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New marine evidence for a Late Wisconsinan ice stream in Amundsen Gulf, Arctic Canada

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ABSTRACT

Amundsen Gulf and adjoining Dolphin and Union Strait and Coronation Gulf form the southwestern end of the Northwest Passage adjacent to the Beaufort Sea. Extensive high resolution multibeam sonar imagery and sub-bottom profiles of the seabed have been acquired, primarily in Amundsen Gulf, by ArcticNet and the Ocean Mapping Group at the University of New Brunswick. These data reveal a variety of seabed landforms including mega-scale glacial ridge and groove lineations, drumlins, moraines, iceberg scours, bedrock outcrops, and discontinuous sediment deposits of variable thickness. The lineations are widespread, especially in southeastern Amundsen Gulf. They resemble modern and paleo bedforms reported from Antarctica, Svalbard, Greenland and other Canadian Arctic channels, where they have been ascribed to ice streams.

The glacial sole marks on the seabed in Amundsen Gulf and regional data from the adjacent mainland and islands outline the configuration of a glacial ice stream from the Laurentide Ice Sheet that occupied Amundsen Gulf and adjoining waterways during the Late Wisconsinan. Part of the northwestward flowing ice stream was deflected around the Colville Mountains on Victoria Island and rejoined the main ice stream in Amundsen Gulf by way of Prince Albert Sound. The grounded Amundsen Gulf ice stream extended northwestward to the outer slope in the Beaufort Sea where it was buttressed by Arctic Shelf Ice. Maximum ice stream extent is inferred to have been coincident with the Late Glacial Maximum. Multi-sequence ice-contact sediments and stratigraphic relations with glaciomarine sediments indicate that several ice advances and retreats occurred in the northwestern part of the gulf. Final retreat from the maximum position began prior to 13,000 cal yr BP and terrestrial dates indicate that the retreating ice front had reached Dolphin and Union Strait by about 12.5 cal ka BP.

1. Introduction

Amundsen Gulf and the connecting channels of Dolphin and Union Strait and Coronation Gulf constitute a contiguous 860 km-long waterway within the Canadian Arctic Archipelago (Fig. 1). Together they form the southwestern segment of the Northwest Passage and separate Banks and Victoria islands from the Canadian Arctic mainland. During the Late Wisconsinan glaciation, this region was inundated by the Laurentide Ice Sheet (LIS), which converged over the western Canadian Arctic and extended into the Beaufort Sea (Prest et al., 1968; Dyke and Prest, 1987a,b; Dyke et al., 2002; Dyke, 2004; Stokes et al., 2006, 2008; England et al., 2009; Lakeman and England, 2012, 2013; Blasco et al., 2013; Batchelor et al., 2014; Nixon and England, 2014; Vaughan et al., 2014).

Geomorphic evidence for faster, thicker glacier ice in the large topographic depressions formed by Amundsen Gulf, Dolphin and Union Strait, and Coronation Gulf was first documented by Fyles (1963). Subsequent field investigations by Sharpe (1984, 1988, 1992), St-Onge and McMartin (1995, 1999), Dyke and Savelle (2000), and Dyke et al. (2003b) reinforced interpretations of fast-flowing glacier ice in these channels. A former ice stream within Coronation Gulf and Dolphin and Union Strait was inferred by Sharpe (1988, 1992) from the glacial record on Victoria Island. Stokes et al. (2006, 2008) interpreted a former ice stream in

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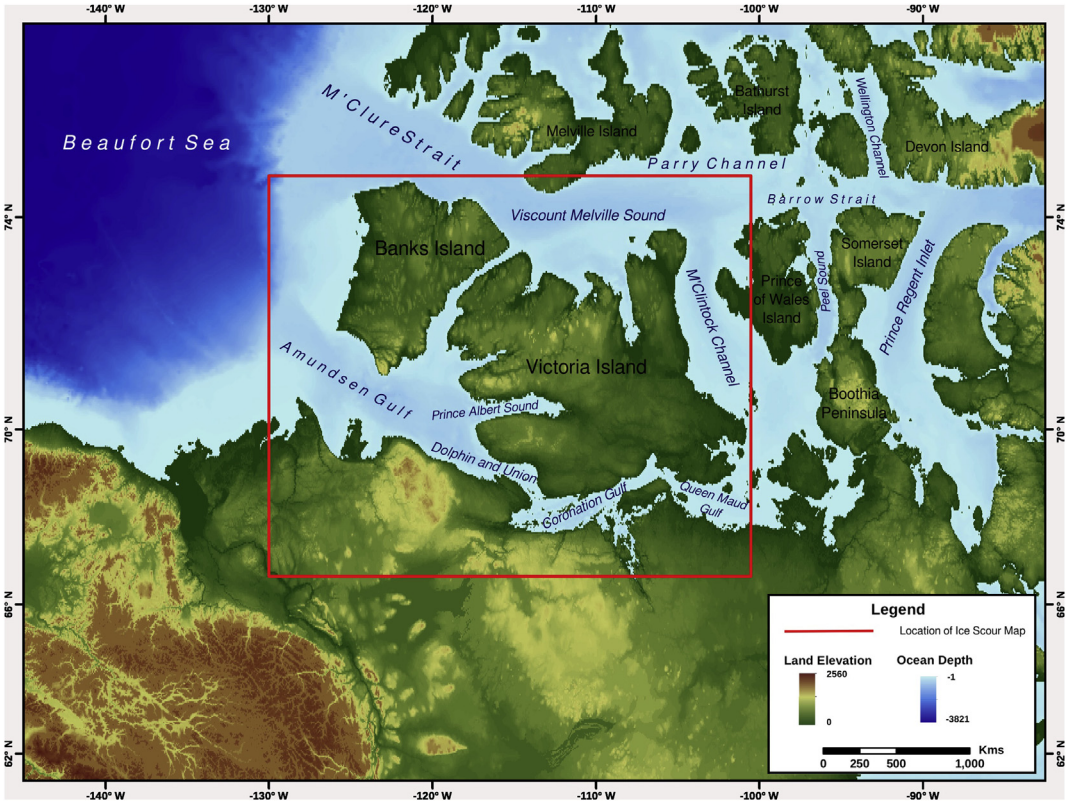

