bluegoose Prairie. Ages on molluscs in this chapter are uncorrected for marine reservoir effect, which is described in detail in Chapter 4. The pattern of sea level change is compared to that previously investigated at other sites in the region. Fossil assemblages allow for the reconstruction of the terrestrial and marine environments of southwest Foxe Basin and Bluegoose Prairie following deglaciation of this region.

Methods

Natural exposures along river banks were identified, measured, and described. Four sections were sampled for terrestrial macrofossils: Aukpar section is located along the Aukpar River (Fig 4.1, #5), Ipigaq section is east of the Putnam Highlands (Fig 4.1, #6), and the two other sections are near Camp 1 from the 2007 field season (Fig 4.1, #7 and #10). Macrofossils observed in the field were carefully removed from section and stored in plastic bags in a cool, dark environment for lab analysis. Three kilogram bulk samples were collected from sedimentary beds containing organics. Marine molluscs were collected whenever observed throughout the study area, primarily from within sections, but from the surface where not otherwise available. Molluscs found in situ were photographed before removal.

In the field, marine molluscs were identified with reference to Dyke et al. (1996) and through consultation with D. Hodgson (Geological Survey of Canada). R. Hetherington (University of Victoria) provided further confirmation of ID for select samples once out of the field. In the lab, marine molluscs were selected for ^{14}C dating from a range of elevations. Preference was given to those found in life position, then to those not in life position, but with articulated valves, and finally to single valves with periostracum present. Where no samples were available in section from a specific elevation range, surface shells were selected for dating. Paleotec Services in Ottawa, ON prepared samples for ^{14}C dating. Radiocarbon analysis was done at the W.M. Keck Carbon Cycle Accelerator Mass Spectrometry (AMS) Laboratory at the University of California, Irvine (Southon et al. 2004).

Paleotec Services also processed the bulk samples for plant and insect macrofossils. The samples were soaked in warm water and sieved for macrofossils. Macrofossils larger than 425 microns (0.425 mm) were identified through comparison with herbarium and insect reference specimens at the Geological Survey of Canada in Ottawa, ON and with the aid of taxonomic keys and illustrations (Martin and Barkley 1961, Porsild and Cody 1980). Some macrofossils found in bulk samples were selected for AMS ^{14}C dating.

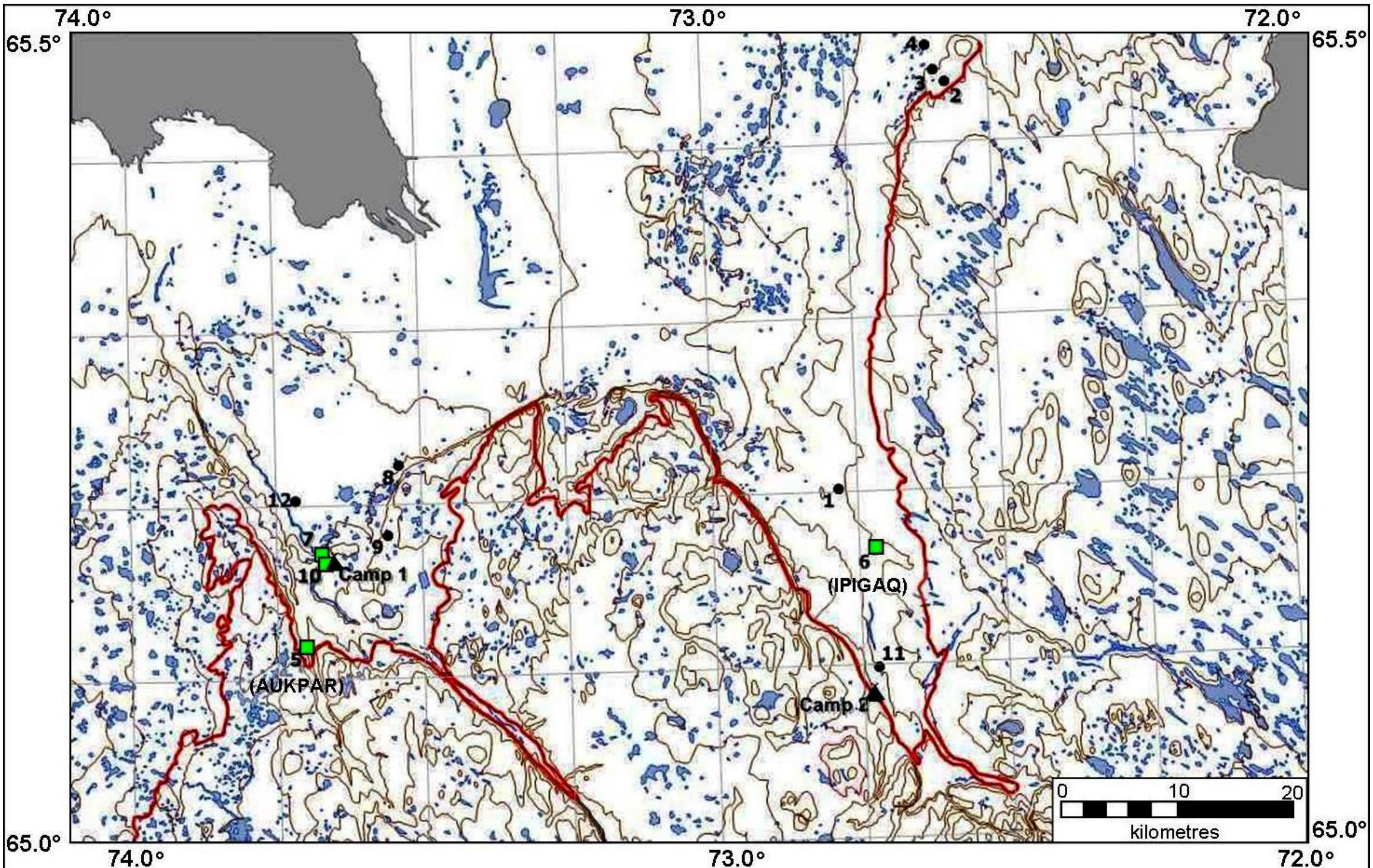


Figure 4.1: Locations of 2007 field camps and locations of ^{14}C-dated fossils. Black dots represent marine macrofossils, green squares represent both marine and terrestrial macrofossils. Numbers correspond with map numbers in Table 4.1. Red line is marine limit.

Results

Radiocarbon Ages

Mya truncata and *Hiatella arctica* were preferentially selected for ^{14}C dating. Both species are suspension feeders, limiting the risk of incorporating old carbon from the substrate, and both live in relatively shallow water, 5 – 40 m deep (Aitken et al. 1993). All of the terrestrial ^{14}C ages used for interpretation were measured from *Salix* sp. (willow). Mollusc samples were selected from a range of different locations and elevations from Bluegoose Prairie (Fig 4.1). Table 4.1 summarizes the ^{14}C data for Bluegoose Prairie. Nineteen out of the 23 samples dated provide ages that fit into the previously established timeline for the area. Four samples are outliers, as described below.

UCIAMS 40352 was collected from a section through offshore marine sediment (Fig 4.1, #7). The top of the section was 53 m asl, the sample was collected at 1.7 m depth, from a unit of horizontally bedded clayey-silt. It is a blackened stem or rhizome from an unidentified plant. It has a $\delta^{13}C$ value of -14. This is noteworthy because organisms that obtain their carbon entirely from marine sources, for example marine molluscs, have $\delta^{13}C$ values of approximately 0, while organisms that intake entirely atmospheric carbon have $\delta^{13}C$ values of approximately -27. The value of -14 indicates either that the sample is contaminated by marine material or that the plant lived in a brackish water or estuarine environment and obtained some of its carbon from marine waters. The age of UCIAMS 40352 is 6510 ± 20 ^{14}C yrs BP, 320 ^{14}C yrs older than the next oldest terrestrial sample. This older age can be explained by either scenario. UCIAMS 40352 is not used for any calculations or interpretation as it is not deemed a reliable age due to its anomalous $\delta^{13}C$ value.

UCIAMS 40353 is a *Potamogeton* sp. (pondweed) half seed collected from a section through offshore marine sediment (Fig 4.1, #10) at 57 m asl, with an age of 2050 ± 20 ^{14}C yrs BP. It was collected from a sediment lens of finely laminated fine sand within a massive silty-clay unit, 70 cm below the surface. Analysis of a bulk sample collected from this section found no other terrestrial macrofossils. While at the time of sampling the lens was believed to be of the same age as the surrounding sediment, the young age indicates it has been reworked from younger sediments by cryoturbation in the active layer; therefore, UCIAMS 40353 is rejected for use in this study.

The lowest elevation mollusc sample was UCIAMS 40420, collected from a hole dug in a coarse Proterozoic bedrock-provenance beach at 31 m. It was selected for dating because it was the only occurrence of molluscs found below 40 m asl. The age of 39 770 ± 390 ^{14}C yrs BP indicates it is reworked Mid-Wisconsinan material. It is not used in this study, but could be useful for establishing mid-Wisconsinan regional ice configuration, and an indication of marine conditions during this period, in future work.

UCIAMS 71229 is a large fragment of a *Mya truncata* valve from Ipigaq, described in Chapter Two, that gives the oldest marine age of the sample set, excluding UCIAMS 40420. The age of 7540 ± 20 ^{14}C yrs BP is 355 ^{14}C years, or nine standard deviations (σ) older than the next oldest age, so it is removed from the data set. It is unknown why this anomalously old age is obtained from this sample.

