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Late-Holocene diatom derived seasonal variability in hydrological conditions off Disko Bay, West Greenland

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ABSTRACT

A decadally resolved diatom record from a sediment core collected from Disko Bay, central West Greenland, reveals variations in hydrological conditions for the late Holocene. The diatom flora record two clear trends in surface water temperatures: a pronounced cooling of surface waters during the Medieval Climate Anomaly (MCA) and a progressive warming in surface waters during the Little Ice Age (LIA), previously identified in North Atlantic studies. Our data support the existence of a previously identified anti-phase relationship between surface water temperatures off West Greenland and climate events recorded in the north-east Atlantic. The diatom assemblages show relatively cool surface water conditions during warmer climatic intervals, e.g. 3.6–2.7 cal. ka BP, the MCA, while relatively warm surface water conditions during colder climatic periods, e.g. the Dark Ages (DA) and the LIA. The exception to this is the Roman Warm Period (RWP), which in West Greenland shows warmer surface waters and climatic conditions. Our data also show the existence of anti-phase relationship between surface and sub-surface water temperatures in Disko Bay during the interval 3.6–2.7 cal. ka BP (cooler surface with warmer subsurface waters) and towards the end of the LIA (warmer surface and cooler sub-surface waters). These anti-phases patterns are possibly linked to: 1) the local spring–summer hydrological conditions (e.g. warmer climatic intervals), such as meltwater flux from sea ice/continental ice and water stratification, and 2) large-scale ocean–climate interactions (e.g. cooler climatic intervals) within the North Atlantic Oscillation (NAO)-type climate see-saw between West Greenland and north-west Europe associated with variability in the Atlantic Meridional Overturning Circulation (AMOC).

1. Introduction

The high diversity of diatom flora in sub-Arctic regions of the North Atlantic makes them a useful tool for reconstructing palaeoenvironments (e.g. Moros et al., 2004; Witak et al., 2005; Witon et al., 2006; Moros et al., 2006b), sea ice concentrations and ice margins (Justwan and Koç, 2008), and quantitative estimates of past sea surface temperatures (SSTs) (Koç Karpuz and Schrader, 1990; Jiang et al., 2001; Birks and Koç, 2002; Andersen et al., 2004a,b; Berner et al., 2008). In this region modern diatom distributions are closely related to hydrological conditions, in particular surface water temperature (Hasle and Syvertsen, 1996). Diatoms have been particularly useful in palaeoenvironmental reconstructions from the continental margins of west and south-west Greenland (e.g. Jensen, 2003; Møller et al., 2006; Moros et al., 2006b; Ren et al., 2009; Krawczyk et al., 2010). Recent palaeoreconstructions of surface and subsurface waters of the West Greenland margin (e.g. Lloyd, 2006; Lloyd et al., 2007; Seidenkrantz et al., 2008; Krawczyk et al., 2010, 2012; Perner et al., 2011; Ribeiro et al., 2012) show late-Holocene hydrological variability superimposed on the widely recognized long-term climate cooling (e.g. Jennings et al., 2002; Kaufman et al., 2009; Vinther et al., 2009). Subsurface water conditions reconstructed using benthic foraminifera appear to reflect more stable, long-term temperature conditions, while surface water temperatures reconstructed from diatom flora (and dinoflagellates) tend to reflect short-term seasonal temperature variations in the shallower photic zone (Moros et al., 2004). During the late Holocene (particularly during the LIA) the broader North Atlantic palaeoreconstructions on the one hand record increased flux of the Arctic water and sea ice, particularly along the East

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Greenland shelf (e.g. Jennings et al., 2002), but also suggest an increase influence of Atlantic water masses on the North Iceland shelf and in the Reykjanes Ridge area in the subpolar North Atlantic (e.g. Andersen et al., 2004b; Justwan and Koç, 2008; Miller et al., 2011; Miettinen et al., 2012). A progressive negative NAO-type signature was suggested to explain the late-Holocene SST variability between the east and west sectors of the North Atlantic (Andersen et al., 2004a; Miettinen et al., 2011). Interestingly, previous diatom-based studies from Disko Bay (Krawczyk et al., 2010) recorded an anti-phase relationship between surface water temperatures and climate patterns recognized in the north-east Atlantic, similar to the anti-phase relationship found at the present day.

Modern phytoplankton studies off south-west Greenland (the MarineBasic-Nuuk (MBN) programme; Jensen and Rasch, 2009, 2010, 2011) show that the annual succession of diatom flora depicts seasonal bloom patterns. These patterns are influenced by various hydrological factors, such as local spring–summer meltwater influx or autumn upwelling of nutrients and large-scale inflow of modified waters sourced in the West Greenland Current (WGC). These monitoring studies allow more detailed investigation of hydrological conditions due to different timing of blooms of particular diatom groups and a link between diatom ecological groups and certain water masses, particularly important in the context of recent oceanic warming (Holland et al., 2008) and melting of the Greenland Ice Sheet (GIS) (Hanna et al., 2008).

