Marine Micropaleontology 88–89 (2012) 65–76

Contents lists available at SciVerse ScienceDirect

Marine Micropaleontology

journal homepage: www.elsevier.com/locate/marmicro

Central Arctic paleoceanography for the last 50 kyr based on ostracode faunal assemblages

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ARTICLE INFO

Article history:
Received 12 August 2011
Received in revised form 12 March 2012
Accepted 19 March 2012

Keywords:
Arctic Ocean
Ostracode
Paleoceanography
Paleoclimatology
Dansgaard–Oeschger
Heinrich
Age models
MIS 1
MIS 2
MIS 3

ABSTRACT

The paleoceanography of the central Arctic Ocean was reconstructed for the last 50 kyr (Marine Isotope Stages (MIS) 1–3) based on ostracode assemblages from 21 ^{14}C-dated sediment cores from the Mendeleev, Lomonosov, and Gakkel Ridges. Arctic sediments deposited during the Holocene interglacial period (MIS 1), the Bølling–Allerød, and larger interstadial Dansgaard–Oeschger (DO) events (3–4, 8, and 12) contain abundant *Cytheropteron* spp., *Henryhowella asperrima*, and *Krithe* spp. at intermediate/deep-depths (~1000 to 3000 m). These assemblages suggest a ventilated deep, Arctic Ocean water mass similar to the modern Arctic Ocean Deep Water (AODW) during these time periods. In contrast, sediment deposited during stadial events corresponding to Heinrich events 1, 2, 3, and 4, (also possibly the Younger Dryas; YD), contain abundant *Polycope* spp. (60–80%) suggesting a greater influence of the Atlantic Layer (AL) on the Arctic Intermediate Water (AIW) and AODW. Reduced sea-ice during the early Holocene, the last deglacial, and MIS 3 interstadials is indicated by the reoccurrence of *Acetabulastoma arcticum*, an epipelagic species that is parasitic on sea-ice dwelling amphipods. One hypothesis to explain these oceanographic changes during longer stadial events, particularly within the last glacial period (MIS 2), involves sluggish ocean circulation, thicker sea-ice cover, and a deeper halocline with ocean exchange between Greenland Sea and Arctic Ocean deep-water through the Fram Strait.

Published by Elsevier B.V.

1. Introduction

The Arctic Ocean influences global climate and ocean circulation through the contribution of Arctic deep-water to the global thermohaline system (Aagaard et al., 1985, 1991; Rudels and Quadfasel, 1991; Aagaard and Carmack, 1994; Anderson et al., 1994; Meincke et al., 1997; Rudels et al., 2004). Many climate and oceanographic studies suggest that large temperature changes in the Arctic are currently occurring in shallow to intermediate water depths (McLaughlin et al., 2009; Polyakov et al., 2011; Spielhagen et al., 2011) as well as declining annual Arctic perennial sea-ice cover (Stroeve et al., 2007a,b; Comiso et al., 2008; Rothrock et al., 2008; Kwok and Rothrock, 2009). Large changes in Arctic Ocean circulation during the last 50 kyr have also been hypothesized from sediment core proxy records (Stein et al., 1994a,b; Cronin et al., 1995; Jakobsson et al., 2001; Nørgaard-Pederson et al., 2003; Polyak et al., 2004; Spielhagen et al., 2004, 2005; Wollenburg et al., 2004; Darby et al., 2006; Polyak et al., 2010). Some studies postulate large changes in the Arctic Ocean during interstadial and stadial events of the last glacial period covering the last 50 kyr, including MIS 2 and 3 (Spielhagen et al., 2004, 2005; Darby et al., 2006). However, many aspects of Arctic Ocean circulation during past climate change cycles remain poorly understood due to low sedimentation rates, limited sediment chronology, and complex oceanographic changes.

This study investigates changes in late Quaternary benthic ostracode faunas from sediment cores in the central Arctic Ocean and applies them to the reconstruction of intermediate and deep-water circulation during the last 50 kyr. The focus is on several key ostracode taxa that act as faunal tracers of major water masses and sea ice conditions, and were recovered from 21 deep-sea sediment cores from the Gakkel, Lomonosov, and Mendeleev Ridges, and the Morris Jesup Rise. These sites cover a large part of the central Arctic Ocean and are presently located within the modern Arctic Intermediate Water (AIW), Canada Basin Deep Water (CBDW) and the Eurasian Basin Deep Water (EBDW) masses (Fig. 1). In addition to studying faunal changes, we attempted to improve Arctic chronology by recalibrating published radiocarbon dates from 22 cores and obtaining new radiocarbon dates from four cores. These recalibrated dates should help to improve interpretations of Arctic oceanography during glacial/interglacial cycles, as well as millennial-scale climate events (Dansgaard–Oeschger interstadial and Heinrich stadial events).

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0377-8398/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.marmicro.2012.03.004

