ARCTIC
VOL. 62, NO. 3 (SEPTEMBER 2009) P. 273–280

New Radiocarbon-Dated Vertebrate Fossils from Herschel Island: Implications for the Palaeoenvironments and Glacial Chronology of the Beaufort Sea Coastlands

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(*Received 14 April 2008; accepted in revised form 29 October 2008*)

ABSTRACT. Palaeontological research on Herschel Island, Yukon, has yielded a diverse collection of Quaternary marine and terrestrial vertebrate fossils. The terrestrial faunal remains, which have largely been collected as allochthonous beach debris at Pauline Cove, are dominated by Yukon horse (*Equus* sp.), with fewer specimens of steppe bison (*Bison priscus*), proboscideans (*Mammuthus primigenius* and a single *Mammut americanum* specimen), and other large and medium-sized mammals. This pattern of a horse-dominated Late Pleistocene fauna is consistent with those from the North Slope of Alaska and further demonstrates that conditions in northernmost Beringia were more arid than those in interior areas such as Fairbanks or the Klondike. This paper presents new AMS radiocarbon dates on terrestrial vertebrate fossils and peat from the island that span the range from greater than 53 000 to modern ^{14}C yr BP. When considered with other data from the region, our new radiocarbon-dated fauna cannot adequately resolve whether the Herschel Island ice-thrust ridge was formed during the Early Wisconsinan or the Late Wisconsinan advance of the Laurentide Ice Sheet over the Yukon Coastal Plain.

Key words: Pleistocene, Yukon, Herschel Island, palaeontology, Beringia, mammals, fossils, Buckland Glaciation, Beaufort Shelf, chronology

RÉSUMÉ. Des fouilles paléontologiques réalisées sur l'île Herschel, au Yukon, ont permis de prélever une collection variée de fossiles marins et de fossiles vertébrés terrestres du quaternaire. Les restes de faune terrestre, qui ont surtout été ramassés sous la forme de débris de plage allochtones à Pauline Cove, prennent la forme de restes de chevaux du Yukon en prédominance (*Equus* sp.), parsemés de quelques spécimens de bisons priscus (*Bison priscus*), de proboscidiens (*Mammuthus primigenius* et d'un seul spécimen de *Mammut americanum*), ainsi que d'autres mammifères de taille moyenne et de grande taille. La prédominance de faune du type cheval du Pléistocène tardif correspond à celle enregistrée sur le versant nord de l'Alaska et montre encore une fois que les conditions qui régnaient dans la partie la plus au nord de la Béringie étaient plus arides que les conditions qui prévalaient dans les régions de l'intérieur, comme à Fairbanks ou au Klondike. Dans ce document, nous présentons de nouvelles dates établies par le radiocarbone SMA quant aux fossiles de vertébrés terrestres et à la tourbe de l'île, dates allant de plus de 53 000 ^{14}C années BP à l'ère moderne. Lorsque ces données sont considérées à la lumière d'autres données de la région, la nouvelle faune datée par le radiocarbone ne nous permet pas de déterminer adéquatement si la dorsale découlant de la poussée des glaces de l'île Herschel a été formée pendant la progression du Wisconsinien précoce ou du Wisconsinien tardif de la nappe glaciaire laurentienne sur la plaine côtière du Yukon.

Mots clés : Pléistocène, Yukon, île Herschel, paléontologie, Béringie, mammifères, fossiles, glaciation de Buckland, plateforme de Beaufort, chronologie

Traduit pour la revue *Arctic* par Nicole Giguère.

INTRODUCTION

Quaternary research on Herschel Island, Yukon, plays a key role in reconstructing the Pleistocene glacial chronology and palaeoenvironments of the Beaufort Sea coastlands. Mackay's (1959) pioneering research suggested that Herschel Island is composed of Beaufort Sea shelf sediments that were upthrust into a ridge by the northwestern lobe of the Laurentide Ice Sheet (LIS). Subsequent surficial geological mapping on the Yukon Coastal Plain and adjacent areas, including Herschel Island, indicated this area was covered by the "Buckland Glaciation," and Rampton (1982) postulated an Early Wisconsinan (ca. 90–65 ka) age for this ice advance (Fig. 1). Since these early studies, much research has attempted to resolve the chronology of the northwest margin of the LIS, especially in the Mackenzie Delta, Mackenzie Mountains, and Tuktoyaktuk coastlands. However, limited work has been conducted on the Yukon

