

Submarine slides from the walls of Smeerenburgfjorden, NW Svalbard

J. A. DOWDESWELL^{1*}, D. OTTESEN² & R. NOORMETS³

¹*Scott Polar Research Institute, University of Cambridge, Cambridge CB2 1ER, UK*

²*Exploro AS, Innherredsveien 7, N-7014 Trondheim, Norway*

³*The University Centre in Svalbard, Postboks 156, N-9171 Longyearbyen, Norway*

**Corresponding author (e-mail: jd16@cam.ac.uk)*

The steep slopes of glacially eroded fjord walls are potential sites for slope failure and mass wasting (Syvitski et al. 1987). Slides of sedimentary material are relatively common, but require that sediment is present on fjord sides, often deposited from glaciers before and during their retreat through fjord systems. This debris then fails to produce slides that run out onto fjord floors and leave scars on fjord side-walls.

Description

On the steep side-walls and floor of Smeerenburgfjorden, a 25 km-long fjord in NW Spitsbergen, Svalbard, more than 30 slide scars and associated depositional zones are observed on both sides of the fjord (Fig. 1) (Ottesen & Dowdeswell 2009). The slide headwalls are usually located on slopes greater than 15°. The depositional zones of the slides are usually, but not always, blocky, and the scar surfaces are also relatively rough (Fig. 1a-d). Many of the slides appear to be composites of several individual failure events (Fig. 1b, c), whereas a few record only single failures (Fig. 1d). Multiple failures include at least four events in Figure 1b and three or more in Figure 1c. Note also that several smaller features, no more than 50 m in length, appear to mark isolated events that have taken place in addition to the larger failures.

Taking the scars and blocky areas together, typical slide lengths are 0.5 to 1 km and widths are between 0.2 and 0.5 km (Fig. 1a-d). The areas of individual slides are generally less than 0.5 km², with slides making up about 10% of the sea-floor in Smeerenburgfjorden (Fig. 1a). The upper scars, from which material has been transferred downslope, are usually a few metres in depth, with clearly defined scar walls (profile x-x' in Fig. 1e). The blocky slide deposits, which often run out onto the relatively smooth fjord floor, are raised a similar amount above the general level of the sea-bed (profiles y-y', z-z' in Fig. 1e). The volume of sediment transferred downslope during individual slope-failure events is, therefore, on the order of a million cubic metres. A shallow sub-bottom acoustic profile shows several blocky slides in cross-section, together with a small area of acoustically stratified fjord basin-fill between them (Fig. 1 f).

Interpretation

Slides on the walls of Svalbard fjords have taken place by the failure of glacial sedimentary material along relatively well-defined headwalls and slip planes (Fig. 1a-d). Slab failure, translating into the deposition of blocks in the runout area, appears to be the main failure mechanism. In terms of timing, some slides appear to have overridden small transverse ridges on the fjord floor. The transverse ridges are just a few metres high and were produced during the earlier retreat of a grounded glacier margin (Ottesen & Dowdeswell 2009). Other slides, by contrast, have been partly buried by subsequent fine-grained sedimentation (Fig. 1a). The draping sediment is probably derived mainly from rainout from sediment-rich plumes of glacier-derived meltwater (e.g. Mugford & Dowdeswell 2011). These cross-cutting relationships suggest that submarine slope failures have continued through the Holocene, over an extended period since deglaciation of the fjord after the last, Late Weichselian glacial maximum.

The distribution of sedimentary slides in Svalbard fjords is variable. The three adjacent NW Spitsbergen fjords, of Smeerenburgfjorden (Fig. 1g), Magdalenefjorden and Raudfjorden, demonstrate this. Magdalenefjorden, 10 km south-west of Smeerenburgfjorden, has a series of individual and composite slides, Smeerenburgfjorden has over 30, whereas none was observed on swath bathymetry of Raudfjorden, 20 km to the east (Ottesen & Dowdeswell 2009). Each fjord has an approximately similar deglacial history, and it is likely that differences in fjord-wall steepness and sediment availability are important controls on the potential for and frequency of failure. Mass-transport deposits of similar dimensions to those in Smeerenburgfjorden have been reported from the steep northern side of Tempelfjorden, further south in Spitsbergen, by Forwick et al. (2010).

The presence of sediment slides, with source areas on steep fjord walls and runout zones onto fjord floors, also has implications for the depositional record in fjord sediments given that about 10% of the floor of Smeerenburgfjorden is affected by slides (Ottesen & Dowdeswell 2009). Where slides impinge on, and sometimes erode into, the usually well-preserved and quasi-continuous fjord-floor deposits, the sedimentary record is disturbed and modified. Thus, it is important to recognise slide deposits in fjord litho- and seismo-stratigraphies when identifying potential sites for the acquisition of sediment cores for the reconstruction of Late Quaternary environmental change. Finally, submarine slides can also cause tsunamis within fjords through water displacement during the sliding process.

References

FORWICK, M., VORREN, T. O. et al., 2010. Spatial and temporal influences of glaciers and rivers on the sedimentary environment in Sassenfjorden and Tempelfjorden, Spitsbergen. *In* HOWE, J. A., AUSTIN, W. E. N., FORWICK, M. & PAETZEL, M. (eds) *Fjord Systems and Archives*. Geological Society, London, Special Publications **344**, 163-193.

- MUGFORD, R. I. & DOWDESWELL, J. A. 2011. Modeling glacial meltwater plume dynamics and sedimentation in high-latitude fjords. *Journal of Geophysical Research* **116**, doi: 10.1029/2010JF001735.
- OTTESEN, D. & DOWDESWELL, J. A. 2009. An inter-ice stream glaciated margin: submarine landforms and a geomorphic model based on marine-geophysical data from Svalbard. *Geological Society of America Bulletin* **121**, 1647-1665.
- SYVITSKI, J. P. M., BURRELL, D. C. & SKEI, J. M. 1987. *Fjords: Processes and Products*. Springer, Berlin.

Fig. 1. Sediment slides in multibeam bathymetry of Smeerenburgfjorden, NW Spitsbergen, Svalbard. (a) A 4.75 km-long section of Smeerenburgfjorden showing a series of slides with scars on fjord walls and runout of sometimes blocky debris onto the otherwise relatively smooth fjord floor. Acquisition system Kongsberg EM1002. Frequency 97 kHz. Grid-cell size 2 m. (b) An area of at least four composite slides of the east side of the fjord. (c) Composite slides on the eastern side of the fjord, probably draped by a thin sediment cover which reduces the definition of the features relative to (b), with the inference that the slides in (c) are older. (d) Single slide on the western fjord wall with runout onto the fjord floor. (e) Cross- and long-profiles through the slide shown in (d). VE x 75, 50, 20 for x, y, and z, respectively. (f) Shallow sub-bottom profile through the slides shown in (a). VE x 60. Acquisition system Edgetech 3300-HM. Frequency 1.5-12kHz, 16-element transducer with 4kW pulse. (g) Location of study area (red box; map from IBCAO v. 3.0).

