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Intra-annual variability of extremely rapid sedimentation onto Gardar Drift in the northern North Atlantic

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ABSTRACT

North Atlantic sediment drifts are valuable archives for paleoceanographic reconstructions spanning various timescales. However, the short-term dynamics of such systems are poorly known, and this impinges on our ability to quantitatively reconstruct past change. Here we describe a high-resolution 319-day time-series of hydrodynamics and near-bottom (4 m) particulate matter flux variability at a 2600 m deep site with an extremely high sediment accumulation rate on the southern Gardar Drift in the North Atlantic. We compare our findings with the actual deposits at the site. The total annual particle flux amounted to ~360 g m^{-2} yr^{-1}, varied from ~0.15 to >5.0 g m^{-2} day^{-1} and displayed strong seasonal compositional changes, with the highest proportion of fresh biogenic matter arriving after the spring bloom in June and July. Flux variability also depended on the changing input of lithogenic matter that had been (re)suspended for a longer time (decades). Active focussing of material from both sources is required to account for the composition and the magnitude of the total flux, which exceed observations elsewhere by an order of magnitude. The enhanced focussing or increased delivery appeared to be positively related to current velocity. The intercepted annual particle flux accounted for only 60% of the sediment accumulation rate of 600 ± 20 g m^{-2} yr^{-1} (0.20 ± 0.07 cm yr^{-1}), indicating higher intra- and inter-annual variability of both the biogenic and lithogenic fluxes and/or advection of additional sediment closer to the seafloor (i.e. <4 m). This temporal variability in the composition and amount of material deposited highlights intra-annual changes in the flux of lithogenic material, but also underscores the importance of (reworked) sediment focussing and seasonality of the biogenic flux. All should be taken into account in the interpretation of the paleorecord from such depositional settings.

1. Introduction

Sediment drift deposits that are formed under the influence of deep watermasses represent valuable archives as they contain long, continuous and often high-resolution records of past ocean dynamics. The drifts in the North Atlantic have yielded important information on past changes in the return flow of the Atlantic Meridional Overturning Circulation (AMOC) (e.g. Bianchi and McCave, 1999; Ellison et al., 2006), which is crucial in modulating (global) climate (Broecker et al., 1985). On the eastern flank of Reykjanes Ridge several sediment drifts are found, with Gardar Drift being the most extensive. The Gardar Drift stretches for over 1000 km from NE to SW between ~1400 and ~3000 m water depth. It is deposited under the influence of the Iceland Scotland Overflow Waters (ISOW) that flow as a deep (western) boundary current (DWBC) towards the SW, parallel to the Ridge. Iceland Scotland Overflow Water represents a mixture of waters from the Nordic Seas and other intermediate waters that are entrained in the subpolar North Atlantic during their descent to depth following passage across the Iceland–Scotland ridge (Van Aken, 1995a; Van Aken and De Boer, 1995). As such ISOW is a precursor watermass of North Atlantic Deep Water and represents an important part of the cold southward flowing limb of the AMOC (Swift, 1984). Sedimentary records from Gardar Drift may thus provide insights into the past dynamics of this deep watermass as well as contain valuable information on changing surface ocean conditions and the linkages between the deep and surface ocean (Bianchi and McCave, 1999; Ellison et al., 2006; Mc Intyre et al., 1999; Raymo et al., 1998). Because of locally enhanced sedimentation rates Gardar drift deposits have yielded such paleoceanographic reconstructions at sub-decadal resolution (Boessenkool et al., 2007). While several studies on the large-scale sedimentary

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processes and long-term development of Gardar Drift have been undertaken (Bianchi and McCave, 2000; Kidd and Hill, 1986), few, if any, have focussed on the intra-annual variability of the sedimentation processes occurring within an open ocean drift setting. Here we present a 319-day time-series of particulate matter fluxes and current dynamics recorded by a benthic bottom boundary (BOBO) lander (Van Weering et al., 2000) deployed at a site on the southern Gardar Drift (Fig. 1A). The BOBO Gardar (BG) site is characterised by an extraordinary high accumulation rate of >2 mm yr^{-1} over at least the last two centuries (Boessenkool et al., 2007) and serves as an example for similar depositional settings. We assess seasonal variability in the magnitude and composition of the particulate flux in the light of changes in current speed and direction and compare our findings with the recently deposited sediments at the site. Additionally, in order to better interpret the site's very high

