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Expanded Late Wisconsinan ice cap and ice sheet margins in the western Queen Elizabeth Islands, Arctic Canada

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A B S T R A C T

Recent mapping of surficial geology and geomorphology in the western Canadian High Arctic (Melville and Eglinton islands), together with new radiocarbon dates acquired from ice-contact raised marine sediments, document expanded late Wisconsinan ice limits for the northwest Laurentide Ice Sheet and the western Innuitian Ice Sheet. An extension of the northwestern margin of the Laurentide Ice Sheet onto Eglinton Island is proposed based on evidence from till containing erratics derived from the Canadian Shield and a pattern of meltwater channels indicating ice retreat offshore into M'Clure Strait. Expansion of the western Melville Island Ice Cap (part of the western, lowland sector of the Innuitian Ice Sheet) to its offshore late Wisconsinan limit was facilitated by coalescence with the Laurentide Ice Sheet, whose buttressing allowed thickening to occur. Estimates of ice extent and thickness (>500 m) of the western Melville Island Ice Cap are in agreement with high marine limits (≤70 m asl). Lateral and proglacial meltwater channels, moraines and glaciomarine, glaciolacustrine and glaciofluvial deposits indicate radial retreat of the western Melville Island Ice Cap onto central highlands after ~13.0 cal ka BP. Older marine limit shorelines on southern Eglinton Island (~13.6 cal ka BP) are broadly synchronous with the early and rapid deglaciation of other areas formerly glaciated by the northwestern Laurentide Ice Sheet to the southeast and southwest (~14.2–13.6 cal ka BP). The collapse of the northwest Laurentide Ice Sheet in M'Clure Strait beginning at ~14.2 cal ka BP, in addition to prior inferred thinning, opens the possibility that it made a significant contribution to meltwater pulse 1A.

1. Introduction

Reconstructions of past environmental change in the Arctic are needed to place modern environmental change into a meaningful context (i.e., the roles of natural vs. anthropogenic controls). The western Canadian Arctic Archipelago (CAA) is a poorly studied region of North America in terms of its glacial history during and since the Last Glacial Maximum (LGM). Nevertheless, parts of this region are known to have supported two ice sheets during the LGM: the lowland (western) sector of the Innuitian Ice Sheet (IIS), which occupied some or all of the western Queen Elizabeth Islands (QEI; Blake, 1970; England et al., 2006), and the northwest sector of the Laurentide Ice Sheet (LIS; Dyke and Prest, 1987; Dyke et al., 2002; Dyke, 2004), which was grounded in eastern M'Clure Strait and on southern Melville Island (Dundas Peninsula; Fig. 1; England et al., 2009). West and southwest of Melville Island, the undefined limits of both ice sheets purportedly constitute the northeast extremity of Beringia (Vincent, 1982, 1983; Harington, 2005).

Sea level models attempting to predict the magnitude of future sea level rise depend on accurate reconstructions of former ice sheet extent and volume as ongoing regional-scale glacioisostatic adjustments contribute to modern sea level change. This is especially important for understudied areas such as the western QEI (Mitrovica and Milne, 2002). The current mismatch between Holocene relative sea-level data and modelled relative sea-level hindcasts for parts of the western QEI (including Melville Island) for example, might be reconciled by increasing ice thickness over the western CAA (Peltier, 2002; Tarasov and Peltier, 2004; England et al., 2009). Geology-based reconstructions of rates and patterns of deglaciation following the LGM are also important data for placing limits on future sea-level rise, as episodic accelerations of ice sheet retreat (recently observed along the margins of the Greenland and Antarctic ice sheets; Rignot et al., 2004, 2006) remain difficult to model (Alley et al., 2008).

Longstanding LGM ice limits shown for the western CAA in Dyke and Prest (1987) and Dyke et al. (2002, 2003b) are based on geological mapping conducted primarily by the Geological Survey

