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Sedimentary processes and depositional environments in glaciated fjord systems — Evidence from Nordfjord, Norway

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ABSTRACT

Fjords situated in past, or present, glacial regimes represent important repositories between land masses (source systems) and the open oceans (sink systems). Newly collected TOPAS high-resolution seismic profiles from the previously glaciated Nordfjord system, on the west coast of Norway, reveal sedimentary processes and depositional environments within fjords in more detail than before. The seismic data show that the fjord basins are characterised by a well-laminated lower unit that is overlain by acoustic transparent lensoidal bodies. We infer the lower unit, which is up to 350 m thick, to be composed of glacimarine sediments. The transparent bodies represent up to 0.25 km^3 large slide debrites that comprise $<5\%$ of the total sediment volume in the fjord. The Nordfjord basin well-laminated sediments were deposited from the fjord mouth to the fjord head as the Fennoscandian Ice Sheet started to retreat from the outer coast at c. 12700 ^{14}C yr BP (c. 15000 cal. yr BP), during the last deglaciation. The entire Nordfjord system was ice free for a short time period before the ~1000 year long Younger Dryas readvance halted the main Fennoscandian deglaciation and over-ran the eastern part of Nordfjord. In contrast to the Last Glacial Maximum, we suggest that the sediments in the ice-covered fjord basins were preserved during Younger Dryas. The rapid isostatic adjustments accompanying the withdrawal of the Younger Dryas ice sheet promoted conditions for failures. We relate the identified Nordfjord slide bodies to this paraglacial environment. This implies that the acoustic well-laminated glacimarine fjord unit has been deposited in about 2000 yr, and that sediment rates as high as 20 cm/yr have existed during deposition.

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1. Introduction

Fjords represent deep incisions into land masses, thus defining important repositories between continents and the open ocean beyond. The incisions commonly have a transverse trend to the coast, contain sediment basins of various sizes and have shallow water near their mouths (e.g. Holtedahl, 1975; Syvitski, 1989; Aarseth et al., 1989). Fjords are localised in high-latitude environments, i.e. north of c. 40°N and south of c. 40°S, and are products of glacial advances and retreats (Syvitski and Shaw, 1995). The longest fjord in the world today is found on the east coast of Greenland, where the Scoresby Sund reaches a maximum length of 350 km. Despite their world-wide distribution, and their prevalence along high-latitude coast lines, the scientific attention to these environments has been moderate. We note that a major effort in understanding fjords was undertaken 10–15 yr ago, resulting in several important contributions on such systems (Syvitski et al., 1986; Syvitski, 1989; Aarseth et al., 1989; Dowdeswell and Andrews, 1995; Hooke and Elverhøi, 1996; Sejrup et al., 1996; Lønne and Syvitski, 1997; Syvitski and Lee, 1997; Aarseth et al., 1997).

These studies revealed that complex and variable depositional processes are active during fjord basin evolution (e.g. Aarseth et al., 1989). However, limited resolution in the bathymetric and seismic data prevented detailed analyses on time and space variations in the processes and the ability to estimate accurate sediment volumes and sedimentation rates. The nearness of fjords to population centres makes it necessary both to quantitatively distinguish between when and why the different processes are active, and to understand long- and short-term mechanisms that cause changes and variability in sedimentary processes, as these might represent a hazard to the population in these regions.

The coastal zone along western Norway (Fig. 1) is heavily dissected by submarine inlets that repeatedly have been covered and excavated by ice sheets during glacial stages (e.g. Sejrup et al., 2005). In 2005, a data-set, comprising metre and decimetre scale information on sea floor morphology and sub-sea floor deposits, respectively, were collected from one of these fjords (Fig. 1b). These data have up to ten times better resolution than those published earlier, allowing for an improved understanding of fjord environments. In this paper we

