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Gradients in activity and biomass of the small benthic biota along a channel system in the deep Western Greenland Sea

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Abstract

Sediments sampled during summers 1999–2002 with the German ice-breaker RV "*Polarstern*" were analyzed to estimate benthic microbial activity and biomass of the smallest sediment-inhabiting organisms (size range: bacteria to meiofauna) along a channel system in the deep western Greenland Sea at about 75°N. Biochemical investigations were expanded by direct counts of bacteria and meiofaunal organisms, including foraminiferans. A total of 36 stations was sampled along the Ardencaple Canyon, extending over 200 km in north-easterly direction from the Greenland continental rise towards the central Greenland Basin. Stations were grouped in defined regions, generally with sampling sites inside the canyon plus accompanying sites on the northern and southern levees. An additional eight stations were sampled along a depth transect crossing the Greenland continental margin and traversing the channel in its midsection. All parameters investigated confirmed no differences between stations within the channel compared to stations on the levees, opposing the hypothesis that the Ardencaple Canyon displays a major pathway for suspension-driven shelf drainage flows. However, investigations showed some general trends in the data: parameters indicating food availability at the seafloor and total microbial biomass generally decreased with increasing water depth and distance from the Eastern Greenland continental margin. Along the depth transect crossing the Greenland margin both parameters exhibited increased values at deep stations on the continental rise. The position of these stations coincides with the position of the ice edge during sampling in summer 2000. Increased food availability and microbial biomass in the sediments most probably reflect raised levels of primary productivity and enhanced sedimentation in the marginal ice zone, thereby pointing to a close pelago-benthic coupling. Bacterial activities in the sediments showed a different picture with generally increasing values with increasing distance from the continental margin, which could probably be explained by a change in bacterial assemblages.

Keywords: Benthic; Activity; Biomass; Bacteria; Meiofauna; Canyons; Greenland Sea

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1. Introduction

Long-range side-scan sonar imagery (Geological Long Range Inclined Asdic, GLORIA) in the early 1990s showed that the eastern Greenland continental margin is dissected by many down-slope-trending canyons, extending from the shelf and slope out onto the rise, and also towards the central Greenland Sea (Mienert et al., 1993, 1995; Hollender, 1996). The canyons may have been formed by dense waters originating from cooling, sea-ice formation and brine rejection close to glacier margins or they may originate from land slides on the upper slope transforming into debris flows and turbidity currents in the past, probably in the Younger Dryas (Vorren et al., 1998). In recent times, these canyons are suspected to represent major drainage routes for shelf waters, thereby contributing to deep water renewal. Shelf drainage flows stimulate energetic currents in otherwise comparatively calm areas, and thus have considerable impact on the sedimentation of particulate matter and the environmental conditions in the deep sea (Rowe et al., 1982).

Current meter recordings from moorings anchored from summer 1993 till summer 1995 in the deep Eastern Greenland Sea repeatedly demonstrated strong, bottom-intensified currents in that area (Woodgate and Fahrbach, 1999). A total of five events, each of about a week's duration, were detected. Woodgate and Fahrbach (1999) suggested sediment-loaded shelf drainage flows to be responsible for the observed "benthic storms" in deeper waters, a hypothesis initially leading to establishment of the German research project ARKTIEF-II.

The aim of the multidisciplinary ARKTIEF-II project was to investigate the development of down-slope drainage flows from the Eastern Greenland shelf and their effects on ecological and sedimentary processes in the deep sea. The objectives of benthic investigations within this project were to assess large-scale distribution patterns of seafloor-inhabiting organisms in and around channel systems crossing the eastern Greenland continental margin and the deep Greenland Sea, and to study benthic processes within these areas and their relevance for the Arctic Ocean ecosystem. Ardencaple Canyon, connecting the Eastern Greenland continental margin with the central Greenland Sea between 74°N and 75°N, was chosen for investigations within the frame of the ARKTIEF-II project. Based on activity and biomass data for the small benthic biota (covering a size range from bacteria to meiofauna) and information on environmental characteristics, it was intended to determine whether the Ardencaple Canyon is an "active" or "fossil" system. We tried to test the following hypotheses: (1) The Ardencaple Canyon provides a pathway for modern down-slope particle transport off Greenland. (2) As a result, the base of the canyon exhibits (a) different environmental conditions (i.e. differing sediment characteristics and enhanced organic matter availability), and (b) a consequently enhanced activity and biomass of the small benthic biota, compared to adjacent regions outside the channel system.

2. Materials and methods

2.1. Area of investigations

In contrast to earlier ideas, detailed bathymetric studies during the project revealed that the Ardencaple Canyon does not originate on the upper slope. Several small troughs at intermediate depths join the canyon in the upper part, but it is not yet clear if these conduits are connected to the shelf (Frahm, 2003). The proximal part of the Ardencaple Canyon, however, forms a bowl-shaped depression at approx. 2800 m water depth on the Eastern Greenland rise at about 74°05′N/12°50′W (Fig. 1). This depression is supposed to be a catchment area for sediment-loaded shelf drainage flows that merge and are further on transported inside the channel. The Ardencaple Canyon is "U"-shaped in cross section and up to 4 km in width. It exhibits a slightly meandering course and finally vanishes in a deep-sea fan at about 74°50′N/6°00′W at water depths around 3550 m. Channel sinuosity is most probably controlled by bedrock structures parallel to the mid-oceanic ridge. Total distance between the positions given above is about 220 km (Fig. 2).