In this study we present a high-resolution diatom record for the past *c.* 3600 years from a sediment core retrieved from outer Disko Bay. The purpose of this study is to investigate the late-Holocene water mass characteristics (SST and general hydrological conditions) off West Greenland based on detailed modern phytoplankton studies in the area (Jensen, 2003; Wroniecki, 2009; Krawczyk et al., 2012) and modern monitoring studies further south (MBN). We aim to improve the understanding of the relationship between diatom flora, local hydrological changes and large-scale ocean–climate interactions in the North Atlantic during the late Holocene.

2. Oceanographic setting

Disko Bay is an open marine bay (68°30′ N and 69°15′ N and 50°00′ W and 54°00′ W, Fig. 1) located in central West Greenland. In Disko Bay proper the topography varies with depths of 300–500 m, with a deepwater trough, Egedesminde Dyb (outer, south-west part of Disko Bay), having a water depth of up to 990 m (Buch, 2000).

The hydrography of Disko Bay is controlled by the West Greenland Current (WGC) encompassing water masses of different origin: cold, low salinity Arctic water from the East Greenland Current (EGC) flowing proximally to the coast as surface current (upper 200 m); and relatively warm and saline Atlantic water from the Irminger Current (IC) flowing off-shore and below (200–500 m) the EGC (Tang et al., 2004). The WGC components are

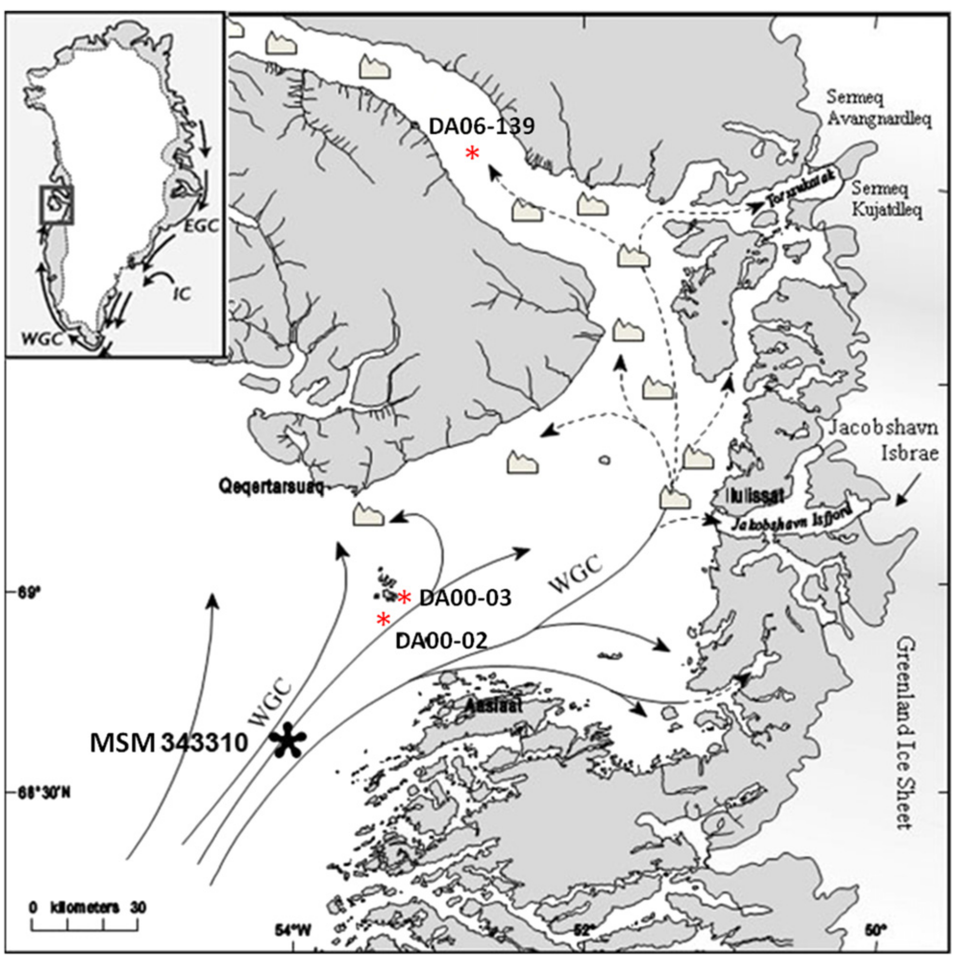

Fig. 1. Location map of Disko Bay showing position of the coring site MSM343310 (solid star) and other cores mentioned in text. The generalized ocean circulation scheme within Disko Bay and West Greenland is also shown. Relatively warm waters: IC, Irminger Current; WGC, West Greenland Current. Cold waters: EGC, East Greenland Current.