The four samples described above are removed from the data set for further calculations and interpretation of glacial history. However, it is noteworthy that UCIAMS 40352 and UCIAMS 71229 are both from Ipigaq section. Both give ages ~500 ^{14}C years older than other samples dated from the same section. Another possible interpretation is that these two ages date initial deglaciation. This would change glacial history reconstructions of the region, indicating that this part of Foxe Basin could have deglaciated ca. 7.5 ^{14}C ka BP, 500 ^{14}C years earlier than indicated by the other ^{14}C ages. If this is the case, this initial deglaciation would have been followed by a minor readvance and then a second and final deglaciation, dated by the other marine molluscs. This would help to explain the differences in marine limit from the east side of Putnam highlands and the northeast portion of the area. It would be valuable to ^{14}C date other molluscs from southern Foxe Basin to see if similar ages occur.

Table 4.1: Radiocarbon data and sample data for all samples dated in Bluegoose Prairie. Map #5 refers to Aukpar section and Map #6 refers to Ipigaq section, described in Fig 4.2. Shaded rows are terrestrial ^{14}C ages; all other rows are marine ^{14}C ages. Conventional ^{14}C ages and $\delta^{13}C$ values reported according to standards outlined by Stuiver and Polach (1977). *Samples are removed from data set for reasons discussed in the text.

Map #	UCIAMS #	Lat/Long (°N,°W)	Elev (masl)	Type	Species	Sample Description	δ13C	^{14}CAge (BP)	Error (+/-)
1	33278	65.252, 72.782	61	Surface	*Hiatella arctica*	Whole valve, leached	2.1	6925	20
2	33279	65.543, 72.574	101	Surface	*Mya truncata*	Whole valve, leached	3.4	7070	20
3	33280	65.552, 72.594	91	Surface	*Hiatella arctica*	Leached fragments	1.2	7065	20
4	33281	65.570, 72.607	80	Surface	Unknown mollusc	Poorly preserved fragments	2.0	6810	25
5	33282	65.148, 73.703	81	In section	*Mya truncata*	In situ, life position	0.9	7185	20
5	34409	65.148, 73.703	81	In section	*Salix* sp.	One leaf	-27	6190	20
5	48216	65.148, 73.703	81	In section	*Salix* sp.	Two leaves	-26.0	6165	20
6	48456	65.207, 72.725	73	In section	*Mya truncata*	In situ, life position	1.9	7005	20
6	33283	65.207, 72.725	73	In section	*Mya truncata*	Articulated	2.5	7155	25
6	33365	65.207, 72.725	73	In section	*Salix* sp.	Well preserved twig	-27.0	6160	20
6	71218	65.207, 72.725	73	In section	*Salix* sp.	Well preserved catkin	?	6030	25
6	71228	65.207, 72.725	73	In section	*Hiatella arctica*	Paired valves, disarticulated	0.3	7090	15
6	71229*	65.207, 72.725	73	In section	*Mya truncata*	Large fragment	1.3	7540*	20
7	40418	65.215, 73.676	53	In section	*Hiatella arctica*	Whole valves, well preserved	-0.4	6975	20
7	40419	65.215, 73.676	53	In section	*Clinocardium ciliatum*	Articulated, in situ	0.1	6855	25
7	40352*	65.215, 73.676	53	In section	Unknown Plant	Silicified blackened twig or rhizome	-14	6510*	20
8	40420*	65.278, 73.538	31	Surface	Unknown mollusc	Poorly preserved fragments.	1.9	39770*	390
9	40421	65.228, 73.559	75	In section	*Mya truncata*	Matching valves, disarticulated	1.9	6895	20
10	40422	65.210, 73.663	57	In section	Unknown mollusc	Whole valves	1.6	6770	20
10	40353*	65.210, 73.663	57	In section	*Potamogeton* sp.	1/2 seed in sediment lens	-29	2050*	20
10	40423	65.210, 73.663	57	In section	*Hiatella arctica*	Paired valves, life position	1.7	7025	20
11	40424	65.123, 72.724	76	In section	*Mya truncata*	Hinge fragment, periostracum intact	1.8	7020	20
12	48247	65.254, 73.716	43	Surface	Unknown mollusc	Poorly preserved fragments.	0.6	6350	20

Terrestrial Macrofossils

Paleotec Services prepared two reports describing the macrofossil assemblages from bulk samples collected at Aukpar (Telka 2008a) and Ipigaq (Telka 2008b), and the present living environment of each organism. A bulk sample from Site #10 (Fig 4.1) was also analyzed, but no macrofossils, other than one half-seed of pondweed (UCIAMS 40353) were found. The information contained in this section is derived from the two Paleotec reports, unless otherwise indicated. Aukpar is 17 m higher than Ipigaq and ~130 ^{14}C years older, based on ^{14}C ages from both sections (Table 4.1). Table 4.2 and 4.3 present the biological assemblages collected at Aukpar and Ipigaq, respectively. Macrofossils in this study are used to gain a general model of palaeoclimate.

Table 4.2: Macrofossil assemblage identified from bulk sample taken at Aukpar section (65.148°N, 73.703°W, 81m asl)

AUKPAR		
Scientific Name	Common Name	Item(s) Found
PLANTS		
Fungi		68 sclerotia
Algae (Characeae) *Chara/Nitella*	Stonewort	9 oogonia
Bryophytes	Mosses	3 operculi (fruiting bodies), many fragments
Equisetum sp.	Horsetail	16 stem fragments
Spargnium hyperboreum	Bur-reed	1 seed
Potamogeton filliformis	Pondweed	18 seeds, 1 half seed
Poa sp.	Grasses	7 floret + caryopsis, 19 caryopses, 7 florets
Carex lenticular type	Sedges	6 seeds, 1 seed with partial perigynium
Carex trigonous type	Sedges	3 seeds
Kobresea sp.	Sedges	3 seeds
Juncus sp.	Rush	1 seed
Salix sp. *S. arctica/arctophila,* *S. herbacea, S. reticulate*	Willow (arctic willow most common)	105 leaves, 7 delicate twigs, 30 seed capsules, 30 seed half-capsules, 10 persistent buds, 2 catkins
Polygonum viviparum	Buckwheat	14 bulbils
Caryophyllaceae *Cerastium* sp. *Silene uralensis*	Pink Family Mouse-Ear Chickweed Nodding Campion	 8 seeds from 2 species 2 seeds
Ranunculus aquatilis L.type	White Water Buttercup	2 seeds, 1 half seed
Papaver sp.	Poppy	3 seeds

Brassicaceae (Cruciferae) *Arabis* type *Draba* type	Mustard Rock Cress n/a	16 seeds 6 seeds 59 seeds
Saxifragaceae *Saxifraga oppositifolia* *Saxifraga* smooth type *Saxifraga* verruscose type *Saxifraga* tuberculate type	Saxifrage Purple Saxifrage n/a n/a n/a	 5 leaves 1 seed, 1 half seed 2 seeds 1 seed
Rosaceae *Dryas integrifolia* *Potentilla* sp.	Rose Family Mountain Aven Cinquefoil	 20 seeds, ~50 leaves 2 seeds
Haloragaceae *Myriophyllum sibiricum* *Hippuris vulgaris*	Water Milfoil n/a Mare's Tail	 5 seeds 2 seeds
Empetrum nigrum	Heath	2 seeds
Asteraceae (Compositae)	Aster Family	17 seeds from 2 genuses
Unidentified macrofossil taxa		3 poorly preserved seeds
Net-veined leaf		small fragments
Twigs		with and without bark, some rounded

ANIMALS

Foraminifera	Forams	>62 trilobite shape, 2 football shape
Tubellaria	Flatworms	8 cocoons
Cristatella mucedo	Bryozoa	5 statoblasts
Nereidae	Ragworm	1 mandible
Carabidae *Elaphrus* sp. *Pterostichus* sp.	Ground Beetles	1 half elytron (poorly preserved) 1 small basal elytron fragment 1 elytron
Trichoptera	Caddisflies	10 larva thoracic fragments, 5 larva half head capsules
Diptera	Flies	1 pupa fragment, many adult soft chitinous fragments
Tipula sp.	Crane Flies	4 immature head capsules, 2 half head capsules
Chironomidae	Midges	90 larvae head capsules, 20 half head capsules, 82 adult thoracic fragments
Ichneiumonidae	Wasps and Ants	2 thoracic fragments
Daphnia sp.	Water Fleas	6 ephippia
Lepiduris sp.	Tadpole Shrimp	2 mandibles
Ostracoda	Ostracodes	16 articulated valves, 37 valves from 2 types
Oribatei	Oribatid Mites	2
Araneae	Spiders	2 cephalothorax
Gastropoda	Snails, Limpets	1 small snail, 1 shell fragment
Pelecypoda	Clams, Mussels	9 small (mm-sized valves), 9 shell fragments
Small mammal feces		1 pellet, 1 half pellet

Table 4.3: Macrofossil assemblage identified from bulk sample taken at Ipigaq section (65.207°N, 72.725°W, 73m asl).

