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Explaining the Storegga Slide

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Abstract

The Storegga Slide occurred 8200 years ago and was the last megaslide in this region where similar slides have occurred with intervals of approximately 100 ky since the onset of continental shelf glaciations at 0.5 Ma. A geological model for the Plio-Pleistocene of the area explains the large scale sliding as a response to climatic variability, and the seismic stratigraphy indicates that sliding occurs at the end of a glaciation or soon after the deglaciation. The slides are in general translational with the failure planes related to strain softening behaviour of marine clay layers. The destabilisation prior to the slide is related to rapid loading from glacial deposits with generation of excess pore pressure and reduction of the effective shear strength in the underlying clays. Basin modelling has shown that excess pore pressure generated in the North Sea Fan area is transferred to the Storegga area with reduction of the slope stability in the old escarpments in distal parts of the Storegga Slide. The slide was most likely triggered by a strong earthquake in an area 150 km downslope from the Ormen Lange gas field and developed as a retrogressive slide. The unstable sediments in the area disappeared with the slide 8200 years ago. A new ice age with infilling of glacial sediments on top of marine clays in the slide scar would be needed to create a new unstable situation at Ormen Lange.

Keywords: Slope stability; Sediment load; Erosion cycle; Risk assessment

1. Introduction

The Storegga Slide (Fig. 1) is one of the largest submarine slides discovered, and has been known since the 1970s (Bugge, 1983). Recent studies conclude that the slide occurred as one main event 8200 years ago and removed between 2500 and 3500 km^3 of sediment from the slide scar (Haflidason et al., 2005). The slide generated a tsunami that hit the west coast of Norway (run up 10–12 m), Scotland (4–6 m), Shetland (20–30 m) and the Faroes (>10 m) (Bondevik et al., 2003).

The Ormen Lange gas field was discovered in 1997 and is the second-largest gas reservoir in Norway. The field is located within the scar of the Storegga Slide (Fig. 1) and close to the steep upper headwall (Fig. 2). When the Ormen Lange license was awarded, knowledge about the Storegga Slide was limited and it was uncertain if the seabed in this area was stable.

The main questions that needed to be answered to evaluate the natural slide risk were

- How can a slope with inclination of 0.5–2° fail and how can the failure develop to a gigantic submarine slide like the Storegga Slide?
- What was the triggering mechanism and where was the slide initiated?
- Is the probability of new large slides too high for a development of the Ormen Lange field?

The answers to these questions required a regional geological and geotechnical approach and detailed analysis of the slide scar morphology. The geological model describes the climate changes, stratigraphy, sediment properties and the margin processes like sedimentation, mass wasting, diagenesis and tectonics. The focus of this paper is to combine geological and geotechnical information with morphological analysis to evaluate the precondition, triggering and development of the Storegga Slide. This paper gives an overview of the acquired knowledge on the origin and evolution of the Storegga Slide. The details

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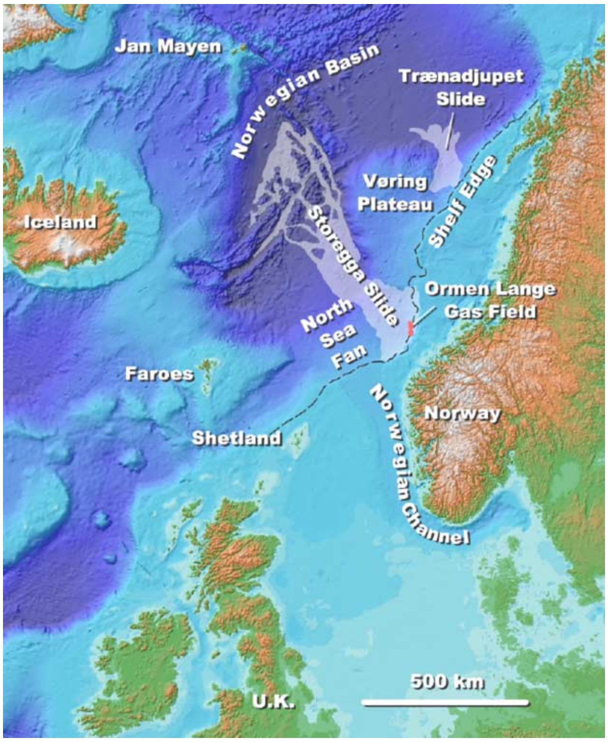

Fig. 1. Location map showing the Storegga and Trænadjupet submarine slides on the Mid-Norway margin.

