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# The Innuitian Ice Sheet: configuration, dynamics and chronology

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**Abstract**

Portrayal of North American ice cover during the Last Glacial Maximum is dominated by the Laurentide Ice Sheet, leaving little detail for the adjacent Innuitian Ice Sheet (IIS). Four decades of geological fieldwork across the Queen Elizabeth Islands now warrant specific treatment of the IIS, including its chronology, configuration, dynamics and retreat. This reconstruction is relevant to the sedimentary history of the Arctic Ocean and to high latitude climate forcing. The IIS was composed of both an alpine and lowland sector. The advance of the alpine sector occurred as recently as 19 $^{14}$C ka BP. Geological evidence configures outflow from alpine and lowland divides that produced several palaeo-ice streams, one extending northwestward across the Canadian Arctic Archipelago to the polar continental shelf. Retreat of the IIS commenced along its southwest margin ~11.6 $^{14}$C ka BP. However, most of the ice sheet remained on the continental shelf during the Younger Dryas. By ~10 $^{14}$C ka BP, marine-based ice experienced widespread calving through the western and central archipelago in response to Holocene warming and ongoing eustatic sea level rise. The sea penetrated the eastern archipelago by 8.5 $^{14}$C ka BP, gutting the alpine sector of the IIS. Regional isobases record the glacioisostatic signature of the ice sheet, and are congruent with the primary geological evidence. The delayed buildup of the IIS was out-of-phase with the growth of the Laurentide Ice Sheet that occasioned climatic and glacio-eustatic forcing in the Innuitian region. Recent modelling experiments reinforce the hypothesis that growth of the Laurentide Ice Sheet culminated in a split jet stream that temporarily favoured augmented precipitation and growth of the IIS.


## 1. Introduction

Three decades ago, Blake (1970) proposed that during the Late Wisconsinan (marine isotope stage 2), the Queen Elizabeth Islands (QEI) of the Canadian High Arctic were covered by the Innuitian Ice Sheet (IIS) that coalesced with the Greenland Ice Sheet to the east and the Laurentide Ice Sheet to the south (Fig. 1). Based on Blake's work, this concept was most clearly illustrated by Prest (1969), who portrayed speculative limits and recessional ice margins. However, until the late 1990s, the principal supporting evidence for the IIS was the ridge of Holocene emergence that crosses the QEI, from Eureka Sound to Bathurst Island (Fig. 1). This ridge, termed the Innuitian uplift (Walcott, 1972), was ascribed to postglacial emergence along the axis of maximum former ice thickness. However, the significance of this emergence vis-à-vis ice sheet magnitude and, more generally, the existence of the IIS was debated due to: (1) the apparent general lack of primary glacial geological evidence (England 1976a, 1992, 1996; Boulton, 1979; Hodgson, 1985; England et al., 1991; Tushingham, 1991); (2) putative evidence that the only extensive glaciations in the region were of much greater antiquity (England and Bradley, 1978; England et al., 1978, 1981; England, 1978; Bell, 1996); and (3) evidence that the fiords and marine channels of the eastern QEI were occupied by a full-glacial sea during the Late Wisconsinan (England, 1983, 1992). Recent studies have discounted evidence of a full-glacial sea and the antiquity of regional glaciation, and have reconciled the glacioisostatic interpretation of the Innuitian uplift with a growing body of geological evidence of extensive Late Wisconsinan glaciation, thereby providing a consensus supporting the IIS