IPIGAQ		
Scientific Name	Common Name	Item(s) Found
PLANTS		
Fungi		15 sclerotia
Algae (Characeae) *Chara/Nitella*	Stonewort	4 oogonia
Bryophytes	Mosses	mostly stem fragments
Equisetum sp.	Horsetail	1 stem fragment
Potamogetum sp.	Pondweed	74 seeds, 16 half seeds
Poaceae	Grass Family	1 grain
Carex lenticular type	Sedge	67 seeds, 3 partial seeds
Salix sp.	Willow	3 twigs, 3 seed capsules, 6 seed half capsules, 3 persistent buds, 1 leaf
Betula glandulosa/nana	Dwarf Birch	1 seed
Ranunculus aquatillis	White Water Buttercup	3 seeds, 1 half seed
Brassiceceae (Cruciferae) *Draba* type	Mustard Family	10 seeds
Haloragaceae *Myriophyllum sibiricum* *Hippuris vulgaris*	Water Milfoil	 3 seeds 5 seeds
Menyanthes trifoliata	Buckbean	4 seeds, 4 half seeds
Unidentified plant taxa		1 half seed
Charcoal		5 fragments
Net-veined leaf		few small fragments
Wood		small rounded 'flakes'
Twigs		very few (except for some willow)
ANIMALS		
Foraminifera	Forams	75 trilobite shape, 1 sputnik shape
Hydra sp.	Hydroids, Jellyfish, Anemones	4 ectoderm tissue (~1.0 cm long)
Cristatella mudedo L.	Bryozoan	2 statoblasts, 13 half statoblasts
Nereidae	Rag worms	7 mandibles
Coleoptera *Dyschiriodes sp.*	Beetles Ground Beetle	1 tibia, 1 mandible 1 half elytron
Chironomidae	Midges	1 adult thoracic fragment
Lepiduris sp.	Tadpole Shrimp	2 mandibles
Ostracoda	Ostracodes	1 articulated valve, 6 valves
Pelecypoda	Clams, Mussels	shell fragments
Small mammal feces		1 pellet
Fish		1 vertebra

Both Aukpar and Ipigaq samples contain a variety of plant and animal species, with the Aukpar assemblage being more abundant and diverse. Most species are found at both sites. The Aukpar bulk sample contained 3.3% organics by volume, and Ipigaq 4.2%. Fossil preservation at Aukpar was very good and at Ipigaq was fair to poor with oxidation present.

Willow (*Salix*) (Fig 4.2) and mountain aven (*Dryas integrifolia*) leaves dominate the Aukpar assemblage. The four willow species identified grow in damp tundra where snow remains late. Mountain aven is a pioneer species that inhabits damp sites of wet meadows, margins of ponds, marshes, along streams, and river terraces. The Ipigaq assemblage contains a few willow macrofossils and no mountain avens. Ipigaq contains one dwarf birch (*Betula glandulosa*) seed, which was absent from Aukpar. Dwarf birch is a key identifying species for the low arctic bioclimatic zone (Jacobs et al. 1997), and grows mainly on acidic rocks and gravel.

Many of the species found in both assemblages are aquatic, including pondweed (*Potamogeton filiformis*), white water buttercup (*Ranunculus aquatilis*), water milfoil (*Myriophyllum sibiricum*), and freshwater algae (*Chara/Nitella*) (Fig 4.3). Pondweed is a circumpolar submerged plant, low arctic in distribution. White water buttercup and water milfoil both inhabit shallow calcareous ponds. *Chara/Nitella* is commonly called stonewort; it prefers lime-rich water with a high pH and usually grows in shallow water. Emergent shoreline species in both samples include mare's tail (*Hippuris vulgaris*) and several sedge species (*Carex* spp.). Aukpar also contains bur-reed (*Sparganium hyperboreum*) and bog-rush (*Juncus* sp), while Ipigaq contained buckbean (*Menyanthes trifoliata*).

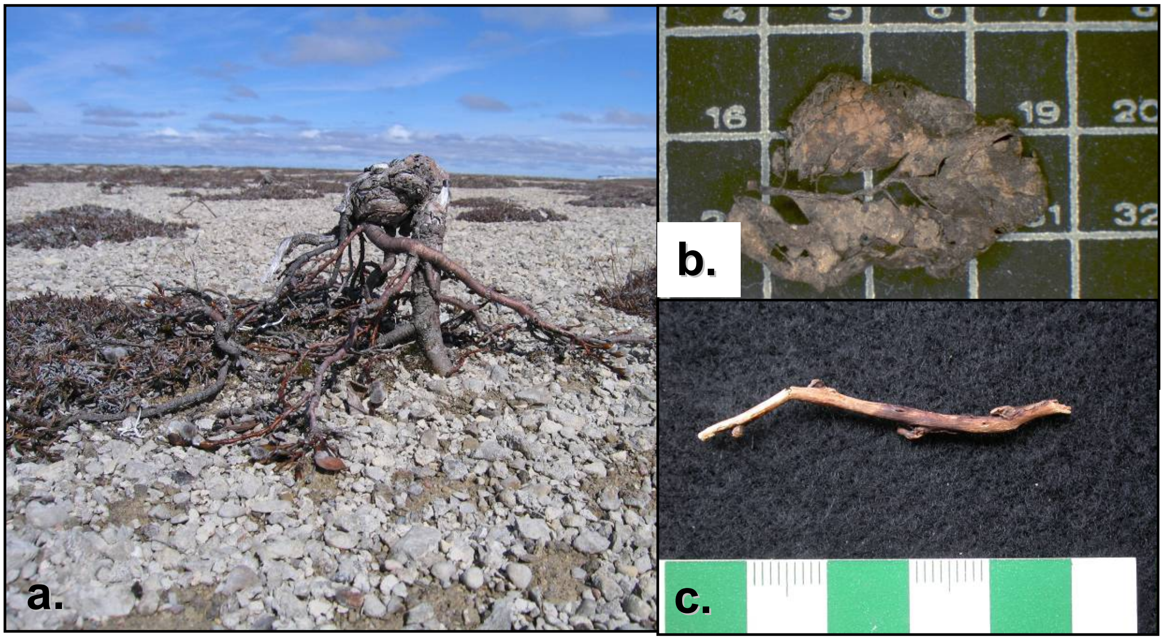


Figure 4.2: Examples of *Salix* (willow). a) A 20 cm willow shrub growing in Bluegoose Prairie today. b) UCIAMS 48216, a *Salix* leaf that yielded an age of 6165 ± 20 (grid is 4mm x 4mm). c) UCIAMS 33365, a *Salix* twig that yielded an age of 6160 ± 20. Photos b and c by Alice Telka, Paleotec Services.

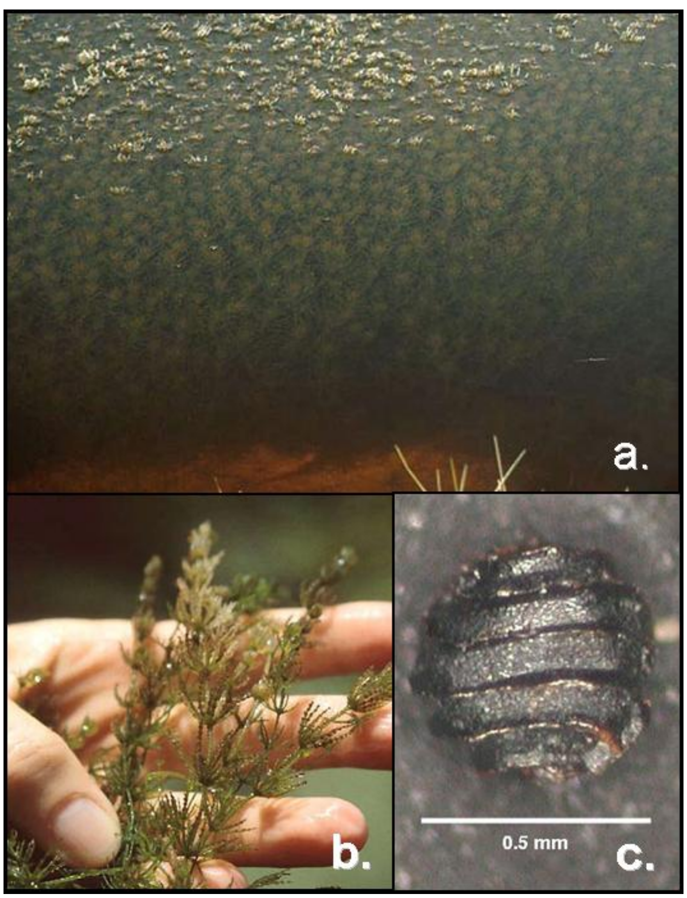


Figure 4.3: Examples of *Chara/Nitella* (freshwater algae). a) dense growths of freshwater algae in a shallow pond. b) close-up of *Chara/Nitella*. c) macrofossil of a *Chara/Nitella* oogonium from Aukpar. Photos a and b by Ann Murray, University of Florida / IFAS Center for Aquatic and Invasive Plants. Photo c by A.Telka, Paleotec Services.

The remaining plant macrofossils found represent species that prefer shorelines and damp lowlands. Mustard family plants (*Draba*) grow in snow beds, moist tundra, in clay on wet/dry gravelly barrens, or calcareous, rocky barrens and sunny slopes. Two species of rock cress occur on Baffin today; it grows on moist but well drained places such as wet meadows or near running water, and on calcareous sand and gravel, commonly by lakeshores or riverbanks. Two members of the pink family occur: mouse-ear chickweed (*Cerastium* sp.) likes rocky, gravelly, or sandy places; nodding campion (*Silene uralensis*) is common in wet tundra, moist meadows along lagoons and lakeshores, in moss by alpine brooks, or in wet clay on gravelly barrens. Purple saxifrage (*Saxifraga oppositifolia*) is common in moist, calcareous gravels.

Animal macrofossils, although not as abundant or diverse as plant macrofossils, are significant. Forams (Foraminifera) and ragworms (Nereidae) inhabit saline environments, including estuaries, inshore waters, hypersaline lagoons, and intertidal areas, and were found in both assemblages. The rest of the animal species inhabit shallow, still bodies of freshwater. Bryozoans (*Cristatella mucedo*) prefer calm or slow water with suspended organic matter and phytoplankton. Tadpole shrimp live at the sediment-water interface of aquatic habitats. Ostracodes (Ostracoda) are bottom-dwelling organisms that prefer organic-rich, well defined clay- to fine silt-textured sediment in low energy environments. Water fleas (*Daphnia* sp.) inhabit any quiet freshwater bodies. They are present in the Aukpar sample only, while *Hydra* sp. (a freshwater relative of jellyfish and anemones), which feeds on water fleas, are found in Ipigaq.