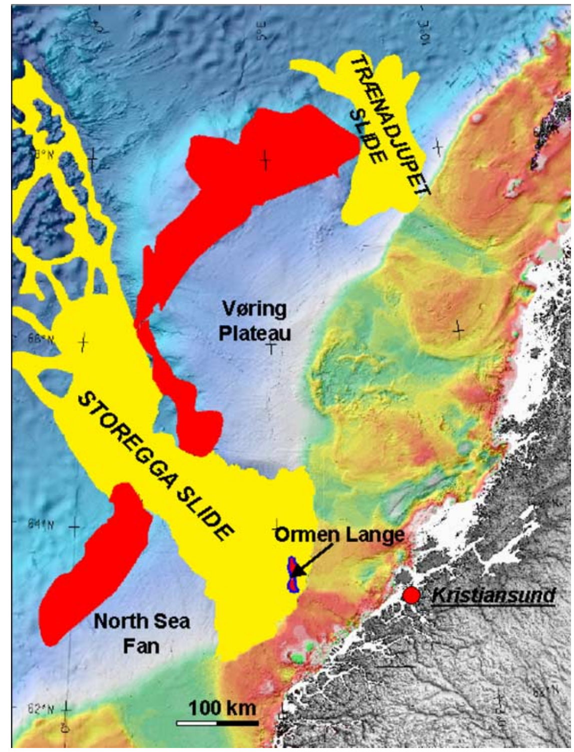

Fig. 3. Location map showing the Storegga and Trænadjupet submarine slides on the Mid-Norway margin. The Møre and Vøring volcanic highs are marked in red to the S and N of the Storegga Slide, respectively.

and background for this overview are presented in other papers in this volume.

2. Physiography

The physiography of the Mid-Norwegian shelf and margin can be divided into four regions: the steep Lofoten margin (Trænadjupet slide), the Vøring Plateau, the Storegga region and the North Sea Fan region (Fig. 1).

The slope in the Lofoten margin leads directly into the deep ocean basin with 3500 m water depth, while in the Vøring region the slope runs into the wide Vøring Plateau (<1500 m water depth), limited to the W and NW by volcanic highs (Fig. 3). The SW and NE boundaries of the Vøring Plateau coincide with the northern sidewall of the Storegga Slide and the southern sidewall of the Trændjupet slide, respectively (Fig. 3).

As in the Lofoten margin, the slope in the Storegga region leads directly into the ocean basin through a 60 km wide opening between the Møre and Vøring volcanic highs (Fig. 3). The south-western limit of the Storegga region is the bathymetric high formed by the North Sea Fan, which slopes gradually down to the Møre volcanic highs and further into the Norwegian Basin. The North Sea Fan is formed by deposition at the termination of the Norwegian Channel, which forms the deep trough around entire south Norway (Fig. 1).

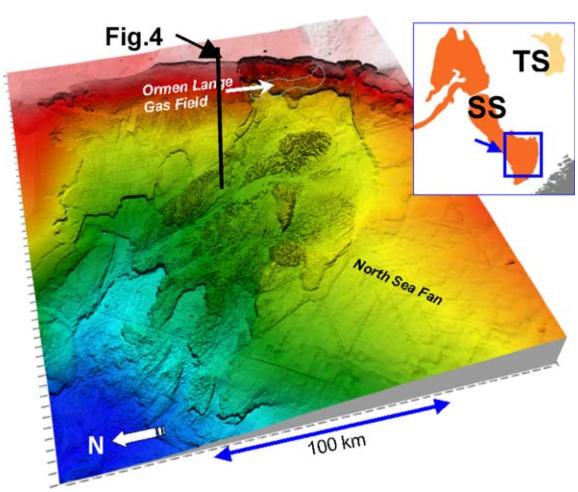

Fig. 2. Bathymetric image of the Storegga Slide. The Ormen Lange gas field is located close to the upper headwall. Index map: SS, Storegga Slide; TS, Trænadjupet Slide.

3. Bathymetry

The upper headwall of the Storegga Slide has a slope gradient of 25–35° and runs from a water depth of about 250 m at the shelf break to about 500 m at its foot.

Over the next 20 km down slope, the water depth increases very gently to about 800–900 m in the field development area. In the headwall area of the older slide R (Solheim et al., 2005; Berg et al., 2005), the water depth again increases rapidly from about 900 to 1100 m in the westerly and deepest part of the license area. For another 150 km further to the west, the overall slope is gentle with an inclination of 0.5–1°, until another scarp with slope inclination of 10–15° leads to water depths of about 2800 m. The average slope inclination from the shelf edge at 250–350 m water depth to the Møre basin in 2800 m is in the order of 0.6–0.7°. The preslide inclination was 1–2° in upper slope and similar to the present slope inclinations in the middle (0.6–0.7°) and lower slope areas (10–15°).