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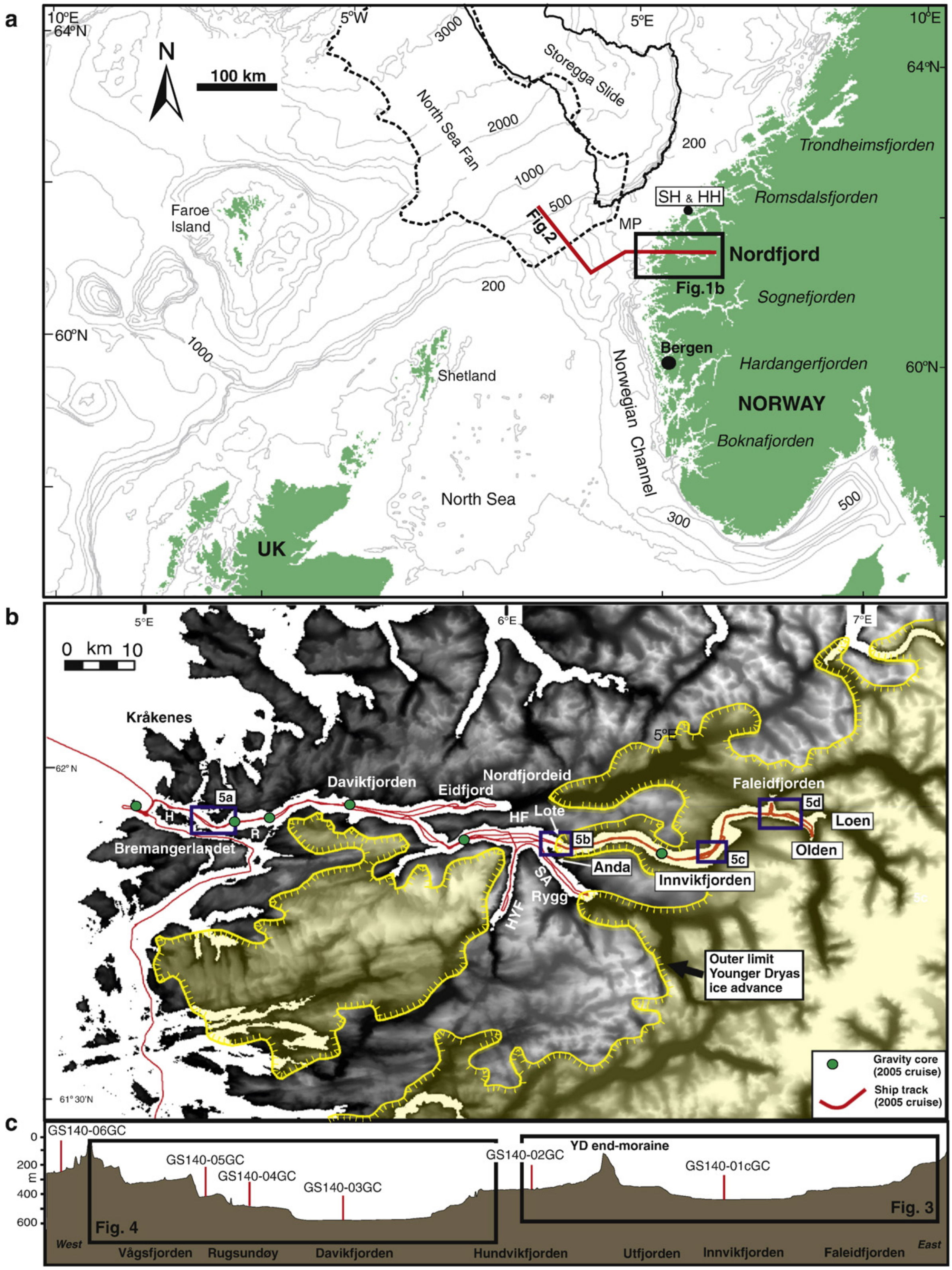

Fig. 1. a) SE Nordic Seas margin. Study area within box. Bathymetry in metres. North Sea Fan and Storegga Slide are outlined. HH: Hamnsundhelleren Cave; MP: Måløy Plateau, SH: Skjonghelleren Cave. b) Nordfjord study area. Extent of Youger Dryas ice readvance and 2005 R/V G.O.Sars ship track are shown. H: Husevågøy; HF: Hundvikfjorden; HYF: Hyenfjorden; SA: Sandane; R: Rugsundøy. c) Nordfjord bathymetric profile. Positions of gravity cores taken during the R/V G.O. Sars cruise in 2005 are shown. GC: Gravity core; YD: Younger Dryas.

use the recently collected TOPAS profiles and the multibeam echo-sounder (MBE) records, in addition to shallow cores, to extract: (1) more detailed information on sedimentary processes within fjord systems, (2) new knowledge on when and why the different processes are active in time and space, and (3) new knowledge on sediment volumes and sediment rates.

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