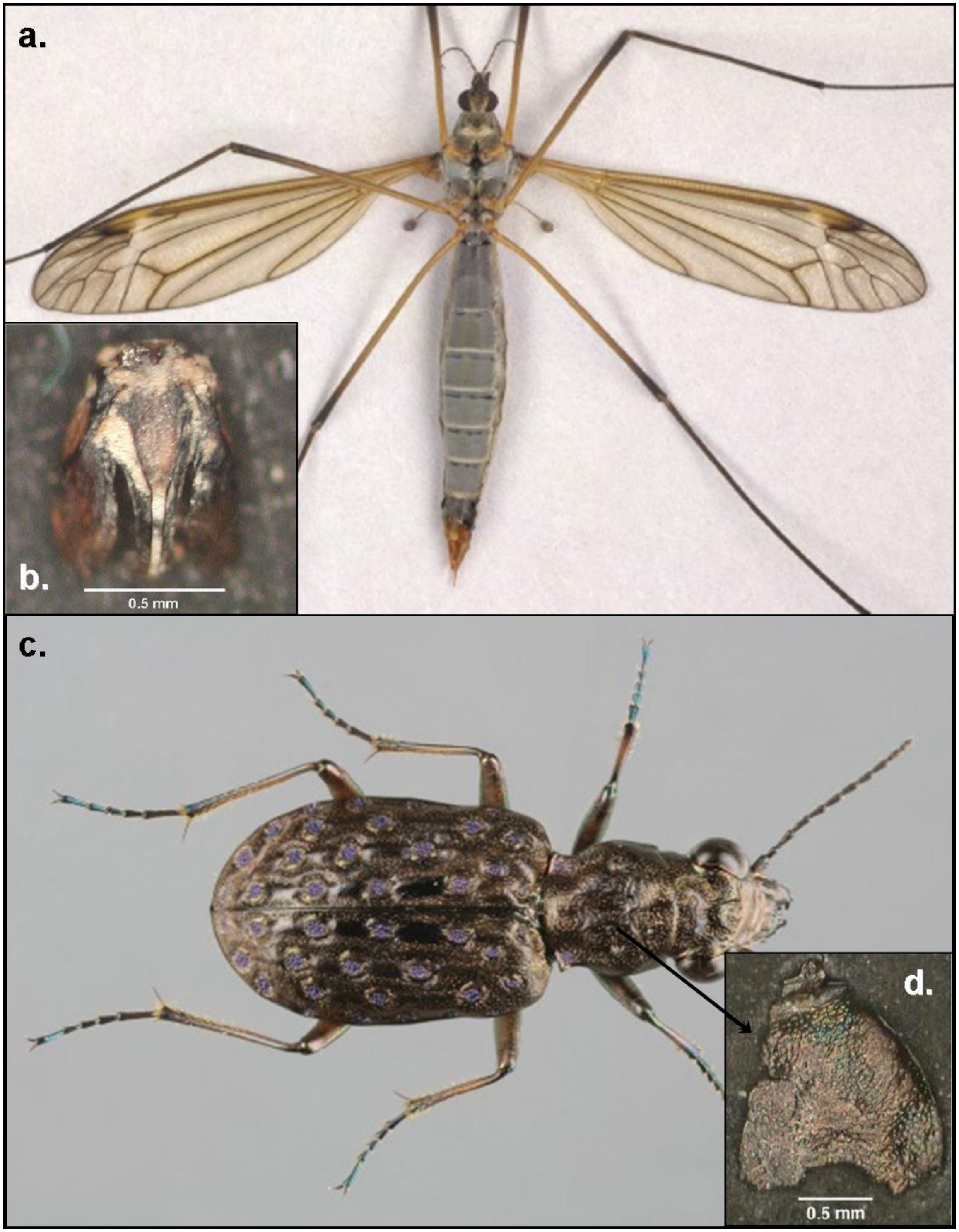


Figure 4.4: Examples of insect macrofossils collected in Bluegoose Prairie. a) Adult crane fly (*Tipula* sp.). b) Magnified image of crane fly head collected from Aukpar. c) Adult ground beetle (*Elaphrus* sp.), a riparian species. d) Magnified image of beetle elytron fragment collected from Aukpar. Photos a and c are copyright Malcolm Storey, www.bioimages.org.uk. Photos b and d are by A. Telka, Paleotec Services.

Aquatic insects found in the Aukpar sample include caddisfly (Trichoptera) larvae, midge (Chironomidae) larvae and adults, and immature crane flies (*Tipula* sp.) (Fig 4.4a,b). All of these insects live in freshwater environments. The ground beetle (*Elaphrus* sp.) is a riparian species, which, alone of all the animal species found, indicates the presence of moving water (Fig 4.4c,d). Insect macrofossils are rare in the Ipigaq sample, consisting of one half elytron of a ground beetle (*Dyschiriodes*) and an adult thoracic fragment of a midge (Chironomidae). *Dyschiriodes*, like *Elaphrus*, is a riparian beetle. A few freshwater molluscs (Pelecypoda and Gastropoda) also occur in both assemblages, indicating an alkaline environment needed to provide calciferous material for forming shells.

Discussion

Deglaciation and Relative Sea Level

Of the 19 accepted ages, the oldest is 7185 ± 20 ^{14}C BP (UCIAMS 33282). This age was measured on a *Mya truncata* specimen collected in life position from Aukpar, 81 ± 5 m asl, ~15 m below local marine limit. Seven other marine molluscs collected also provided ages greater than 7.0 ^{14}C ka BP. Previous ages on marine molluscs from Bluegoose Prairie were 6830 ± 150 ^{14}C BP and 6590 ± ^{14}C BP (Blake 1966). These previous ages are from the GSC lab, where ^{14}C ages are corrected to δ^{13}C of 0‰, instead of the conventional -25‰, essentially correcting them for a 400 ^{14}C year mean global reservoir age. Therefore, equivalent conventional ages for these previous samples would be ~7.2 ^{14}C ka BP and 7.0 ^{14}C ka BP.

Table 4.4: Radiocarbon data for marine molluscs dated in Bluegoose Prairie, with corrections for modern reservoir age (McNeely et al. 2006) and deglacial reservoir age. Deglacial reservoir-corrected ages are used to construct the relative sea level curve (Fig 4.5).

UCIAMS #	Elev (masl)	Type	Species	δ13C	Conventional ^{14}C age[1] (BP)	Error (+/-)	Modern R-corrected ^{14}C age[2] (BP)	Error (+/-)	Deglacial R-corrected ^{14}C age[3] (BP)	Error (+/-)
33279	101	Surface	*Mya truncata*	3.4	7070	20	6350	35	6085	30
33280	91	Surface	*Hiatella arctica*	1.2	7065	20	6345	35	6080	30
33282	81	In section	*Mya truncata*	0.9	7185	20	6465	35	6200	30
33281	80	Surface	Unknown mollusc	2.0	6810	25	6090	40	5825	35
40424	76	In section	*Mya truncata*	1.8	7020	20	6300	35	6035	30
40421	75	In section	*Mya truncata*	1.9	6895	20	6175	35	5910	30
48456	73	In section	*Mya truncata*	1.9	7005	20	6285	35	5300	30
33283	73	In section	*Mya truncata*	2.5	7155	25	6435	40	6020	35
71228	73	In section	*Hiatella arctica*	0.3	7090	15	6370	30	6105	25
33278	61	Surface	*Hiatella arctica*	2.1	6925	20	6205	35	5940	30
40422	57	In section	Unknown mollusc	1.6	6770	20	6050	35	5785	30
40423	57	In section	*Hiatella arctica*	1.7	7025	20	6305	35	6040	30
40418	53	In section	*Hiatella arctica*	-0.4	6975	20	6255	35	5990	30
40419	53	In section	*Clinocardium ciliatum*	0.1	6855	25	6135	40	5870	35
48247	43	Surface	Unknown mollusc	0.6	6350	20	5630	35	5365	30

[1]Conventional ^{14}C ages reported according to standards outlined by Stuiver and Polach (1977).

[2]Modern R-corrected age = Conventional ^{14}C age – 720 ± 15 ^{14}C years (McNeely et al. 2006)

[3]Deglacial R-corrected age = Conventional ^{14}C age – 985 ± 10 ^{14}C years

Marine ^{14}C ages for Bluegoose Prairie are corrected for deglacial marine reservoir age of 985 ± 10 ^{14}C years in Table 4.4. Corrections to modern marine reservoir age of 720 ± 15 ^{14}C years for Foxe Basin (McNeely et al. 2006) are provided for comparison. The new deglacial reservoir-corrected ages provide a minimum age of deglaciation of ~6.2 ^{14}C ka BP. The most recent reconstruction of the Laurentide Ice Sheet shows Foxe Basin completely ice covered at ca. 7.0 ka ^{14}C BP, and ice-free at ca. 6.5 ka ^{14}C BP, based on modern reservoir corrections (Dyke 2004). These new ages, combined with the deglacial reservoir age, indicate Foxe Dome may have persisted longer than previously thought.