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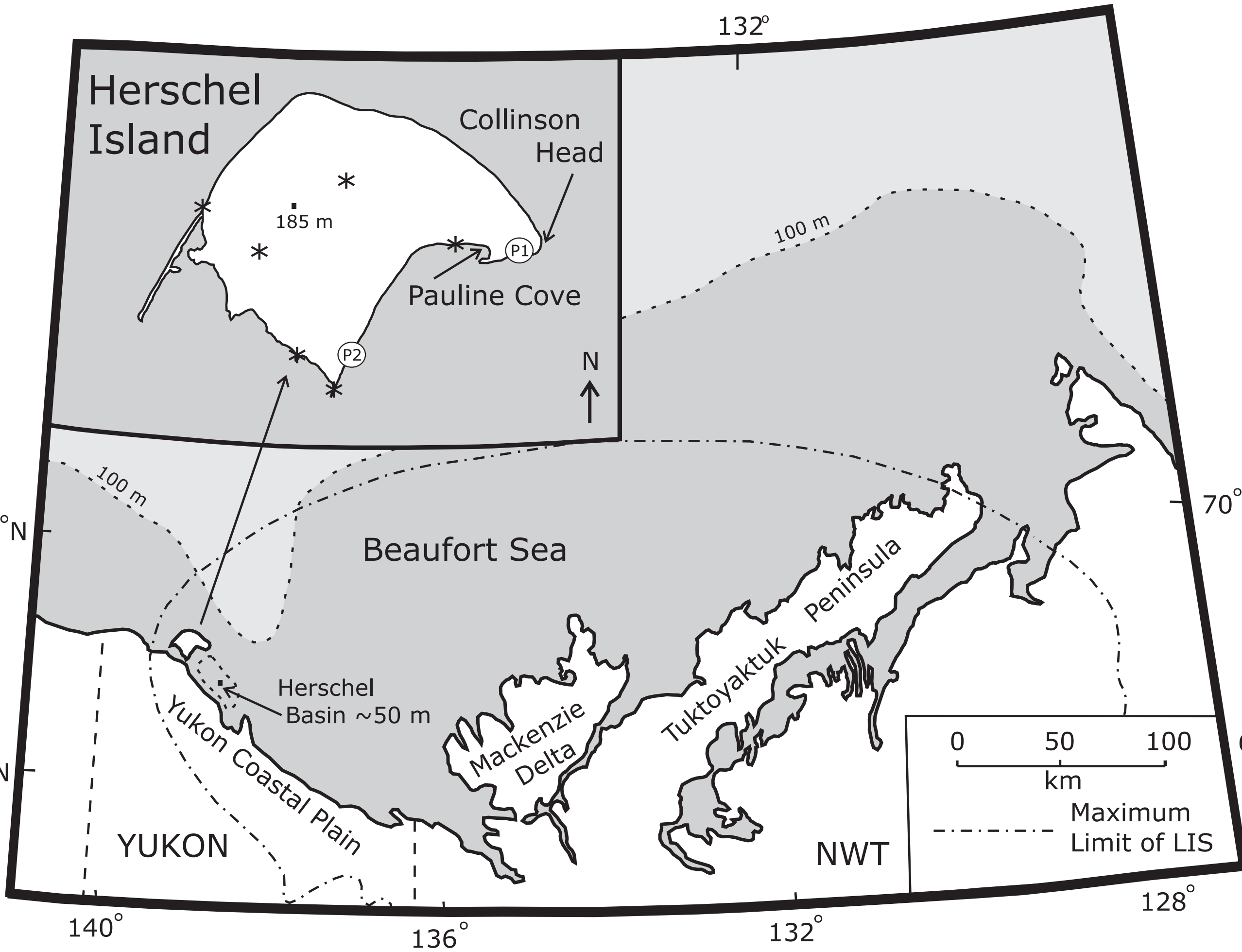

FIG. 1. Map of the Beaufort Sea coastlands of the Yukon and Northwest Territories. Maximum limit of the Laurentide Ice Sheet (LIS) is after Rampton (1982, 1988). Shaded area offshore to 100 m below sea level demonstrates the approximate extent of the exposed Beaufort Shelf during Late Pleistocene sea-level minima. The inset map of Herschel Island shows the prominent fossil collecting locality at Pauline Cove. Asterisks (*) indicate other fossil collecting localities, and "P1" and "P2" indicate peat collecting localities.

Coastal Plain or Herschel Island in recent years, and there is no definitive model of how the Quaternary deposits found there correlate with those from other areas covered by the northwest margin of the LIS. Furthermore, Herschel Island has yielded an impressive Quaternary fossil assemblage, and terrestrial mammal remains recovered there are considered to represent a far northeast corner of the Holarctic "mammoth-steppe" biome (Guthrie, 1990).

In this paper, we present new AMS radiocarbon ages from a variety of Pleistocene fauna that have important implications for the chronology of Herschel Island's glacier ice-thrust origin and regional palaeoenvironments of the Beaufort Sea coastlands.

