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Holocene climate variability at multidecadal time scales detected by sedimentological indicators in a shelf core NW off Iceland

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Abstract

A Holocene sediment record is presented from the Djúpáll trough, situated on the inner shelf northwest of Iceland. The paleoclimatic development has been interpreted on the basis of mass accumulation rate, carbonate content, mean grain size, sediment petrology and 29 radiocarbon dates. The results demonstrate in the early Holocene (10,000–8000 cal year BP) high sediment accumulation rates attributable to the effect of enhanced sediment mobilisation under influence of a relatively low sea level and remobilisation of glacial sediments on the sparsely vegetated Vestfirdir peninsula. The data suggest that a general southward displacement of the Polar Front commenced around 5000–4000 cal year BP.

A new proxy for Holocene climatic variability is presented by the basalt/plagioclase ratio in the 63–100 μm fraction. High basalt/plagioclase values are primarily related to periods of increased storminess and bottom current energy, which enhanced the transport of basaltic sediment from the coastal zone towards the outer shelf. Advection of polar waters containing basalt-rich IRD from the eastern Greenland Blosseville Kyst basalt province may also have contributed to increased basalt/plagioclase ratios. The correlation between basalt/plagioclase ratios and proxies of solar activity (^{14}C production and ^{10}Be flux) was explored and suggests that some of the centennial-scale peaks in colder climate could be related to increased nuclide production in the upper atmosphere. In addition, it was found that the Medieval Warm Period (c. 1100–700 cal year BP) was characterised by strong cyclone activity over the Iceland region. Intense atmospheric circulation during this period has been confirmed also by other studies in the northern North Atlantic region.

Keywords: basalt/plagioclase ratios; carbonate production; storm activity; Holocene; Iceland

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1. Introduction

Studies on Holocene climate oscillations suggest that our present interglacial period is far from being climatically stable (Aaby, 1976; Bond et al., 1997, 2001; McDermott et al., 2001; Meese et al., 1994; Bianchi and McCave, 1999). Iceland is an important study region for Holocene climate changes due to its geographical position in the transition zone between polar and temperate climate regimes with a potential to monitor even relatively small climate variations (Lamb, 1979).

A considerable amount of paleoclimatic work has been carried out on the Icelandic terrestrial archive (Arnalds, 1987; Caseldine, 1987; Hallsdóttir, 1990, 1995; Ingólfsson, 1991; Norddahl, 1991; Norddahl and Haflidason, 1992; Björck et al., 1992; Caseldine and Stötter, 1993; Caseldine and Hatton, 1994; Gudmundsson, 1997; Geirsdóttir et al., 1997; Stötter et al., 1999; Hardardóttir et al., 2001), while studies based on marine sediments were less common (Haflidason, 1983; Hagen, 1995). More recently attention has turned to paleoenvironmental records from the shelf and fjords of northwest and north of Iceland (Knudsen et al., 2004; Andrews et al., 2003; Andrews and Giraudeau, 2003; Knudsen and Eiríksson, 2002; Larsen et al., 2002; Geirsdóttir et al., 2002; Andrews et al., 2001a,b,c; Eiríksson et al., 2000a,b; Jiang et al., 2002; Castañeda, 2001; Smith, 2001) aimed at understanding climate variability and ocean processes through the Holocene.

This study presents a paleoclimatic record from Djúpáll trough northwest of Iceland (Core KN 158-4-72GGC, latitude 66°40′26″N and longitude 24°11′34″W, 234-m water depth.). The main objective was to detect Holocene centennial to millennial scale paleoceanographic changes NW of Iceland by means of petrographical and sedimentological indicators combined with high-resolution AMS ^{14}C dating.

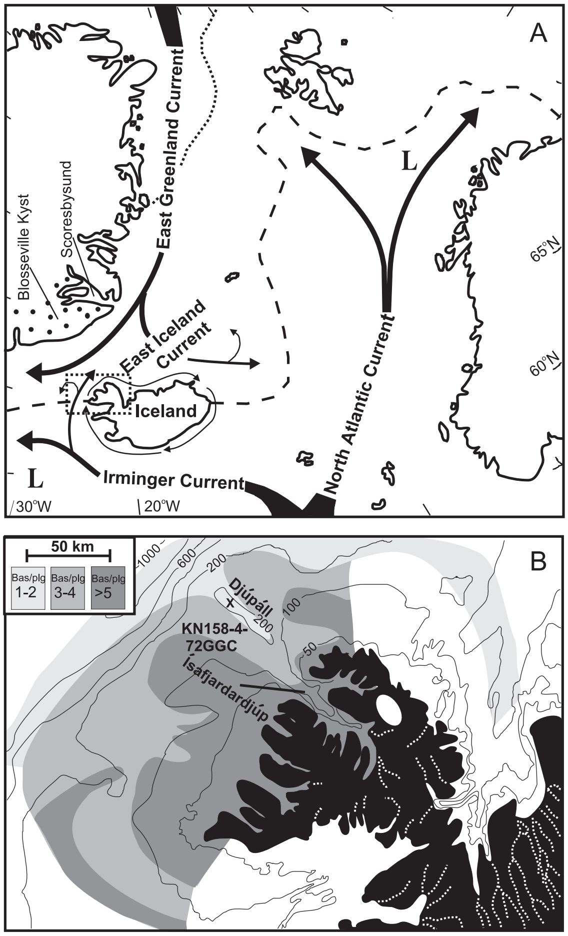

Fig. 1. (A) Main surface currents in the Nordic Seas. Dotted line: typical ice limit during mild summers. Stipled line: typical ice limit during severe winter. (Modified from Jennings et al., 2001). Approximate position of the Icelandic low and the Barents low are denoted with L (Björnsson, 1969). Blosseville Kyst basalt province is marked by dots—a large part of the province is ice covered. (B) Location map showing the Vestfirdir peninsula and bathymetry of the shelf of the Vestfirdir peninsula with location of core KN 158-4-72GGC in the Djúpáll trough. White shows the present extension of the Drangajökull Glacier (modified from Thors, 1974), and white dotted lines indicate major river drainage routes (Castañeda, 2001). Grey shaded areas show the basalt/plagioclase ratio in fine sand (from Thors, 1974) on the basis of interpolation of data from 130 shipek grab samples (6 samples located along Djúpáll trough).

2. Setting

2.1. Modern oceanography and climate conditions

The modern surface hydrography in the area NW of Iceland (Fig. 1A) is characterized by the Irminger Current (IC)—a branch of the warm and salty Atlantic Current, which moves northwards along the west Iceland coast and continues along the north Icelandic coast as the North Icelandic Irminger Current (NIIC) extending down to several hundred meters. To the north and west of the Vestfirdir peninsula temperatures drop in a steep gradient due to the influence of