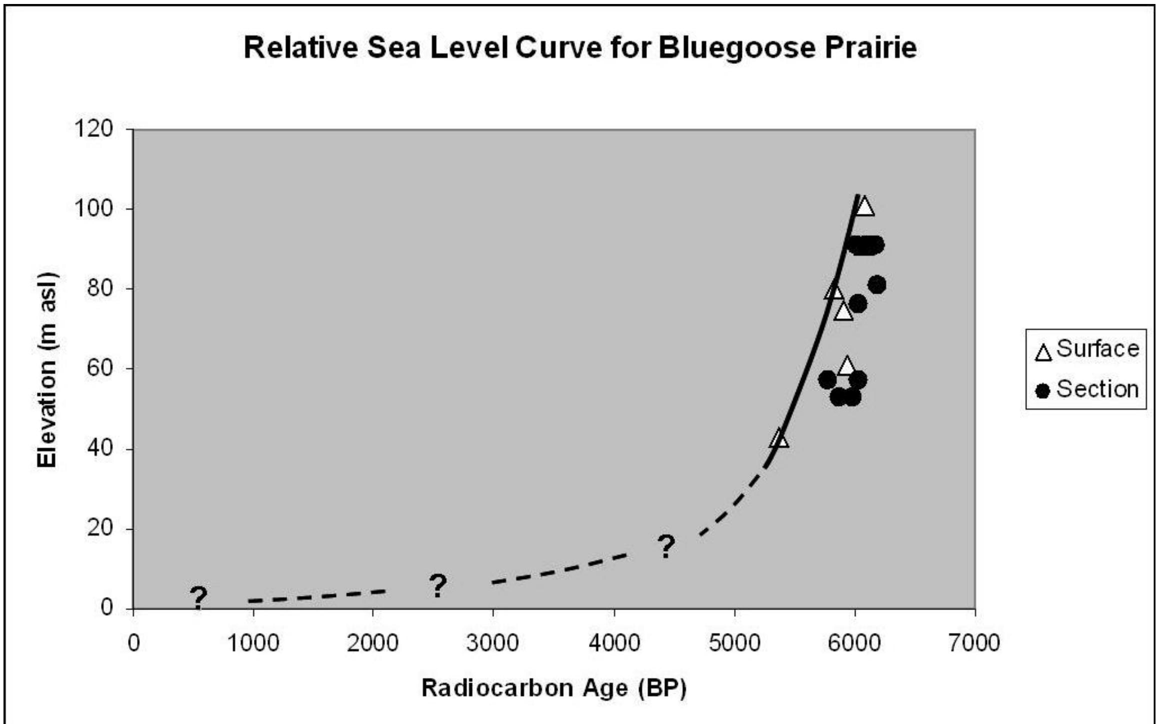


Figure 4.5: Relative sea level curve for Bluegoose Prairie based on mollusc ^{14}C ages presented in Table 4.4. Ages have been corrected for deglacial reservoir age of 985 ± 10 ^{14}C years. Error bars are too small to appear on the scale of the graph (elevation ± 5, ^{14}C age ± 25-35).

A relative sea level curve is presented for Bluegoose Prairie using mollusc ^{14}C ages (Fig 4.5). Samples collected from in section fall on or below the curve as they lived below sea level. Samples collected from the surface fall on or slightly below the curve, as they lived at depth but most likely washed up on shore at sea level. There is more variance in curves based on mollusc ages, which approximate sea level, than in curves based on samples that precisely mark a specific beach level (e.g., driftwood and whale bones) (Dyke et al. 1996). The curve is therefore drawn subjectively by hand, assuming it is generally exponential. The exact shape of the curve is difficult to assess as no samples were found below 43 m asl, however the most likely pattern is continuous postglacial emergence as Foxe Peninsula was heavily loaded during the Last Glacial Maximum. Bluegoose Prairie, therefore, falls within sea-level zone 1, as is predicted by its location (Clark et al. 1978). As sea level dropped, the shoreline migrated northwest to its current location. Bluegoose Prairie is still an area of active postglacial uplift.

The Bluegoose Prairie relative sea level curve is compared to others from the area (Fig 4.6). Curves for areas surrounding Foxe Basin and Hudson Strait all show continuous postglacial emergence, with rapid initial emergence. The exception is the curve for Ajaqutalik on Melville Peninsula, which indicates a period of relative standstill from 6.0 to 5.0 ^{14}C BP, followed by continued emergence (Dredge 1995). This break in the curve is based on a single marine mollusc age. If this age is eliminated, the Ajaqutalik curve follows the same exponential emergence pattern as the other curves. Marine limits in the region range from 90 m asl near Kimmirut, NU (Hodgson 2005) to 140 m asl on the east coast of Melville Peninsula (Dredge 1995).

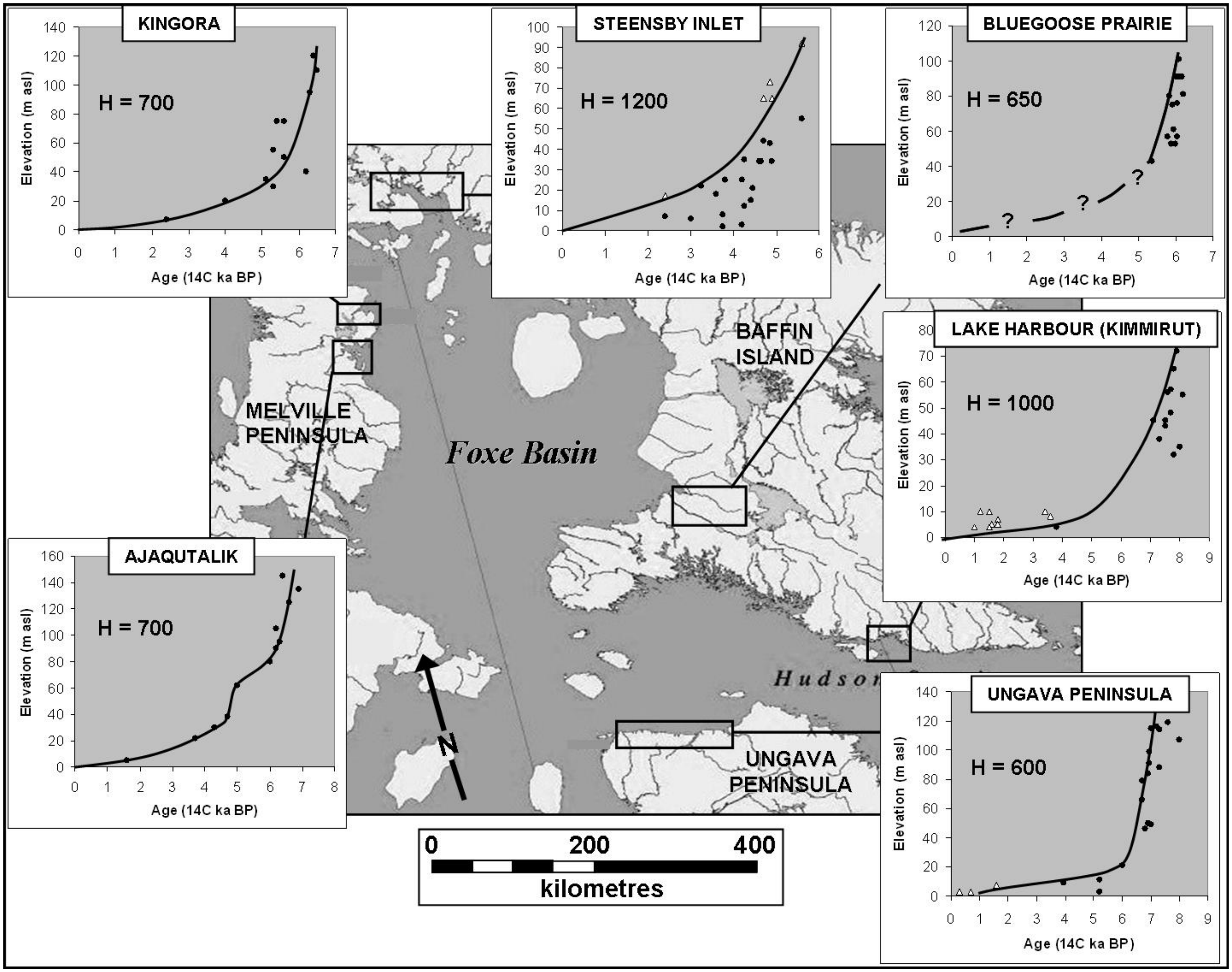


Figure 4.6: Relative sea level curves for other areas bordering Foxe Basin and Hudson Strait. Clockwise from left: Kingora and Ajaqutalik curves from Dredge 1995, Steensby Inlet curve from Dyke 2007, Lake Harbour curve from Hodgson 2005, Ungava curve from Matthews 1967a. White triangles represent bone, wood, etc. which fall on or above the curve. Black dots represent marine molluscs, which fall on or below the curve. H is the curve half-life, in ^{14}C years.

The Bluegoose Prairie relative sea level curve is based on the shape of nearby curves below 40 m asl and therefore is theoretical below that elevation, but curve half-life can be estimated to be ~650 ^{14}C years. Curve half-life is the time taken to accomplish half of remaining emergence (Dyke and Peltier 2000). Average curve half-life for sites near the centre of the Laurentide Ice Sheet (Foxe Basin and Hudson Bay) is 1.2-1.4 ^{14}C ka (Dyke and Peltier 2000). Bluegoose Prairie demonstrates rapid uplift relative to these values. Other relative sea level curves in the region also demonstrate low half-lives (Fig 3.6). The two Melville Peninsula curves (Dredge 1995) have half lives of ~700 ^{14}C years and the Ungava curve (Matthews 1967a) has a half life of ~600 ^{14}C years. The relative sea level curve for Frobisher Bay, 300 km to the east, has a curve half-life of 700 ^{14}C years (Dyke and Peltier 2000). Steensby Inlet (Dyke 2007) and Lake Harbour (Hodgson 2005) have curve half-lives of 1200 ^{14}C years and 1000 ^{14}C years, respectively, which could signify restrained rebound under ice that persisted longer in these areas. These two locations also have the lowest marine limits in the region, supporting the idea of restrained rebound.