The Study Area

Herschel Island or *Qikiqtaruk* is a Yukon Territorial Park, 100 km^2 in area, 3 km off the north coast of mainland Yukon Territory in the southern Beaufort Sea (Fig. 1 inset). The coastal shelf between the mainland and Herschel Island is submerged by as little as 2 m, and recent assessments suggest that the island was connected to the mainland as recently as ~650 years ago (Burn, 2009). The maximum elevation on the island is approximately 185 m above present sea level. Herschel Island is composed of a variety of ice-rich marine and terrestrial sediments that are typically deformed. Mackay (1959) suggested that the volume of the submerged Herschel Basin on the Beaufort Shelf is similar to that of Herschel Island, providing further evidence to support the proposed ice-thrust origin of Herschel Island. Although the island per se (a landmass surrounded by water) may have been formed only in the last two millennia following marine transgression (Burn, 2009), for the purposes of this paper, we consider the term "Herschel Island" to refer to the landmass that was upthrust by glacier ice during the Late Pleistocene and is presently represented by Herschel Island.

General Stratigraphy of Herschel Island

Sediments exposed on Herschel Island are a complicated mix of shallow-water, marine, and terrestrial sediments that exhibit a high degree of faulting, folding, and other deformation resulting from glacier ice-thrust. At several sections, sediments are overturned, folded, and faulted, making stratigraphic correlations difficult (Rampton, 1982). Bouchard (1974) and Rampton (1982) described deposits at a number of sites on Herschel Island and suggested a generalized Late Quaternary stratigraphy. Following Bouchard (1974) and Rampton (1982), the deposits can be separated into four general units: 1) lower marine clay, 2) "mixed" preglacial sediments and peat, 3) marine clay, and 4) postglacial lacustrine, terrestrial, colluvial, and beach sediment.

1. The lowermost sediments exposed on Herschel Island are composed of brown and grey clay with sand and silt laminae. At some exposures, sediments from this unit contain marine shells, which led Rampton (1982) to interpret a marine origin. The age of these deposits and their possible correlation with Beaufort Shelf sediments are unknown.

2. Above the lowermost marine clay is a "mixed" preglacial sediment package composed of clay, sand, silt, and gravel representing marine, nearshore marine, shoreline brackish, and terrestrial environments. These "mixed" sediments often contain organic detritus, including twigs, wood, and peat, in addition to marine ostracods. Rampton (1982) suggested that this unit correlates with similar sediments beneath Buckland till recognized on the Yukon Coastal Plain that yielded radiocarbon dates of older than 51 100 (GSC-151-2) and 51 000 ^{14}C yr BP (GSC-1798-2).

3. Marine clays overlie the "mixed" sediment unit at many sites. These dark grey clays contain pebbles and shells of marine origin and are often ice-rich. Bouchard (1974) and Rampton (1982) identified this layer as the uppermost "preglacial" unit. Near Collinson Head (Fig. 1), layers of pale brown to dirty, massive ice were observed in the marine silt and clay (Pollard, 1990). This buried ice is interpreted as glacier ice and is overlain unconformably by 1–2 m of icy diamicton (Pollard, 1990). At some sites at Collinson Head, the "mixed" sediment unit is unconformably overlain by 2.5 m of silty diamicton containing cobbles and small boulders (Pollard, 1990).

   Harington (1989) provided an average radiocarbon age of ~16 000 ^{14}C yr BP (RIDDL-765, RIDDL-766; Table 1) on the well-preserved skull of a Yukon horse (*Equus lambei*, CMN 43815) recovered by S. Dallimore from sand and silt stratigraphically above this uppermost "preglacial" marine sediment unit. The specimen was seemingly in situ, judging by the minimal cover of loose colluvium on the surface of its high bluff location (S. Dallimore, pers. comm. 2008).

4. Post-glacial terrestrial and lacustrine sediments, including coastal beach sediments and colluvium, overlie the marine clays at some sites. Fossil pollen obtained from peat (up to 2 m thick) that had developed in sediments from a drained thaw pond was dated to 9380 ± 170 ^{14}C yr BP (GSC-1483; Rampton, 1982). Rampton inferred that early Holocene vegetation consisted of birch (*Betula*) shrub tundra, which contrasts with today's sedge (Cyperaceae)-dominated tussock tundra in the area. A pronounced thaw unconformity at the base of these sediments is widespread (Rampton, 1982).