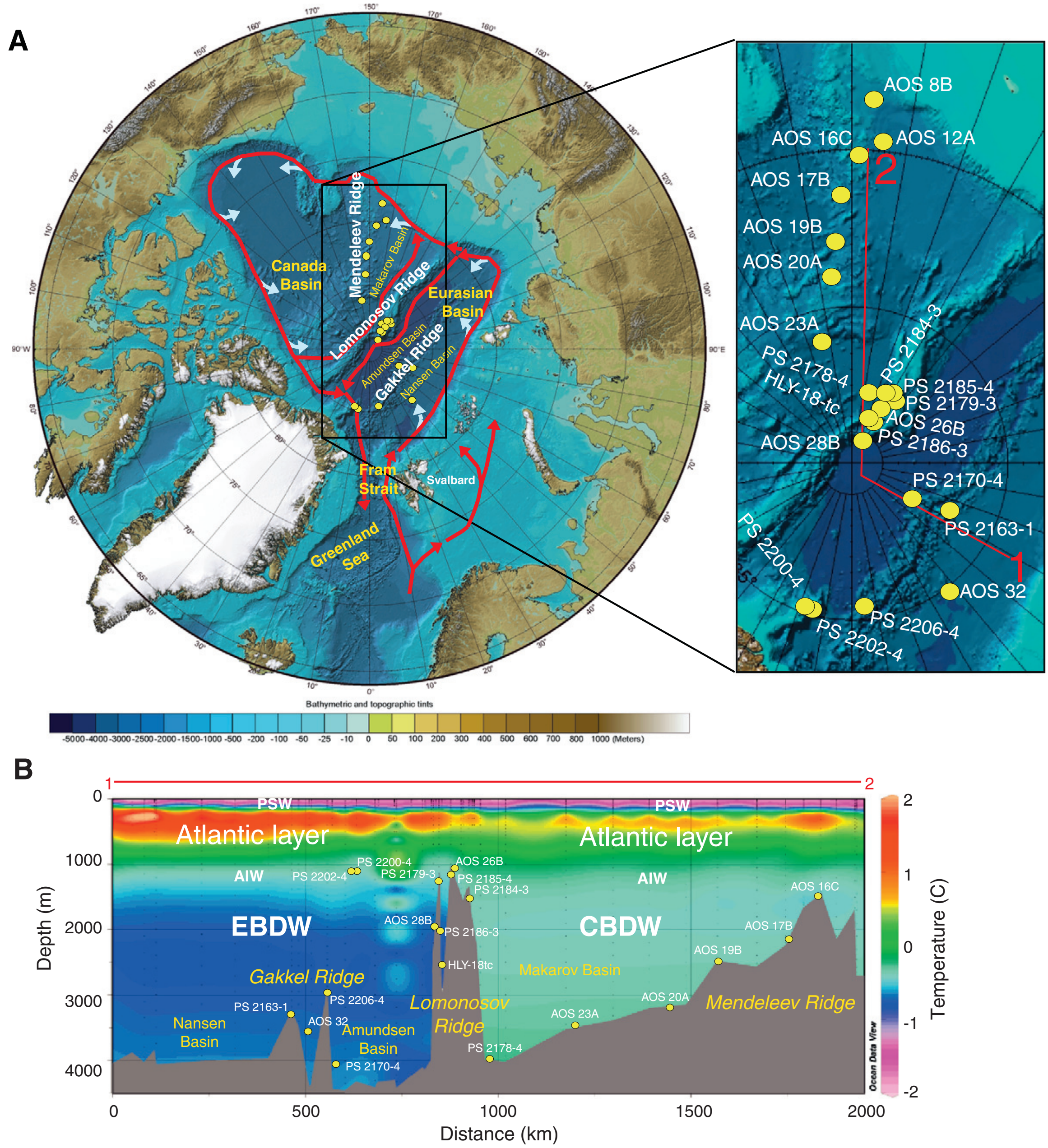

Fig. 1. A. International Bathymetric Chart of the Arctic Ocean with the 21 core sites from this study (from Jakobsson et al., 2008). See supplemental information on the location of the core sites in Table 1. Also shown is the generalized circulation of the Atlantic Layer (AL) within the Arctic Ocean (red). The blue arrows demonstrate brine formation on the continental shelves. B. Cross sectional temperature profile of the modern Arctic Ocean with cores from this study marked (AOS94B8B and AOS94B12A not shown).

2. Background

2.1. Modern Arctic oceanography

Today, the central Arctic Ocean is stratified into four primary layers: the Polar Surface Water (PSW) (Jones, 2001; Rudels et al., 2004) (also known as the Polar Mixed Layer, or PML), the Atlantic Layer (AL), the Arctic Intermediate Water (AIW), and the Arctic Ocean Deep Water (AODW) (Aagaard and Carmack, 1989; Anderson et al., 1994). The AODW is separated into the Canada Basin Deep Water (CBDW) and the Eurasian Basin Deep Water (EBDW) by the Lomonosov Ridge (Fig. 1B). The PSW (~0 to 50 m), primarily sourced from glacial melt and transpolar currents from the Siberian shelf to the Fram Strait and Beaufort Sea Gyre, is relatively cold (0 to −2 °C) and fresh (~32 to 34 ppt) (Fig. 1B) (Anderson and Jones, 1992; Jones, 2001; Karcher and Oberhuber, 2002; Rudels et al., 2004; Woodgate et al., 2007). An ~100 m deep halocline separates the PSW from the underlying AL (Fig. 1B) (Rudels et al., 1996). Today, the AL occurs from ~200 to 1000 m and is warmer (≥0 °C as defined by Rudels et al. (2004)), and more saline (~34.3 to 34.75 ppt), than the overlying PSW (Fig. 1B). The core of the AL, between 300 and 500 m water depths, and can reach temperatures exceeding 2 °C (Fig. 1) (Rudels et al., 2004). The AIW, which lies beneath and is influenced by the AL (Fig. 1B), refers to a water mass at depths of ~1000 to 1500 m in the Eurasian Basin and up to ~2000 m in the Canada Basin. This water mass is also referred to as the upper-AODW (upper-CBDW, upper-EBDW). The AL appears to influence the temperature and salinity of the modern AIW (~−0.5 to 0 °C; ~34.6 to 34.8 ppt), and as we discuss below, probably experienced large changes during the last 50 kyr (Fig. 1). The AODW fills the deep Arctic Basins beneath the AIW, at