Marine Palaeoenvironment

Southwest Foxe Basin today lies in the arctic-subarctic marine transition zone (Dyke et al. 1996). The majority of marine molluscs found in this zone are *Mya truncata* and *Hiatella arctica.* Both of these species can tolerate long winters with temperatures below 0 °C and seasonally varying salinities, such as from meltwater. Both molluscs can also survive the abrasive action of sea ice in the intertidal zone (Dyke et al. 1996), which may explain why they are relatively abundant in samples. Syvitski et al. (1989) observed that *Mya truncata* and *Hiatella arctica* populations establish themselves in deglacial environments once the ice margin has retreated onto land and sedimentation rates are still relatively high. Once the ice margin has retreated more than 20 km from the shoreline, sediment discharge is reduced and these two species are replaced by other assemblages (Syvitski et al. 1989).

Marine molluscs collected from Bluegoose Prairie include *Mya truncata, Hiatella arctica*, *Clinocardium ciliatum*, *Portlandia arctica*, *Macoma calcarea*, *Serripes groenlandicus*, and *Astarte borealis*. Gastropods and loose barnacle fragments were also collected. The purpose of collecting marine fossils was for ^{14}C dating, and identification of molluscs was done primarily to ensure the consistency of mollusc species chosen for dating, therefore the list of mollusc species is not exhaustive.

All of the species collected from raised marine sediments are represented in the region today (Dyke et al. 1996), however no modern molluscs have been collected at Bluegoose Prairie, so the exact assemblage present today is unknown. Three mollusc species dating 6-6.5 ^{14}C ka BP have been collected in Frobisher Bay that are not found in Arctic Canada today: *Volsella demissa*, *Nucula delphinodonta*, and *Lyonsia hyaline*, suggesting more favourable environmental conditions than today (Matthews 1967b). Only *Mya truncata* and *Hiatella arctica* have been recorded living in Frobisher Bay (Matthews 1967b). It is unknown whether *V.demissa, N.delphinodonta*, or *L.hyaline* exist in deglacial Bluegoose Prairie assemblages, as identification of samples was not exhaustive. As Frobisher Bay and southwest Foxe Basin are at similar latitude, it is possible that marine conditions in southwest Foxe Basin were also more favourable 6-6.5 ^{14}C ka BP than today.

Very few molluscs were found below 50 m asl. The lowest sample was collected at 43 m asl and yielded the youngest marine ^{14}C age of 6350 ^{14}C BP. The only occurrence of mollusc fragments below that elevation is mid-Wisconsinan in age (UCIAMS 40420). Dyke et al (1996) present two ideas to explain why relatively few molluscs younger than 6 ka ^{14}C BP have been collected in the region:

1) A decrease in interest may exist within the scientific community in dating molluscs well below marine limit.

2) A dynamic deglacial environment had higher meltwater flux and water mass turnover, which may have created greater number and variety of habitats. High sedimentation rates during deglaciation may have enhanced preservation.

In light of the lack of molluscs found in Bluegoose Prairie, despite actively searching for them, I believe the second of the two hypotheses to be the main cause for the small number of samples collected younger than 6 ^{14}C ka BP. Sections in marine sediments do not exist below 50 m asl, likely because of the very low gradient. No shells were found on the surface or in mud boils below 43 m asl. The relatively impoverished assemblage of modern molluscs from similar-latitude Frobisher Bay supports the interpretation that late Holocene conditions are less favourable for mollusc growth and preservation.

The diverse mollusc assemblage observed in Bluegoose Prairie 6-7 ^{14}C ka BP compared to the paucity of marine fossils in younger sediments may also reflect a warmer marine environment immediately following deglaciation of Foxe Basin. Other studies have found temperatures were slightly warmer than present throughout the North Atlantic and Arctic oceans from 8.5-2.5 ^{14}C ka BP (Andrews 1972, Williams et al. 1995).

Terrestrial Palaeoenvironment

The two terrestrial assemblages represent a cross section of life living in Bluegoose Prairie at a particular point in time. Both contain a collection of aquatic plants and animal fossils that indicate shallow freshwater. The water bodies in both cases were possibly ephemeral, due to the absence of aquatic beetles. Absence of these beetles could also be a result of sample size. Leaves, twigs, and seeds indicate the presence of shoreline shrubs and ground-hugging plants and flowers. The difference in shrub and ground plant species between the two sites could indicate differences in substrate, as mountain avens, found in Aukpar, prefer damp areas and dwarf birch, found in Ipigaq, prefer acidic rocks and gravel. The ponds likely drained as base level dropped, and were incised by streams that carried the material to the coast, depositing it contemporaneously with marine material. Both samples contain a number of species that prefer high pH, calcareous environments, which includes most of Bluegoose Prairie due to the dominant limestone substrate.

Terrestrial life colonized Bluegoose Prairie shortly after deglaciation. Both Ipigaq and Aukpar sections are ~15 m below marine limit and isostatic uplift was rapid. The terrestrial materials sampled lived soon after initial deglaciation in those areas, based on rapid rebound demonstrated in the relative sea level curve (Fig 4.5). All fossils identified in both assemblages are found on southern Baffin Island today, suggesting the climate immediately following deglaciation was similar to today (Telka 2008a,b) (Fig 4.7).

Figure 4.7: Camp 1 from 2007 field season, in early July. Photo shows a typical wetland ecosystem, possibly ephemeral, present in Bluegoose Prairie today.

Bluegoose Prairie is part of the low arctic bioclimatic zone (Jacobs et al. 1997). The closest modern climate data is available from a weather station at the southeast corner of Amadjuak Lake (Fig 4.8), ~110 km southeast of Bluegoose Prairie (Jacobs et al. 1997), which operated from July 1988 – July 1995 (Table 4.5). Environment Canada (www.climate.weatheroffice.ec.gc.ca) has weather stations at Iqaluit, NU and Cape Dorset, NU, which provide climate data from 1953 and 1970, respectively, to present (Table 4.5). Iqaluit is ~250 km southeast of Bluegoose Prairie and Cape Dorset is ~150 km to the southwest (Fig 4.8).

At all three stations, July is the warmest month and February the coldest. Iqaluit and Cape Dorset have very similar temperatures. The Amadjuak Lake station recorded slightly warmer mean July temperatures and slightly colder mean February temperatures. It did not record maximum and minimum temperatures as extreme as the other two stations, but this is expected due to the significantly shorter time that it was in operation. Iqaluit and Cape Dorset receive similar annual precipitation, but Cape Dorset accumulates a deeper snow pack. Amadjuak Lake receives less annual precipitation and no snow pack values were recorded, as the station was unmanned and only field checked every July. Days above 0°C were not measured at Amadjuak Lake, but an annual mean of 66 days above 5°C was recorded.

The higher summer and lower winter temperatures recorded at Amadjuak Lake can be explained by its inland location and higher elevation; it does not experience the moderating effects of a nearby sea. The coastal location of Iqaluit and Cape Dorset also likely contributes to the greater amounts of precipitation these communities receive. As Bluegoose Prairie is between these three weather stations, it likely has a similar climate. Coastal areas of Bluegoose Prairie probably receive greater precipitation amounts, while areas further inland and at higher elevation probably experience slightly colder winters and warmer summers.

Table 4.5: Climate data for locations near Bluegoose Prairie. SE Amadjuak Lake data from Jacobs et al. 1997. Iqaluit and Cape Dorset data from Environment Canada (www.climate.weatheroffice.ec.gc.ca; accessed November 11, 2010).

Location	Mean July T (°C)	Max July T (°C)	Mean Feb T (°C)	Min Feb T (°C)	Mean Annual Precip (mm)	Mean Annual Precip as Snow (mm)	Mean April Snowpack (cm)	Days per Year >0°C
SE Amadjuak Lake (July 1988-July 1995)	9.1	12.6	-33.8	-38.4	388	Not measured	Not measured	Not measured
Iqaluit (1953-2009)	7.7	25.8 (2001)	-28.0	-45.6 (1967)	412	236	29	93.1
Cape Dorset (1970-2009)	7.4	25.0 (1984)	-26.0	-42.2 (1964)	403	296	59	76.3

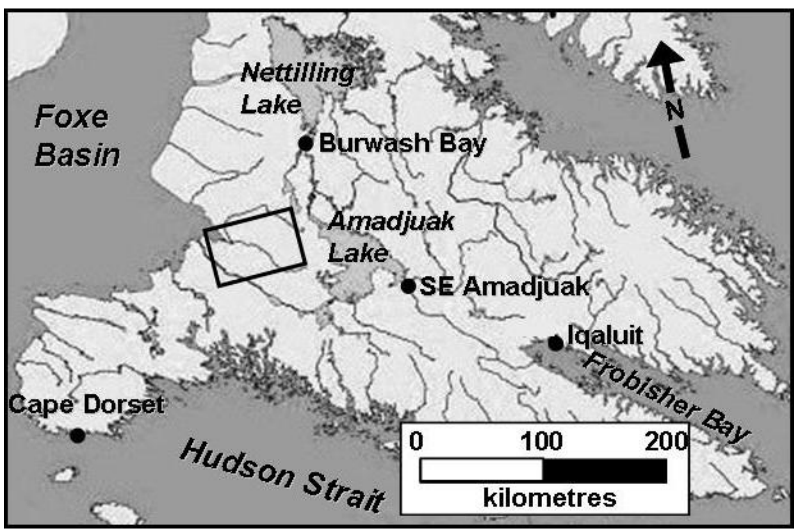


Figure 4.8: Locations of weather stations (Table 4.5) and lake core site (Fig 4.9) mentioned in the text. Box shows the location of Bluegoose Prairie.