Glacial Chronology

Rampton (1982) assigned the "Buckland Glaciation," the single glacial advance on the Yukon Coastal Plain that formed the ice-thrust ridge of Herschel Island, to the Early Wisconsinan interval (Fig. 1). He suggested that the Buckland Glaciation represented the all-time maximum advance of the LIS, which he considered correlative with the Toker Point glaciation of the Tuktoyaktuk coastlands (Rampton, 1988; Vincent, 1989, 1992). Others, however, have contested this model, arguing that the maximum LIS advance occurred during the Late Wisconsinan (~30–12 ka) (Dyke and Prest, 1987; Dyke et al., 2002). Data from the Tuktoyaktuk coastlands (Dallimore et al., 1997; Murton et al., 1997; Bateman and Murton, 2006; Murton et al., 2007) and the Richardson and Mackenzie Mountain Front (Duk-Rodkin and Hughes, 1995; Duk-Rodkin et al., 1996) make a compelling case for a Late Wisconsinan maximum for the entire northwest margin of the LIS. Additional discussions on LIS chronology have centered on the timing of regional drainage diversion events in the unglaciated basins of the Yukon (Hughes et al., 1981; Lemmen et al., 1994; Zazula et al., 2004). Further complications with correlation between terrestrial and off-shore sediments in the Beaufort Sea coastlands, especially for the regions west of the Mackenzie Delta, as well as the lack of conclusive field evidence, preclude acceptance of either the Early Wisconsinan or Late Wisconsinan models for glaciation on the Yukon Coastal Plain (Blasco et al., 1990; Dinter et al., 1990). However, the fossil horse cranium (CMN 43815) radiocarbon-dated to ~16 000 ^{14}C yr BP (RIDDL-765, RIDDL-766) and collected from a probable in situ context may provide a minimum age for deglaciation of the Herschel Island ice-thrust ridge.

Herschel Island Palaeontology

Vertebrate palaeontological investigation on Herschel Island began with Harington in 1973 (Harington, 1989, 1990). S. Dallimore and S. Wolfe (Harington, 1989, 1990) have also made fossil collections from Herschel Island, which are now housed at the Canadian Museum of Nature. Since 1985, researchers from the Yukon Government (J. Hunston, J. Storer, and G. Hare), with assistance from the Yukon Territorial Park Rangers, have collected fossils as part of heritage resource management activities on the island. The vast majority of Quaternary fossil bones recovered on the island are from allochthonous beach debris at Pauline Cove (Fig. 1, inset). Most fossils show evidence of abrasion and typically have rounded edges as a result of wave transportation and weathering (Fig. 2). Isolated fossils have occasionally been recovered at other beaches around the island. Apart from the Yukon horse cranium, the few fossils of probable in situ context include a possible bowhead whale and a seal specimen recovered from preglacial marine deposits (Harington, 1989).

A plethora of faunal remains from both marine and terrestrial vertebrates have been collected and identified from Herschel Island (Harington, 1989; Fig. 2). Marine mammal remains include specimens from whales (cf. *Balaena mysticetus*, cf. *Delphinapterus leucas*), seals (*Phoca hispida*, *Phoca* sp.), walrus (*Odobenus rosmarus*), and polar bear (*Ursus maritimus*). Remains from large and medium-sized terrestrial mammals include specimens from typical members of the Beringian "mammoth-fauna," including woolly mammoth (*Mammuthus primigenius*), steppe bison (*Bison priscus*), horse (*Equus lambei*), American mastodon (*Mammut americanum*), caribou (*Rangifer tarandus*), tundra muskox (*Ovibos moschatus*), helmeted muskox (*Bootherium bombifrons*; Harington, 1989), wolf (*Canis lupus*), arctic fox (*Vulpes lagopus*), and red fox (*Vulpes vulpes*).

In conjunction with palaeontological investigation in July 2003, Storer collected two peat samples from exposures on the coast of Herschel Island (P1 and P2, Fig. 1 inset; Table 1). Sample P1 (Beta 189289), collected from deformed frozen sediments, consists of silt with detrital woody organic material and yielded a radiocarbon date of more than 45 130 ^{14}C yr BP. The limited vascular plant macrofossil remains observed in the peat include identifiable specimens of buttercup (*Ranunculus*) and sedge (*Carex*). Sample P2 (Beta 189290), collected from a horizontal bed, consists of a highly compressed bryophyte-dominated peat that yielded a radiocarbon date older than 45 200 ^{14}C yr BP. Like sample P1, it contains identifiable macrofossil remains of buttercup and sedge. Unfortunately, the stratigraphic context of these peat samples and their relations with previously recognized units (i.e., Rampton, 1982) were not clear at the time of collection.

Small subsamples were cut from the fossil vertebrate specimens and submitted for AMS radiocarbon dating to Beta Analytic (Beta), Oxford Radiocarbon Accelerator Unit (OX), Lawrence Livermore National Laboratory (RIDDL), and University of Aarhus AMS Radiocarbon Dating Laboratory (AAR).

