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ORIGINAL RESEARCH ARTICLE

Deep water masses in the Iceland Basin during the Last Interglacial (MIS 5e): Evidence from benthic foraminiferal data☆

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Summary The Last Interglacial period, marine isotope stage (MIS) 5e, is a potential analogue for the Holocene. In this study, we investigated a marine sediment core, AMK-4442, recovered from the northern part of the Iceland Basin. The multiproxy approach used in this study, which includes foraminiferal and lithological analyses, identifies the difference in intensity of deep circulation between MIS 5e and the Holocene. Our data indicate that during early MIS 5e, the Iceland-Scotland Overflow Water (ISOW) flux into the Iceland Basin was suppressed. We suggest that the less active North Atlantic Deep Water (NADW) formation at this time was related to the obstruction of warm surface water inflow into the Nordic Seas.

1. Introduction

The Subpolar North Atlantic is a key region for the reflection of changes in the Atlantic Meridional Overturning Circulation (AMOC). AMOC is driven by deep water formation due to surface water cooling and subsidence in the Nordic Seas. The warm (roughly, 8—15°C) and saline (35—36 psu) Atlantic surface waters are delivered to that region in large volume by the North Atlantic Current (NAC) (Haine et al., 2008). Near 53°N, the NAC splits into several branches. One branch circulates along the Reykjanes Ridge to form the Irminger

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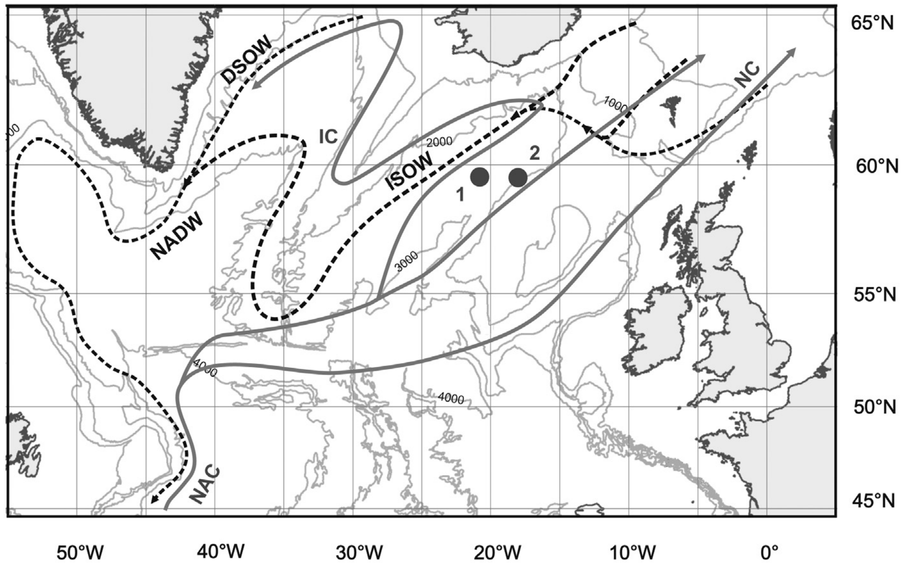

Figure 1 The position of the studied core and a general diagram of the deep (dashed black lines) and surface (solid gray lines) circulation (after Brambilla et al., 2008; Rhein et al., 2011): NAC, North Atlantic Current; NC, Norwegian Current; IC, Irminger Current; DSOW, Denmark Strait Overflow Water; ISOW, Iceland-Scotland Overflow Water; NADW, North Atlantic Deep Water. 1 — the studied AMK-4442 core; 2 — previously investigated AMK-4438 core (Lukashina, 2013a,b).

Current (IC). South of the Denmark Strait, a small branch of the IC separates to circulate along the west coast of Iceland. The remainder of the IC merges with the East Greenland Current (roughly, $T < 4°C$, $S < 34.60$ psu). Other branches of the NAC flow past Ireland, the Faroes, and into the Nordic Seas to become deep water (Brambilla et al., 2008; Haine et al., 2008; Rhein et al., 2011) (Fig. 1).

From the Nordic Seas, deep water masses enter the subpolar Atlantic region. Denmark Strait Overflow Water (DSOW) with temperature 0—2°C and salinity 34.88—34.93 psu is derived from the overflow of deep water through the Denmark Strait. Iceland-Scotland Overflow Water (ISOW) with temperature 1.8—3°C and salinity 34.98—35.03 psu is formed from the deep water masses that overflow through the deep saddle in the Faroe Bank Channel over the Iceland-Faroe Ridge and the Wyville Thomson Ridge (Dickson and Brown, 1994; Haine et al., 2008; Sarafanov et al., 2009; Wright and Miller, 1996). ISOW flows southward through the Iceland Basin and, subsequently, along the Reykjanes Ridge, after which it merges with the DSOW near Cape Farewell to form North Atlantic Deep Water (NADW) with temperature 1.6—4°C, salinity roughly, 34.9 psu — the densest of the salty northern water masses ($\sigma_\theta = 27.80$ kg/m^3) that propagates throughout the World Ocean (Dickson and Brown, 1994; Haine et al., 2008).

It is well known that there were three different AMOC states prevailing during interglacials, glacials and so-called Heinrich events respectively (e.g., Rahmstorf, 2002).

During interglacials, particularly during the one of the Holocene analogues, MIS 5e (Eemian; 117—128 ka), the circulation of deep water masses was similar on a basic level to that of the modern age (Kukla et al., 2002). Intensive advection of the warm Atlantic surface waters into the high latitudes and active deep convection with NADW formation occurred in the Nordic Seas stabilizing the AMOC system.

In glacial periods, ice sheets appeared around the Nordic Seas; these sheets weakened the NAC, which partially shifted toward the Iberian Peninsula (Barash, 1988; Eynaud et al., 2009). As a result, the circulation system of the AMOC was significantly suppressed (Kleiven et al., 2003; Oppo and Lehman, 1993).

When icebergs melted (Heinrich events), the surface water layer became fresher because of influx of huge amount of melting water. This led to the appearance of a halocline (Cortijo et al., 1997; Knies et al., 2007). Deep convection processes may have occurred further south, that is, between 50° N and 60° N, in areas not affected by the salinity decrease what led to instability of AMOC system (Vidal et al., 1997, 1999).

Studies of marine sediments that include deep-water benthic foraminiferal analyses have shown that benthic foraminifera are sensitive to the Late Pleistocene glacial—interglacial shifts. This sensitivity enables their use in reconstructions of the deep paleocirculation (Gooday, 2003; Smart, 2002, 2008; Smart and Gooday, 1997; Thomas et al., 1995).

The primary goal of the present work is to trace changes in deep water circulation during the last two glacial—interglacial transitions in the northern part of the Iceland Basin with a special emphasis on MIS 5e using benthic foraminiferal variability.

2. Material and methods

2.1. Core location and stratigraphy

A marine sediment core, AMK-4442 (59°32,08 N, 21°51,13 W; water depth 2787 m; core length 286 cm), was recovered from the northern part of the Iceland Basin during the 48th voyage of the research vessel "Akademik Mstislav Keldysh"