In a previous study, lake sediment samples were taken from a sheltered inlet in Burwash Bay, at the south end of Nettilling Lake (Jacobs et al. 1997), ~90 km northeast of Bluegoose Prairie (Fig 4.8). Burwash Bay is ~30 m asl, and was inundated by marine waters until ca. 5 ^{14}C ka BP. Two lake cores record pollen counts from 4750 ^{14}C BP to present (Fig 4.9). Most of the vegetation types found in the lake cores are also present in the two Bluegoose Prairie terrestrial macrofossil assemblages. The pollen diagram shows that most modern plant taxa have been present in southern Baffin Island since at least 4750 ^{14}C BP. Plant populations have undergone only minor changes in that time. There has been a slight decrease in shrub population (e.g., *Betula*, *Salix*), with a corresponding increase in sedge percentage (Cyperaceae, including *Carex* sp.).

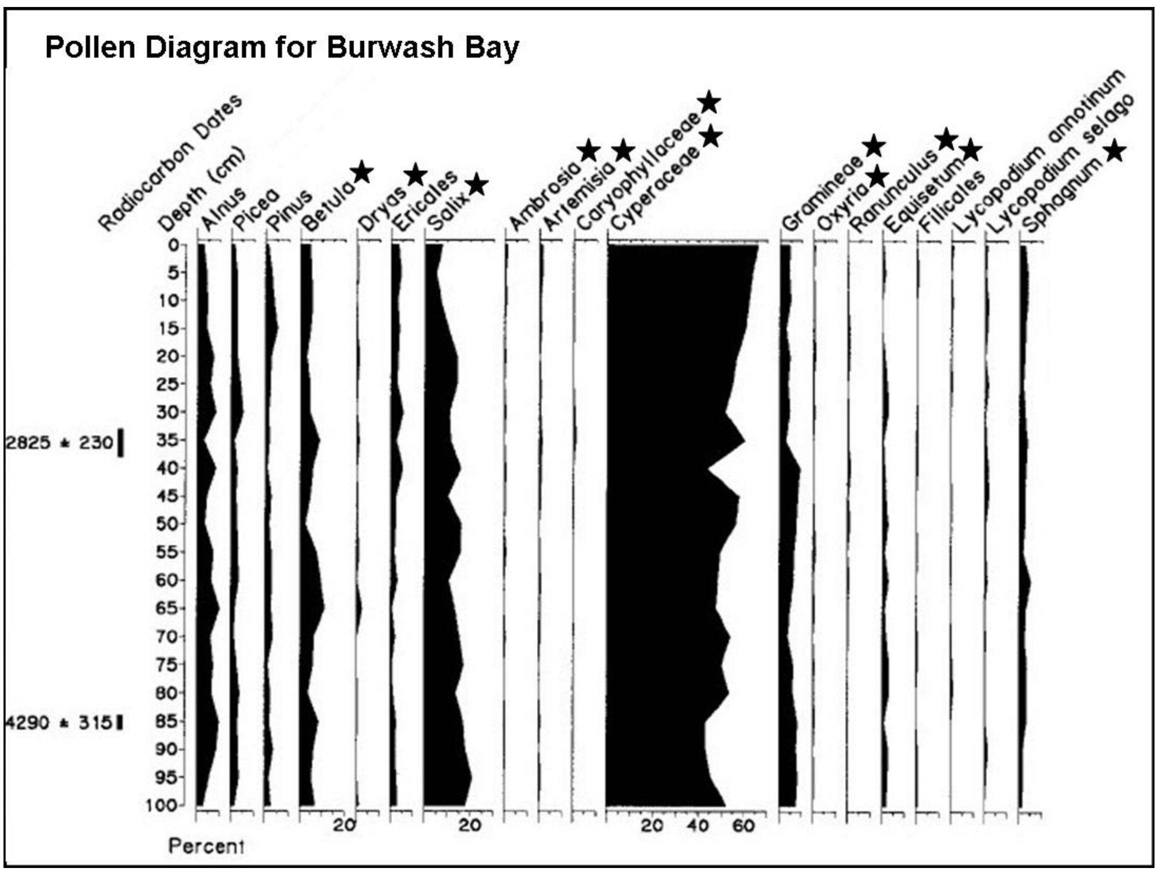


Figure 4.9: Pollen percent diagram for Burwash Bay. Plants with stars beside them are also found in Bluegoose Prairie samples (may not be identified to same level). (From Jacobs et al. 1997).

A palaeovegetation map of Canada (Dyke et al. 2003a) classifies Foxe Peninsula as herb tundra at 6.0 ^{14}C ka BP, based on pollen sites at Hall Peninsula, Frobisher Bay, and Ungava Peninsula (Fig 4.10). Herb tundra is defined as "a treeless area lacking shrubs other than small, prostrate willows and dominated by bare ground and herbs, typically sedge, grass, and sage with a variety of forbs" (Dyke et al. 2003a). By 5.0 ^{14}C ka BP, Foxe Peninsula is included in the shrub tundra ecoregion, based on a pollen site at Amadjuak Lake (Fig 4.10; Jacobs et al. 1997). Shrub tundra refers to "a treeless area with a nearly continuous cover of sedge, grass, sage, and forbs along with prostrate and semi-erect willows as well as one or more additional shrubs, chiefly dwarf birch, alder, and juniper, in increasing order of required warmth" (Dyke et al. 2003a).

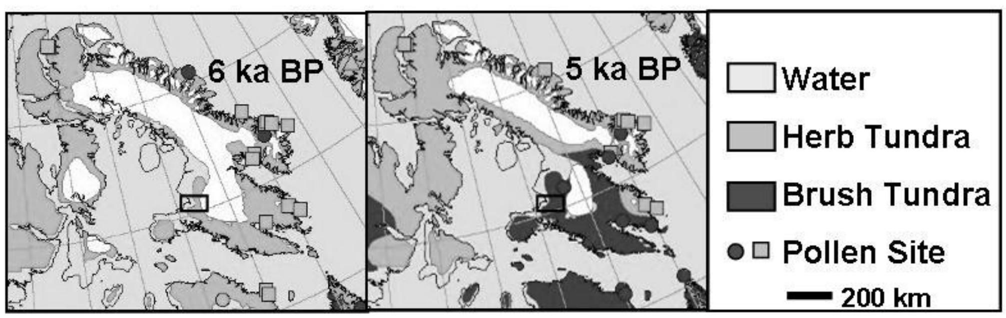


Figure 4.10: Palaeovegetation maps of Baffin Island for 6 ^{14}C ka BP and 5 ^{14}C ka BP (from Dyke et al. 2003a).

The macrofossil assemblages at Aukpar and Ipigaq are consistent with herb tundra. The Aukpar assemblage includes a single dwarf birch (*Betula glandulosa*), which could indicate Aukpar was a part of the shrub tundra ecoregion very soon following deglaciation. This interpretation is based on only one seed, which could have been transported from a distance away. More *B. glandulosa* macrofossils from the area are necessary to confidently classify it as shrub tundra. Bluegoose Prairie was herb tundra very soon after deglaciation, indicating a warm, productive environment.

Other studies state that temperatures at 6 ^{14}C ka BP were warmer than today. Estimates of thermal maximum for eastern Arctic Canada range between

6 and 4 ^{14}C ka BP (Jacobs et al. 1997, Williams et al 1995). Southern Baffin Island has experienced a relatively stable local bioclimatic system since at least 4750 ^{14}C yrs BP (Jacobs et al. 1997). The climate at Bluegoose Prairie immediately following deglaciation was likely warmer than today, but as no species were found in either assemblage that are no longer present today, the difference in temperature is believed to be small.

Conclusion

Deglacial reservoir-corrected ^{14}C ages on marine molluscs near marine limit in Bluegoose Prairie provide a minimum age of deglaciation of 6.2 ^{14}C ka BP. The relative sea level curve for Bluegoose Prairie indicates postglacial uplift was rapid following deglaciation, then tapered off in the last 4000 years. Initially, sea level dropped ~8m/100 ^{14}C years. After ca. 5 ^{14}C ka BP, the rate of sea level drop decreased. Meltwater runoff and sedimentation also likely tapered off. The marine environment of southeast Foxe Basin was warmer during and immediately following deglaciation than today, with high seasonal input from glacial meltwater. This strong inflow provided complex marine environments favourable for diverse mollusc assemblages and high sedimentation rates conducive to preserving these molluscs. No mollusc samples were found below ~43 m asl, likely because the reduced meltwater run off and decreased sedimentation decreased viable habitat and chance of preservation.

Macrofossil assemblages collected in Bluegoose Prairie show that terrestrial environment immediately following deglaciation was similar to today. A diverse assortment of plant and animal species lived in Bluegoose Prairie only a century after deglaciation, indicating rapid colonization. Previous studies indicate that temperatures in eastern Arctic Canada ca. 6 ^{14}C ka BP were warmer than today. I extrapolate based on this and other research that Bluegoose Prairie immediately following deglaciation had an ecosystem similar to or more productive than today.

CHAPTER 5: SUMMARY

The Surficial geology of Bluegoose Prairie has significance because of the site's location between three major features of the northeastern Laurentide Ice Sheet during the LGM: Foxe Dome to the northwest, Amadjuak Divide to the northeast, and Hudson Strait to the south. Despite its location, little work has previously been done to study this area. Interpretation of the glacial history of Bluegoose Prairie is important for reconstructions of the Baffin Sector of the Laurentide Ice Sheet.

The purpose of this study is to provide information on the surficial geology and glacial history of Bluegoose Prairie that was lacking. It was conducted as part of the South West Baffin Integrated Geoscience (SWBIG) Project, in cooperation with the Geological Survey of Canada and the Canada-Nunavut Geoscience Office. The main questions addressed by this thesis are:

1) What is the distribution of surficial materials in Bluegoose Prairie?

2) What were the patterns of glaciation and deglaciation in Bluegoose Prairie?

3) When did deglaciation of Foxe Basin and Bluegoose Prairie occur, and what was the environment associated with deglaciation?

4) What was regional reservoir age for Foxe Basin during deglaciation?

This chapter summarizes the answers to these questions.