Radiocarbon Results and Interpretations

Radiocarbon dates obtained on 13 Herschel Island vertebrate fossils span the range from greater than 53 000 to modern ^{14}C yr BP (Table 1). These data include four specimens that yielded infinite ages (ages beyond the range of radiocarbon dating) and four others that are close to that limit and may also be interpreted as infinite. Another pattern from our radiocarbon data set is the absence of dates between 36 160 ± 530 (Beta 70841) and 17 490 ± 90 ^{14}C yr BP (Beta 185981). However, the limited number of radiocarbon-dated vertebrate specimens in our data set precludes our drawing definitive chronological conclusions.

It is important to consider these new radiocarbon ages from vertebrate fossils in the context of the glacial history of the Yukon Coastal Plain and formation of the ice-thrust ridge of Herschel Island. Of greatest significance are the bones that yielded infinite radiocarbon ages. Since none of our newly dated fossil bones were recovered in situ, the stratigraphic significance of the specimens is ambiguous. This uncertainty leads us to question how these infinite radiocarbon-aged fossils relate to the regional glacial chronology and timing of the Herschel Island ice-thrust event, as well as the origin of the fossil vertebrate remains recovered along the beaches.

We propose two hypotheses to explain these infinite radiocarbon ages from the vertebrate fossils:

1. The first hypothesis is that these ages reflect animals that inhabited the Herschel Island ice-thrusted ridge prior to the Late Wisconsinan. Thus, these dates support Rampton's (1982) original suggestion of Early Wisconsinan (or earlier?) age for the Buckland Glaciation and the formation of Herschel Island.

2. The second is that they represent terrestrial mammals that lived and died on Beaufort Sea coastlands (both exposed coastal shelf and Yukon Coastal Plain) and were incorporated into the sediments that were later ice-thrust by a Late Wisconsinan advance of the LIS.

DISCUSSION

The possibility that terrestrial mammals inhabited Herschel Island prior to the Late Wisconsinan is problematic in light of growing evidence for a Late Wisconsinan all-time maximum advance of the LIS along the northwest margin (Duk-Rodkin et al., 1996; Dyke et al., 2002). Radiocarbon dates between ~33 700 and 20 000 ^{14}C yr BP (Dallimore et al., 1997) and optically stimulated luminescence (OSL) ages averaging ~21 ± 8.7 ka (Bateman and Murton, 2006) from aeolian sediments beneath glacial (Toker Point Stade) deposits on the Tuktoyaktuk Peninsula, Northwest Territories, support a Late Wisconsinan glacial chronology. However, the Buckland Glaciation of the Yukon Coastal Plain (including Herschel Island) may not be correlative to the Toker Point Stade event recognized on the Tuktoyaktuk coastlands. Vincent (1989) suggests that the Buckland Glaciation on the Yukon Coastal Plain may be correlative to the glaciomarine "Flaxman Member" of the Gubik Formation on the Alaskan North Slope (Dinter et al., 1990). Extensive thermoluminescence dating of the Flaxman Member suggests that an ice lobe on the Yukon Coastal Plain deposited glaciomarine sediments on the Beaufort Shelf between 70 and 80 ka correlative to Marine Isotope Stage 5a (Dinter et al., 1990; Brigham-Grette and Hopkins, 1995). The single OSL age of ~63 ka from sediments on a site on the