Fig. 1. Index map showing the location of the study area in the Canadian Arctic Archipelago. The red box outlines the study area. Bathymetry data were derived from GEBCO.

Amundsen Gulf, Coronation Gulf and Dolphin and Union Strait based on satellite imagery, terrestrial information and limited marine imagery, which was further defined by MacLean et al. (2012) from extensive multibeam imagery. As well, Batchelor et al. (2012, 2013a,b, 2014), from seismic reflection profiles, interpreted that glacial ice advanced northwesterly through Amundsen Gulf to the shelf break in the Beaufort Sea at least eight times during the Quaternary. Some of those advances, however, may have been oscillations of the same ice front rather than by entirely separate ice streams. Ice streams from Amundsen Gulf and M'Clure Strait were inferred to have been the source of glacigenic bedforms at localities in the Arctic Ocean basin, such as the Chukchi Plateau (Polyak et al., 2001; Stokes et al., 2005, 2006, 2008; Jakobsson et al., 2008, 2014; England et al., 2009; Lakeman and England, 2012, 2013).

Although, ice streams have been proposed for many of the marine channels of the Canadian Arctic by various authors (i.e., Denton and Hughes, 1981; Clark and Stokes, 2001; De Angelis and Kleman, 2005, 2007; MacLean et al., 2010; Stokes et al., 2005, 2006, 2008; England et al., 2006, 2009), few studies have documented the geomorphological and geological records of past ice streaming in detail. The objectives of this research are to characterize the past flow dynamics of the former ice streams that occupied Amundsen Gulf, Dolphin and Union Strait, and Coronation Gulf during the last glaciation. This knowledge will constrain conceptual and numerical models of Late Wisconsinan ice cover in Arctic Canada (i.e. Tarasov et al., 2012) and will lend greater insight into the myriad variables that occasioned deglaciation. Terrestrial areas bordering the channels in the study area were in part overrun by ice flow that was mainly funnelled through the waterways, including a late westerly ice advance on Victoria island subsequent to retreat of the Amundsen Gulf ice stream (Sharpe, 1992). See Prest et al. (1968) for regional data, Kerr (1994), Sharpe and Nixon (1989) for the record from mainland areas of the Northwest Territories and Nunavut adjoining the waterways, Sharpe (1992) and Dyke and Savelle (2000) for information relating to southern Victoria Island. See England et al. (2009), Lakeman and England (2012), Evans et al. (2014), Vaughan and England (2014); Vaughan and England (2011), Vaughan et al. (2014) and Nixon and England (2014) concerning the record on Banks Island and adjoining regions.

Relevant physical parameters pertaining to the channels in the study area include the following data pertaining to the bedrock geology and bathymetry. Precambrian metamorphic, meta sedimentary and igneous rocks form the southern shore of Coronation Gulf, Melville Hills mid-way along the south coast of Amundsen Gulf, a high bluff at the southern end of Banks Island, and some upland areas on Victoria Island. Lower Paleozoic strata form the south coast of Dolphin and Union Strait, extend northwestward along the mainland coast of Amundsen Gulf as far as the Melville Hills, and form most of Victoria Island. Cretaceous strata form the south coast of Amundsen Gulf northwest of Melville Hills except for Parry Peninsula where Cambrian-Ordovician strata occur. Banks Island is mainly underlain by Cretaceous and Tertiary strata except for Devonian strata in the northeast and Precambrian rocks at the southernmost tip of the island (Sharpe, 1992; Kerr, 1994; Wheeler et al., 1996). The various rock units that compose the onshore bedrock geology are inferred to underlie the adjacent marine areas (Wheeler et al., 1996).

Coronation Gulf contains a series of islands and an irregular seafloor with maximum water depths of 387 m (Canadian Hydrographic Service (2004). Depths of 15 m near the southeastern end of Dolphin and Union Strait increase to 137 m midway along the strait