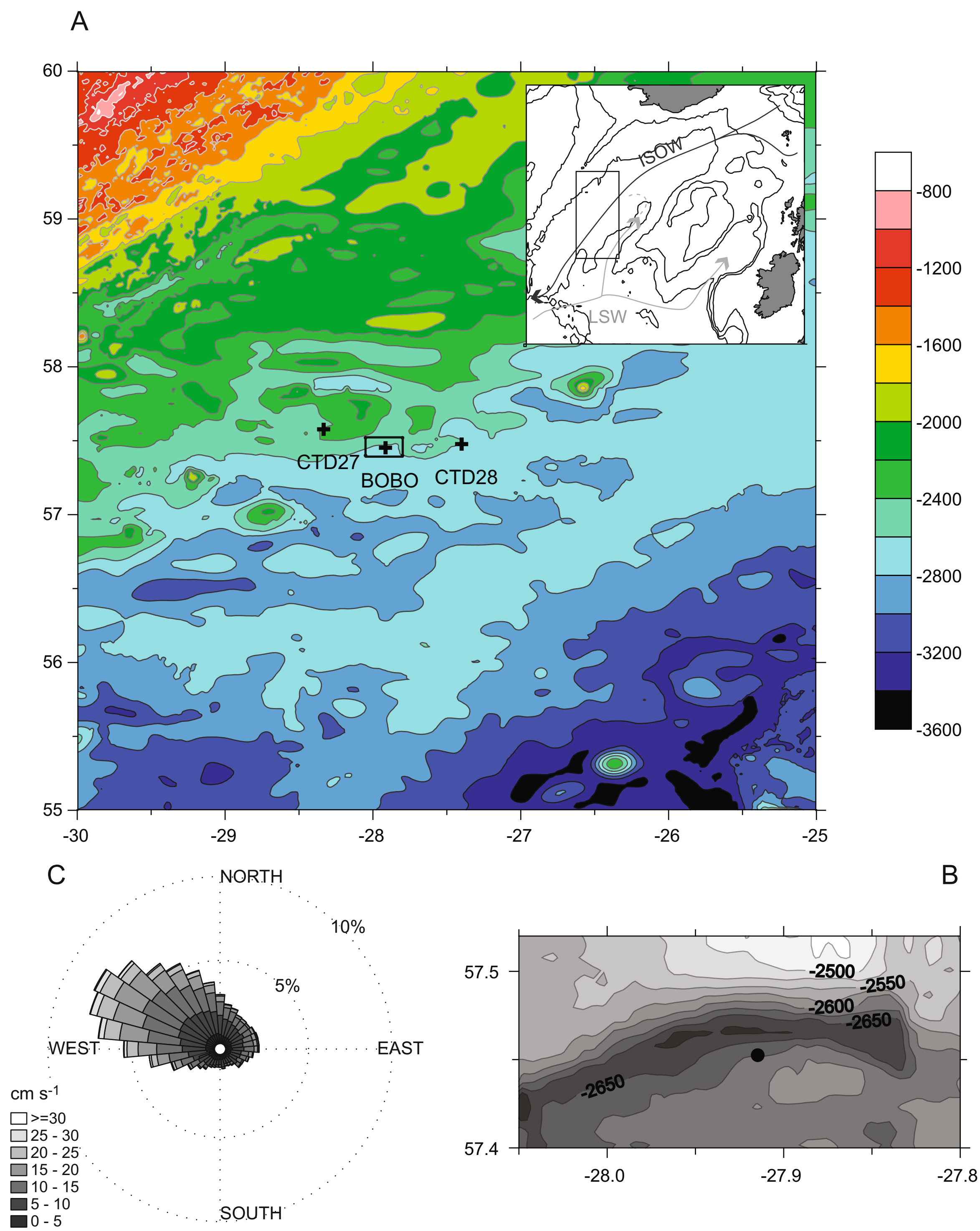

Fig. 1. A: Bathymetry of the SE flank of the Reykjnanes Ridge with the positions of the lander and adjoining CT D profiles indicated. Inset shows simplified circulation paths of ISOW and LSW (black and grey, respectively). Bathymetry data are from the BODC GEBCO_08 grid. B: Detailed bathymetric setting around the BOBO lander deployment site (star). Depths are in m. C: Directional histogram of current speed throughout the deployment period. Note that bathymetry has caused ISOW flow at the site to divert from its normal course to the SW.