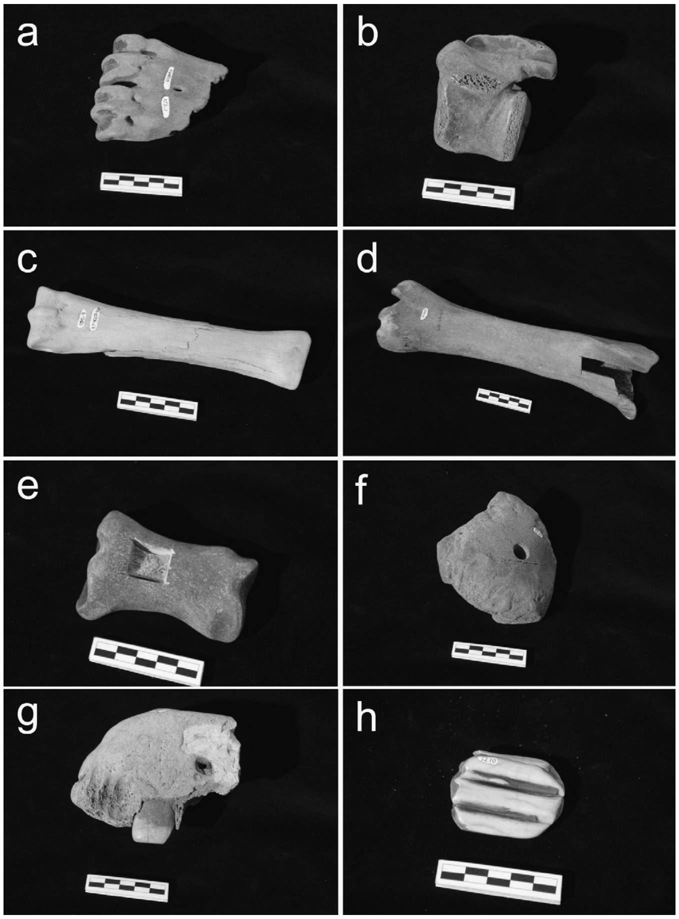

FIG. 2. Selected vertebrate fossils from Herschel Island, with reference scale in centimetres: a) *Bison priscus* metapodial distal end, YG 153.1; b) *Ovibos moschatus* lumbar vertebra, YG 155.1; c) *Equus* sp. right metacarpal, YG 155.9; d) *Equus* sp. left tibia, YG 206.6; e) *Equus* sp. first phalanx, YG 206.36; f) *Mammut americanum* cuboid, YG 33.3; g) *Odobenus rosmarus* mandible fragment, YG 12.1; h) well-rounded *Bison* sp. mandibular molar, YG 12.10. For details on specimens (a) to (g), see Table 1. Specimen (h) is included here to show the water-worn nature of many Herschel Island fossils.

northeastern Tuktoyaktuk Peninsula may thus relate to pre-Late Wisconsinan glacial outwash (Bateman and Murton, 2006). However, Polyak et al. (2001) have suggested that the Flaxman Member may be the result of ice-shelf activity off the coast of northern Alaska and not related to glacial events on the Tuktoyaktuk Peninsula or Yukon Coastal Plain. The present data amassed from a variety of Quaternary contexts in the Beaufort Sea coastlands are inconclusive in regard to the timing of the Buckland Glaciation on the Yukon Coastal Plain and the chronology of the ice-thrust event that formed Herschel Island. Thus, the possibility that terrestrial mammals inhabited Herschel Island before Late Wisconsinan times must still be considered.

Another possible interpretation of our new terrestrial faunal data is that fossils from Herschel Island may actually represent pre-Late Wisconsinan animals that were living on the exposed Beaufort Shelf, whose bones were incorporated into the ice-thrusted sediments that formed Herschel Island during a Late Wisconsinan glacial advance of the LIS. Subsequent erosion of the sediments around Herschel Island would have exposed these fossil bones and retransported them to the collecting localities at Pauline Cove. The now submerged area adjacent to the Yukon Coastal Plain was exposed when global sea levels were reduced during late Pleistocene cold periods (Blasco et al., 1990). The Beaufort Shelf experienced several transgression and regression events in response to Quaternary glaciations (Blasco et al., 1990; Dinter et al., 1990) and was undoubtedly inhabited by Pleistocene terrestrial mammals, including horse, mammoth and bison, during periods of low sea level. The speculative gap between ~36 000 and 17 000 ^{14}C yr BP in our data set of radiocarbon dates might support the Late Wisconsinan glacial advance model. However, the horse cranium from Herschel Island dated ~16 000 ^{14}C yr BP (Harington, 1989) suggests that the island was ice free and available for inhabitation by large mammals at least by that time. Our terrestrial faunal data set has a limited number of radiocarbon-dated specimens, and more dates from Herschel Island fauna are needed to determine whether this temporal distribution pattern is actually significant and how it relates to the established chronologies for other areas of the Beaufort Sea coastlands.

The stratigraphic significance of the new radiocarbon dates (> 45 000 ^{14}C yr BP) from Pleistocene peat beds on Herschel Island is difficult to interpret. On the one hand, these peats may actually be autochthonous Herschel Island deposits and represent an island origin earlier than 45 000 ^{14}C yr BP. Or, they may represent former terrestrial surfaces from the exposed Beaufort Shelf that became part of Herschel Island sediments as a result of ice-thrust by the advancing LIS after 45 000 ^{14}C yr BP. Given the radiocarbon ages and the dominance of woody terrestrial debris, it is probable that these peats represent deposits correlative to some Pleistocene interstadial or interglacial period. Further fieldwork is necessary to resolve the origin of peat deposits on Herschel Island and place them within the overall Quaternary stratigraphy.