Surficial Geology Map

The Surficial geology map included in this thesis is the first published for Bluegoose Prairie. It outlines the dominant surficial materials and landforms. Marine limit is delineated on the map, which is important for reconstructions of ice margins and relative sea level change. Identification of till coverage, provenance, and thickness is valuable for planning drift prospecting, increasing the attractiveness of the region to the mineral exploration industry. The map also includes information on stratigraphy and ^{14}C ages. The publication of all of this information in a concise format as a GSC open file makes it easily and freely available to all interested parties from both the economic sector and the scientific community.

Ice Flow and Deglaciation

The distribution of surficial sediments, landforms, and ice flow indicators leads to the interpretation of a complex glacial history including changes in ice flow direction of over 100°. The complex, multiphase nature of ice flow in this region is important for mineral exploration, as these phases of ice flow need to be taken into account for both the planning and interpretation of drift prospecting projects.

During LGM ca. 18 ^{14}C ka BP, and for nearly 12 ^{14}C ka afterwards, ice flow across the study area was to the southwest, away from Amadjuak Ice Divide, which extended across southern Baffin Island from the Foxe Dome. During Phase One, plumes of limestone-derived till were deposited across Proterozoic bedrock on the west side of the map area, and striations were carved into rock in the southwest. This flow continued until the collapse of the Foxe Dome and marine inundation of Foxe Basin. Deglaciation of Foxe Basin began along its south margin, and Foxe Peninsula, along the basin's southern shoreline, would have deglaciated soon after collapse of the dome.

The oldest ages on marine molluscs collected from Bluegoose Prairie are 7.2 ^{14}C ka BP. This marine ^{14}C age is corrected using the deglacial reservoir age of 985 ± 10 ^{14}C years. Application of this reservoir correction gives a minimum age of deglaciation of Bluegoose Prairie, and southern Foxe Basin, of ca. 6.2 ^{14}C ka BP. This age is from a delta (Aukpar) section interpreted in this thesis as being deposited during Phase Three of ice flow on Bluegoose Prairie, when sea level was ~90 m asl. The length of time required for sea level to drop 30 m from the maximum marine limit on Bluegoose Prairie of 120 m asl is ~350 ^{14}C years. The age of 6.2 ^{14}C ka BP may therefore underestimate the age of deglaciation by ~350 ^{14}C years. The most recent reconstruction of the Laurentide Ice Sheet places the opening of Foxe Basin at 6.5 ^{14}C ka BP (Dyke 2004). This study supports that approximation.

Collapse of the Foxe Dome ca. 6.2 - 6.5 ^{14}C ka BP interrupted the constant southwest flow of ice across Bluegoose Prairie, initiating Phase Two. With the major ice dispersal centre for the Foxe Sector gone, the ice divide migrated onto Baffin Island, separating ice flowing west towards Foxe Basin, including Bluegoose Prairie ice, from ice flowing east towards Baffin Bay.

Once marine incursion of Bluegoose Prairie began, deglaciation was rapid. Active calving margins in Foxe Basin resulted in fast ice flow and drawdown of Foxe Peninsula ice. Large glaciofluvial deposits on Putnam Highland were deposited, likely as eskers, during Phase Two, indicating a high sediment load and rapid melting. A large esker was also deposited in the southeast corner of the study area during this time.

As sea level continued to drop and Bluegoose Ice retreated further, three separate areas of flow developed in Phase Three. Dominant landforms formed during that time include a series of morainal fragments on Putnam Highland. Massive amounts of meltwater were also deposited on Putnam Highland, dissecting the large eskers to form the irregular glaciofluvial mounds present today. Rapid northwest flow deposited kilometre-scale flutes and till lineations in the east side of the study area.

Warm temperatures contributed to the deglaciation of Bluegoose Prairie, and isostatic rebound was rapid, as demonstrated by the relative sea level curve presented in this thesis. This curve indicates Phases Two and Three of ice flow would have occurred over ~450 ^{14}C years. Isolated bodies of ice sustained independent ice flow patterns through Phase Four until disappearance of the final glacial ice remnants near Amadjuak Lake.

Palaeoenvironment

Macrofossil assemblages form Aukpar and Ipigaq are diverse and include *Salix* sp. (willow) samples with ages between 6.2 to 6.0 ^{14}C ka BP. These ages provides additional evidence that deglaciation was rapid, as a thriving ecosystem was established only a few hundred years after collapse of the Foxe Dome. Represented in the assemblages are species of algae, fungi, mosses, grasses, sedges, lichen, flowers, and shrubs. Animal macrofossils include worms, crustaceans, and insects. All of the species identified are still present in freshwater wetlands on south Baffin Island today. The presence of such a diverse assemblage of fauna and flora within a couple hundred years of deglaciation of Foxe Basin evidences a climate that was as warm as, or warmer than, today, and indicates rapid colonization from nearby ice-free areas.

Reservoir Age

Perhaps the most significant contribution of this thesis is the measurement of deglacial reservoir age for Foxe Basin. The discovery of contemporaneous pairs of marine and terrestrial macrofossils provided the rare opportunity to measure a reservoir age specific to the time of deglaciation. The general paucity of appropriate ^{14}C material in the Arctic necessitates the use of modern reservoir age to correct marine ^{14}C ages in most cases. While these corrections are region-specific, they are not time-specific. The deglacial reservoir age of 985 ± 10 ^{14}C years presented in this thesis is significantly greater than modern reservoir age for the region, 720 ± 15 ^{14}C years. Use of this new reservoir age results in greater accuracy of marine ^{14}C corrections and calibration to calendar years. It is recommended for all deglacial marine ^{14}C ages in Foxe Basin and adjacent Hudson Strait where a site-specific deglacial reservoir age is not available.

Recommendations for Future Work

This thesis provides preliminary analysis and interpretation of the Surficial geology of Bluegoose Prairie. More detailed work would be valuable to study several aspects of the Surficial geology.

Further study into the form, stratigraphy, and origin of the large glaciofluvial deposits on Putnam Highlands is needed. While this study provides a valid hypothesis for their formation based on available information, only preliminary fieldwork was conducted on these landforms during the course of ground-truthing for the map. More detailed investigation may provide further insight into the speed and nature of deglaciation in the area.

The elongate flutes and till lineations in the northeast portion of the map indicate rapid flow to the northwest. Further investigation into this region could determine if this was the site of an ice stream and, if so, what its relative timing was with other palaeo-ice streams in the eastern Arctic.

More studies into the palaeoenvironment of Baffin Island are needed to compare past climate to today and to predict what changes future climate change may incur on arctic ecosystems. As of the production of this thesis, very few palaeoenvironment studies had been conducted in the region.

One marine mollusc and one plant macrofossil from Ipigaq each dated to 6.5 ka ^{14}C BP. These ages, combined with a difference in marine limit between eastern Putnam Highland and northeast Bluegoose Prairie, provide data that could be explained by a readvance of ice in the east part of Bluegoose Prairie. Further fieldwork and ^{14}C ages are needed to test this hypothesis.

As marine molluscs are the most widely available source for ^{14}C dating in the eastern Arctic, the correction for marine reservoir effect is important. This study provides the first deglacial reservoir age for Foxe Basin. More measurements on deglacial reservoir ages are necessary for Foxe Basin, Hudson Bay, and Hudson Strait. Spatially and temporally relevant reservoir ages provide more accurate reconstructions of deglacial events and better correlation with other dating techniques, such as terrestrial ^{14}C, cosmogenic nuclide, and optical luminescence.

Conclusion

This study provides the first data and interpretations for the glacial and postglacial history of Bluegoose Prairie. The Surficial geology map is informative to many groups, including local Inuit, mineral exploration companies, and Quaternary scientists. Radiocarbon ages add to the catalogue of ages for the eastern Canadian Arctic, and the relative sea level curve provides information on isostatic rebound rates for southern Foxe Basin. Macrofossil assemblages indicate a warm, productive postglacial environment, and provide insight into the speed at which arctic ecosystems respond to climate change. The new, deglacial reservoir age for Foxe Basin shows that regional reservoir age has changed over time, and improves the accuracy of deglacial reconstructions based on marine ^{14}C ages. This thesis provides preliminary Surficial geology information for Bluegoose Prairie, upon which future studies may build.

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APPENDICES

Appendix A: Surficial Geology Map

The paper map attached in the back pocket forms a part of this work.

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Scale is 1:100,000. Covers NTS 036H/01, 036H/02, 036H/03, 036H/04, 036H/05, 036H/06, 036H/07, 036H/08.

Appendix B: CD Data

Electronic data and files listed below and appended as a CD form a part of this work under the copyright of this author.

The .xls files were created with Microsoft Excel, but may be opened in any spreadsheet program. The .dbf and .shp files contain field data, and can be opened with any GIS program. The PDF file was created with Adobe Acrobat, but may be opened in any PDF program.

File Name	**Description**	**Size**
Ice Flow Indicator Table.xls	Ice flow indicator descriptions and measurements	14 kb
Ice Flow Indicators.dbf	Ice flow indicator descriptions and measurements	9 kb
Ice Flow Indicators.shp	Locations of ice flow indicators	1 kb
Sample Table.xls	Sample descriptions	27 kb
Samples.dbf	Sample descriptions	63 kb
Samples.shp	Locations of samples	3 kb
Station Table.xls	Station (field site) date and location descriptions	60 kb
Stations.dbf	Station (field site) date and location descriptions	120kb
Stations.shp	Locations of stations (field sites)	5 kb
Surficial Material Table.xls	Surficial material descriptions	95 kb
Surficial Material.dbf	Surficial material descriptions	241 kb
Surficial Material.shp	Locations of surficial materials	6 kb
Vickers et al. 2011.pdf	Digital copy of surficial geology map	22 Mb