4. Stratigraphy

The overall seismic stratigraphy covering the last 3 My (Naust Formation) is divided into five main sequences (Naust W, U, S, R and O) with boundaries that can be traced throughout the Mid-Norwegian margin (Berg et al., 2005). The sequences are linked to the main glaciations, but each sequence may contain more than one shelf glaciation. Naust units S, R and O have been subdivided into a total of 16 sub-units in the Ormen Lange area, based on seismic data, and supported by geological and geotechnical analyses of sediment samples, as well as the results of borehole geophysics (Fig. 4). The deposits of the Naust Formation are overlying the thick siliceous oozes of the Kai and Brygge formations.

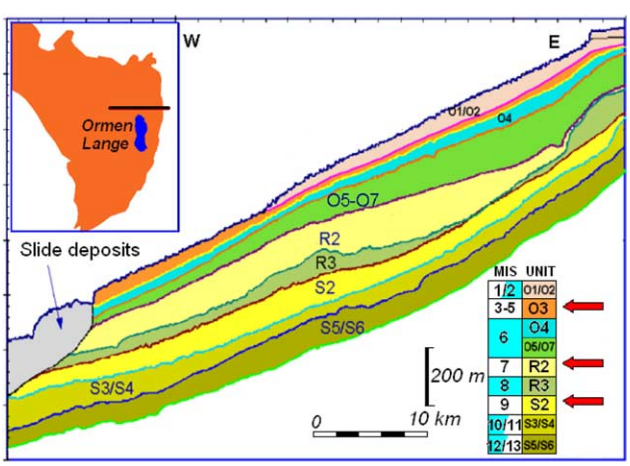

Fig. 4. Transect illustrating the main stratigraphic sub-division of the layers involved in the Storegga Slide. A tentative correlation to the marine isotope stages (MIS) is based on datings from the geoborings in the Ormen Lange area. Blue indicate cold periods (glaciations). S2, R3, etc. mark sub-units of the Naust Formation (Berg et al., 2005). Red arrows indicate the main failure units. See Fig. 2 for location of the profile.

5. Preslide conditions

5.1. Oceanography

The modern configuration of water masses and circulation pattern in the Nordic Seas was fully established in the Miocene (Thiede and Myhre, 1996). This circulation system consists of warm and saline Atlantic water moving northwards as the Norwegian Atlantic Current. It dominates the upper water column down to the strong thermocline (temperature gradient) which fluctuates at a water depth of 500–700 m, where the water temperature drops from 5 to 6° to less than 0 °C (Alendal et al., 2005). The Norwegian Atlantic Current was a main transport agent for fine-grained sediments from the south into the study area.

Current speeds of more than 1 m/s have been measured above the thermocline and 0.5–0.6 m/s below (Bryn et al., 2005). Hence, this level is an important sedimentation boundary with non-deposition above the thermocline. During glaciations and deglaciations the ocean current system along the Mid-Norwegian margin was less vigorous.

5.2. Sedimentation

During the period from 54 to 2.5 Ma fine-grained oozes and shales of the Brygge and Kai Formations dominated the sedimentation. The main depocentre of the Brygge Formation, where over 1500 m of sediment accumulated, is in the Storegga area immediately west of the Ormen Lange Field. In most of the Storegga and the North Sea Fan regions, the formation has a thickness of 600–1000 m, but on the Vøring Plateau it is less than 400 m thick over extensive areas. The main depocentre of the Kai Formation, with over 1000 m of mainly contouritic deposits, is located in the northern flank of the Storegga Slide area. In the central parts of the Storegga area and at dome structures the sediments of Kai formation are very thin or absent (Bryn et al., 2005). The Brygge formation is the main failure unit in several evacuation craters reported by Riis et al. (2005) and is exposed in the distal escarpments of the Storegga Slide.

In response to Pliocene climatic cooling and uplift of the Norwegian mainland, a prograding sediment wedge was built out along the Norwegian margin (Riis, 1996). In the late Pliocene the first ice sheet covered Scandinavia, and about 1.1 million years ago the ice sheet extended across the Norwegian shelf to reach the shelf break (Haflidason et al., 1991). During the last 500 ky there have been a series of ice advances across the shelf (Sejrup et al., 2000). Glacial sediments were largely deposited from fast flowing ice streams in front of the main transverse depressions on the shelf (Fig. 5) (Rise et al., 2005; Berg et al., 2005; Hjelstuen et al., 2004). The most significant deposit is the North Sea Fan to the south of the Storegga Slide (Figs. 1, 3 and 5), where up to 1700 m of sediments were deposited during the last 2.5 million years (Nygård et al., 2005).