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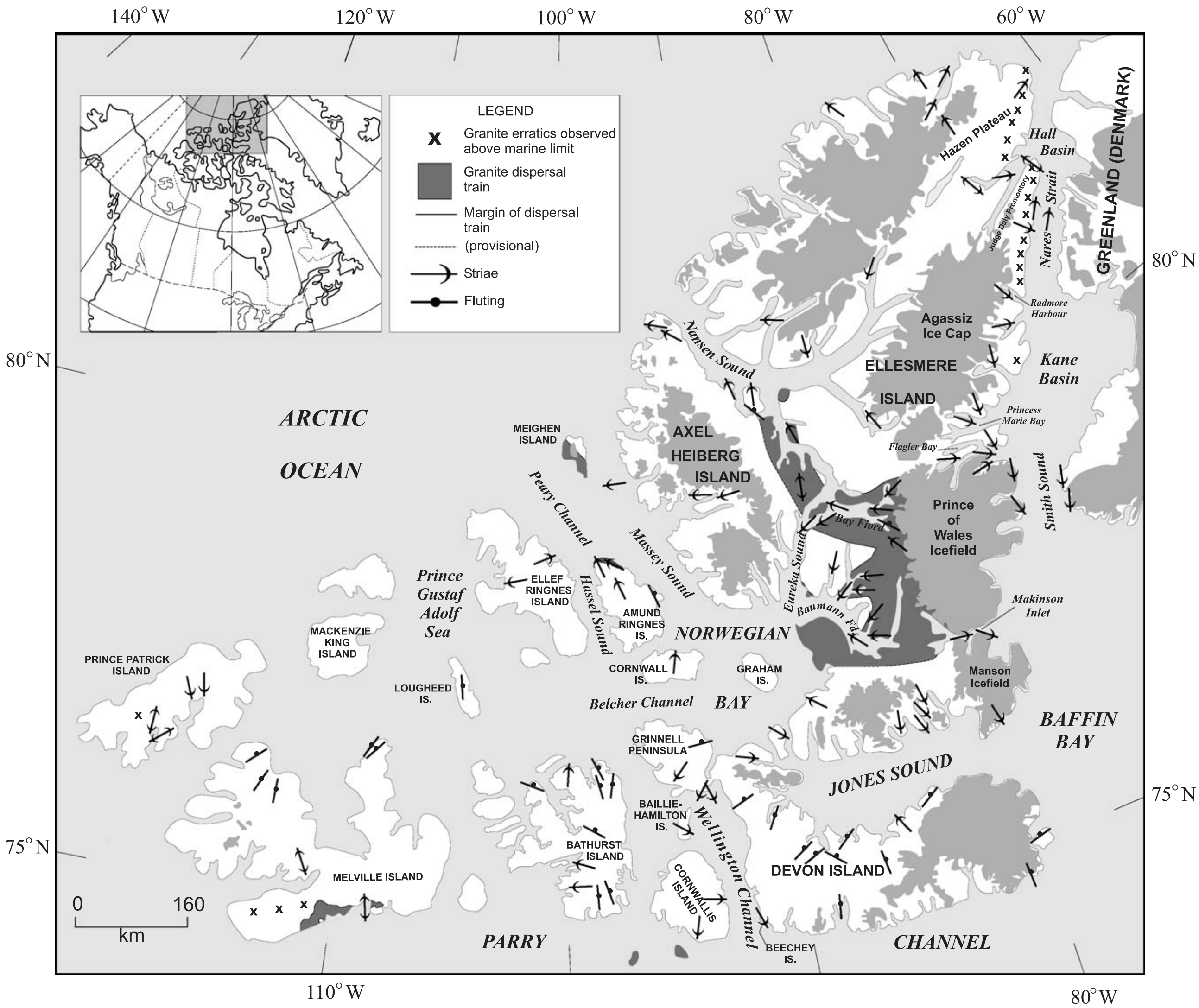


Fig. 1. Map of the Queen Elizabeth Islands and NW Greenland showing place names used in text, modern icefields (shaded light grey), ice flow indicators, and granite dispersal trains extending across Ellesmere, Axel Heiberg, Amund Ringnes and Meighen islands. Note presence of granitic till from Laurentide Ice Sheet on southern Melville Island.

(Blake, 1992a, b, 1993; Blake et al., 1996; Bednarski, 1998; Dyke, 1998, 1999; England, 1998, 1999; Bischof and Darby, 1999; Ó Cofaigh, 1999; Ó Cofaigh et al., 1999, 2000; Smith, 1999; England et al., 2000, 2004; Lamoureux and England, 2000; Dyke et al., 2002, 2003a; Atkinson, 2003; Atkinson and England, 2004; Dyke, 2004).

Recent reconstructions of glaciated North America during the Last Glacial Maximum (LGM) naturally focus on the predominant Laurentide Ice Sheet (Dyke et al., 2002; Dyke, 2004). Although these continental reconstructions present a generalized IIS, salient features documented by glacial geological evidence have arisen since EPIOLG (Clark and Mix, 2002), and these warrant more detailed presentation at a regional scale. Furthermore, a significantly larger radiocarbon database along the western and southern margin of the IIS now refines the history of deglaciation and postglacial emergence across the QEI (Lamoureux and England, 2000; Atkinson, 2003; Bednarski, 2003; Atkinson and England, 2004).

The primary objective of this paper is to integrate previous and ongoing research in order to clarify and develop new perspectives on the IIS. Although the IIS did not contribute significantly to global ice volume at the LGM (<7% of the total ice equivalent sea level lowering contributed by North American ice sheets; Clark and Mix, 2002), understanding its activity along the margin of the Arctic Ocean helps address the nature of high-latitude palaeoenvironmental change. The secondary objective is to use this synthesis to address broader themes including: the linkage between the IIS and other circumarctic ice sheets (Siegert and Marsiat, 2001; Mangerud et al., 2002; Brigham-Grette et al., 2003); its response to climate forcing (Rogers et al., 2001; Bromwich et al., 2002, 2004); its contribution to sedimentation in the Arctic Ocean (Polyak