Pleistocene Vertebrates of the Beaufort Sea Region

Our new radiocarbon-dated fauna from Herschel Island add to the limited vertebrate palaeontological data from the Low Arctic and southern Beaufort Sea region, which include the specimens of Pleistocene terrestrial and marine mammals recovered from the Mackenzie Delta and Beaufort Sea coastlands on the mainland, the islands off the Beaufort Sea coast near the Mackenzie Delta (e.g., Summer, Richard's, Garry and Baillie Islands, as well as Immerk in Mackenzie Bay), and Banks and Melville islands (Harington, 1990). As on Herschel Island, few fossil vertebrates have been recovered in situ and few have been radiocarbon dated; thus, their stratigraphic and palaeoenvironmental significance are often difficult to resolve.

Harington (2005) reports woolly mammoth specimens from northwestern Banks Island (CMN 38655) and southwestern Melville Island (CMN 11833) dating to 20 700 ± 270 ^{14}C yr BP (TO-2355) and ~21 000 ^{14}C yr BP (21 000 ±

TABLE 1. Radiocarbon dates from Herschel Island.

Age (14C yr BP)	Lab Number	Material Dated	Element	Specimen Number	Location	Reference
46 900 ± 0	Beta 185980	*Bison priscus*	metapodial	YG 153.1	Herschel Island - Pauline Cove	this study, Figure 2a
17 265 ± 65	OX-17070	*Ovibos moschatus*	cranium	YG 155.7	Herschel Island - Pauline Cove	this study
17 100 ± 90	Beta 185979	Same specimen as above				this study
51 700 ± 1100	OX-17071	*Ovibos moschatus*	vertebra	YG 155.1	Herschel Island - Pauline Cove	this study, Figure 2b
modern	Beta 136364	*Rangifer tarandus*	metatarsal	YG 12.45	Herschel Island - Pauline Cove	this study
modern	Beta 189293	*Rangifer tarandus*	innominate	YG 12.32	Herschel Island - Pauline Cove	this study
16 200 ± 150	RIDDL-765	*Equus lambei*		CMN 43815	Herschel Island – northeast coast	Harington, 1989, 2003
16 700 ± 200	RIDDL-766	Same specimen as above				Harington, 1989, 2003
17 490 ± 90	Beta 185981	*Equus* sp.	metacarpal	YG 155.9	Herschel Island - Pauline Cove	this study, Figure 2c
36 160 ± 530	Beta 70841	*Equus* sp.	phalanx	YG 12.6	Herschel Island - Pauline Cove	Harington, 2003
> 45 130	Beta 189292	*Equus* sp.	phalanx	YG 12.7	Herschel Island - Pauline Cove	this study
> 47 000	AAR-11195	*Equus* sp.	tibia	YG 206.6	Herschel Island - Pauline Cove	this study; Figure 2d
> 53 000	AAR-11194	*Equus* sp.	phalanx	YG 206.36	Herschel Island - Pauline Cove	this study, Figure 2e
45 800 ± 2500	AAR-11192	*Equus* sp.	phalanx	YG 206.37	Herschel Island - Pauline Cove	this study
> 45 130	Beta 189289	peat	wood		Herschel Island	this study
> 45 200	Beta 189290	peat	wood		Herschel Island	this study
> 45 130	Beta 189291	*Mammut americanum*	cuboid	YG 33.3	Herschel Island - Pauline Cove	this study; Figure 2f
1290 ± 40	Beta 224129	*Ursus maritimus*	humerus	YG 96.1	Herschel Island - Pauline Cove	this study
15 290 ± 70	Beta 185982	*Odobenus rosmarus*	radius	YG 12.2	Herschel Island - Pauline Cove	this study
45 630 ± 1580	Beta 70839	*Odobenus rosmarus*	mandible	YG 12.1	Herschel Island - Pauline Cove	Harington, 2003; this study, Figure 2g

320, GSC-1760; 21 600 ± 230, GSC-1760-2), respectively. Harington (2005) suggests that these dates represent animals that moved northwest from the Mackenzie Delta region during the Last Glacial Maximum. The presence of woolly mammoth in the Mackenzie Delta during the Last Glacial Maximum is confirmed by a date of 19 440 ± 290 (I-8578) on a mammoth bone recovered from near Tununuk (Rampton, 1988; Harington, 2003). Another woolly mammoth recovered from Nicholson Peninsula, Northwest Territories, has been dated to 34 000 ^{14}C yr BP (Burns, 2001). The presence of saiga antelope (*Saiga tatarica*; NMC 12090) dated to 14 920 ± 160 ^{14}C yr BP (ETH-3898) on the Baillie Islands, Northwest Territories, provides evidence for a hyper-arid environment on the northeastern extremity of Beringia (Harington and Cinq-Mars, 1995).