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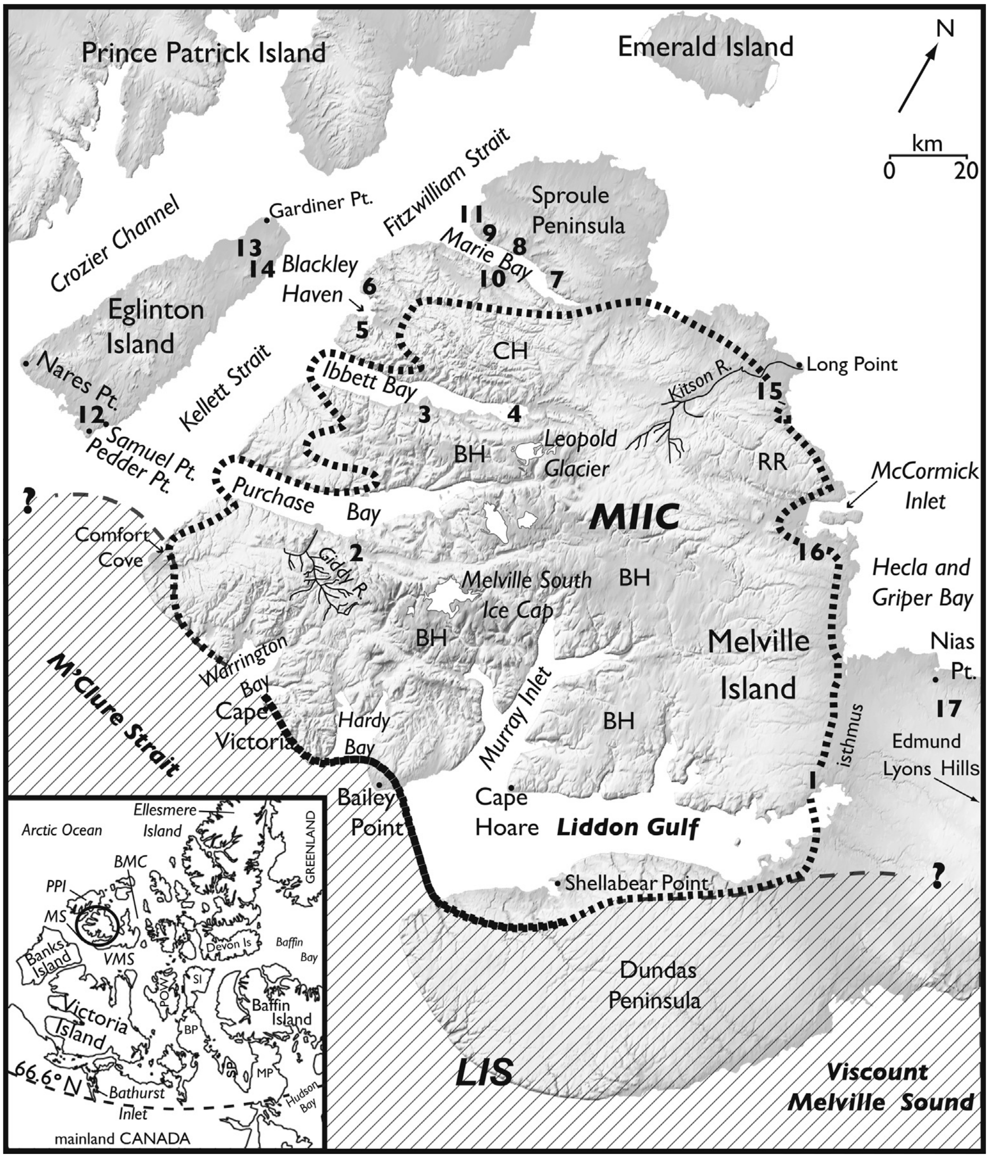

Fig. 1. Study area with place names mentioned in text. BH (Blue Hills), CH (Canrobert Hills), RR (Raglan Range). Site numbers (in bold) refer to radiocarbon dates listed in Table 1. Areas covered by modern ice caps are shown in white. Areas glaciated by the LIS during the LGM are indicated by diagonal lines (grey dashed line marks its margin; England et al., 2009). Heavy dashed line on western Melville Island outlines minimum limits for the western MIIC from Hodgson (1992) and England et al. (2009). Inset: Queen Elizabeth Islands with study area circled. BP (Boothia Peninsula); BMC (Byam Martin Channel); MS (M'Clure Strait); MP (Melville Peninsula); PPI (Prince Patrick Island); POW (Prince of Wales Island); SI (Somerset Island); SP (Simpson Peninsula); VMS (Viscount Melville Sound).

of Canada (Prest, 1957, 1969; Fyles, 1965; Vincent, 1982, 1983; Hodgson et al., 1984; Hodgson, 1992, 1994; Fig. 1). Earlier reconstructions show prominent ice-free land representing the northeastern limit of Beringia, as proposed by Harington (2005). A more recent revision of the northwestern sector of the LIS (England et al., 2009) extends the LGM western margin across northern Banks Island and M'Clure Strait to the southwest tip of Melville Island, ~200 km northwest of its formerly proposed limit (Dyke and Prest, 1987). This revision is based on the remapping of glacial and marine landforms and sediments across both coastlines of Melville and northern Banks islands bordering M'Clure Strait and includes >80 new radiocarbon dates on glacially transported shells in till (constraining the age of ice advance) and on shells within ice-contact deglacial shorelines (constraining the age of ice retreat; England et al., 2009). The primary objective of this paper is to present new data documenting the nature and timing of past ice sheet activity to the north and west, across western Melville Island and adjacent Eglinton Island (Fig. 1).

1.1. Previous research

Western Melville Island has previously been portrayed as either part of a fully glaciated QEI during the LGM, with contiguous, radially-flowing island-based ice caps (e.g., Prest, 1969; the western IIS, England et al., 2006) or as supporting only a small ice cap, the western Melville Island Ice Cap (MIIC) leaving ~25% of its area unglaciated (Hodgson, 1992; Dyke, 2004). The most recent depiction of western Melville Island during the LGM was based on extensive mapping of aerial photographs and ~3–4 months of fieldwork completed between 1964 and 1989, (Hodgson et al., 1984; Hodgson, 1992). These studies found that weathered bedrock is by far the most common surficial material; however,

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