Palaeoenvironments of the Beaufort Sea Coastal Lowlands

Vast areas of the Beaufort Sea shelf were exposed during Pleistocene glacial intervals (Blasco et al., 1990; Dinter et al., 1990; Fig. 1). Widespread dune and other aeolian deposits along the lowlands adjacent to the Beaufort Sea (Carter, 1981; Hill and Nadeau, 1984; Vincent, 1989; Dallimore et al., 1997; Bateman and Murton, 2006) indicate that Beaufort coastlands were extremely arid during Pleistocene cold phases. The presence of Late Pleistocene saiga antelope further confirms this assertion (Harington and Cinq-Mars, 1995). Guthrie and Stoker (1990) suggested that this hyper-arid environment would have favored horses over other typical Beringian large mammals, such as woolly mammoths and bison. This pattern is a stark contrast to the bison-dominated Pleistocene faunas from the interior of Alaska and the Yukon (Guthrie, 1990). The pattern of horse-dominated faunas for northernmost Eastern Beringia is supported by our faunal data from Herschel Island. The specimens collected and accessioned between 1985 and 2007 in the palaeontology collection of the Yukon Government include 70 horse fossils (40%) out of a total 177 identified terrestrial vertebrate specimens. Also included are 35 bison (20%), 30 caribou (17%), 19 muskox (11%), 17 carnivore (10%), and 6 probocidean (3%) specimens. The ability of horses to survive long periods without free water and sustain themselves on large amounts of low-quality winter grassland forage enabled them to out-compete other members of the Pleistocene mammoth-fauna along the hyper-arid Beaufort Sea coastal lowlands (Guthrie and Stoker, 1990).

The presence of American mastodon on the Beaufort Sea coastlands is confirmed by our fossil specimen from Herschel Island (Fig. 2f). Since these browsers are typically associated with forested environments, it is logical to assume this specimen may date to the Last Interglacial period when spruce extended northward to the Arctic Ocean (Carter and Ager, 1989; Brigham-Grette and Hopkins, 1995). It is probable that this American mastodon specimen originates from deposits that are correlative to the wood-rich, infinite-aged peats from the “mixed” preglacial sediments described by Rampton (1982). In addition, the recovery of interglacial and glacial-type faunal remains from the same site on Herschel Island sheds further light on the high degree of fossil recycling within Arctic Quaternary contexts.

CONCLUSIONS

New radiocarbon dates obtained on vertebrate fossils recovered from Herschel Island figure importantly in the discussion on Late Pleistocene glacial events and paleoenvironments along the Beaufort Sea coastlands. In particular, several infinite radiocarbon ages are difficult to reconcile with a proposed Late Wisconsinan glacial advance, though these fossils may originate from older Beaufort Shelf sediments that were entrained during the Laurentide ice-thrust event that formed the ridge of Herschel Island. The possible correlation of the Buckland Glaciation on the Beaufort coast with the glaciomarine Flaxman Member deposits off the coast of northern Alaska may suggest that the Herschel Island ice-thrust ridge was present since at least the later stages within the Last Interglacial, MIS 5a. The ambiguities regarding the origin of the Herschel Island fauna and our inability to positively correlate these dated fossils to key stratigraphic units or depositional events precludes our drawing any definitive conclusions regarding the chronology for the glacial advances. However Harington's (1989) date of ~16 000 ^{14}C yr BP on a fossil Yukon horse cranium recovered from probable in situ context suggests that the Herschel Island ice-thrust ridge had been formed and subsequently deglaciated and was available for inhabitation by Pleistocene mammals by that time. The dominance of horse in the Herschel Island Pleistocene fauna is a stark contrast to the bison-dominated faunas of interior Alaska and Yukon. A focus on the recovery of in situ Pleistocene terrestrial fossils from clear stratigraphic contexts and the acquisition of more radiocarbon dates are key to resolving several outstanding geological, palaeontological, and palaeoenvironmental questions for Herschel Island and the Beaufort Sea coastal lowlands.

ACKNOWLEDGEMENTS

We thank past and present staff from Herschel Island Territorial Park and Yukon Historic Sites for their continued support with palaeontology on Herschel Island. We also thank Paul Matheus and Elizabeth Hall for their hard work in the field and identification of some of the Herschel Island specimens. We are grateful to Eske Willerslev, Jaco Weinstock, and Paula Compos for enabling us to include their unpublished radiocarbon dates in this manuscript. We thank Jeff Hunston for his continued support for all things related to Yukon Heritage. Our gratitude is extended to Dick Harington for making early contributions to the Yukon Government Palaeontology Collection and for his informative discussions on all aspects of Yukon palaeontology. We thank Chris Burn, Julian Murton, and Julie Brigham-Grette for helpful discussions about how our data might fit into the big picture. Suggestions and comments by Chris Burn, Scott Dallimore, and two anonymous reviewers led to substantial improvements to the manuscript.

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