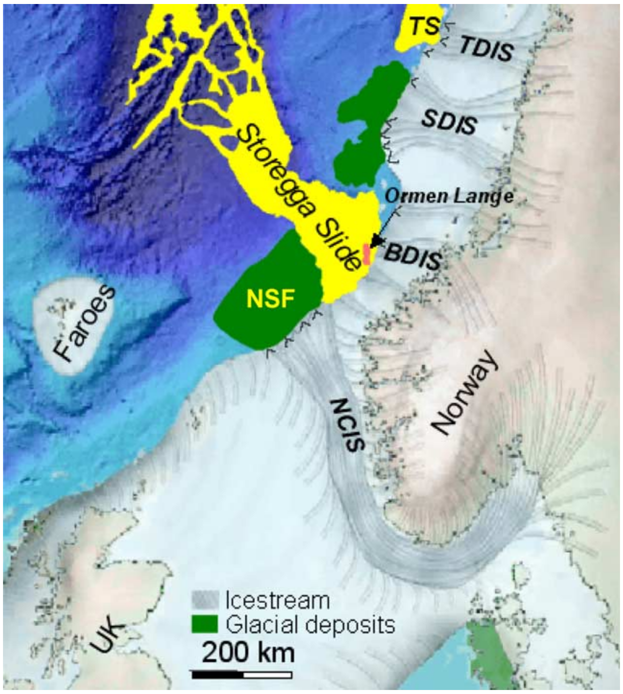

Fig. 5. The main depocenters (green color) of glacial sediments. NSF, North Sea Fan; NCIS, Norwegian Channel Icestream; BDIS, Buadjupet Icestream; SDIS, Sklinnadjupet Icestream; TDIS, Traænadjupet Icestream; TS, Trænadjupet Slide. The grey lines illustrate the ice flow and sediment transport out to the shelf edge. The main depocenters through the last 500 ky have been in the North Sea Fan area. The depocenter north of the Storegga Slide represents probably one glaciation (MIS 10,400–350 Ka) (Berg et al. 2005; Dahlgren et al., 2002).

Peak glaciation, with ice extending to the shelf break and proglacial deposition, represent only short parts of a glacial–interglacial cycle. The longest periods are represented by hemipelagic deposition of fine grained sediments (Berg et al., 2005) (Fig. 6).

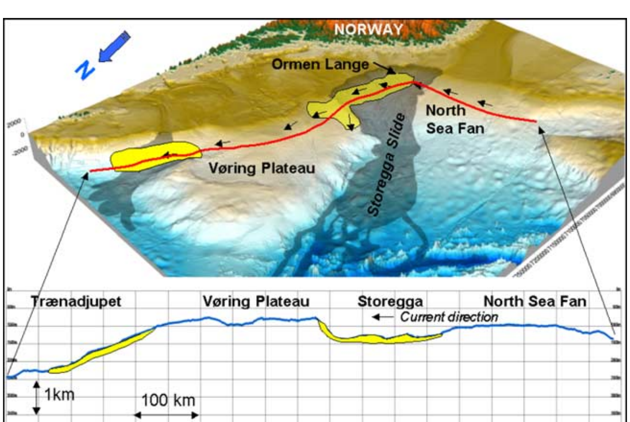

Fig. 6. Location of the main contouritic drifts (yellow) is controlled by the seabed topography and current direction. Deposition of soft marine clays is presently ongoing in the slide area.

Table 1
Summary table showing the estimated ages of megaslides in the Storegga and North Sea Fan regions during the last 500 ky

Slide	Age	Area
Storegga Slide	8200	Storegga
Tampen Slide	100 Ka (or slightly older)	Mainly North Sea Fan
R-Slide	300 Ka	Storegga
More Slide	400 Ka	North Sea Fan
S-Slide	500 Ka	Storegga

5.3. Mass wasting

Reflection seismic data show major submarine slides along the Mid-Norwegian margin during the past 2.5 million years. The Storegga Slide was the last in a series of megaslides in the same area (Evans et al., 1996).

The first generation of slides has a character of evacuation features (craters) generated by highly mobile sediment that was exposed to loading by the prograding sediment wedge in the Pliocene (Riis et al., 2005). The first major slide of similar type and size as the Holocene Storegga Slide occurred in the same area ca. 500 ky ago (Bryn et al., 2003; Solheim et al., 2005). From this time major slides have occurred in the Storegga area on a semi-regular basis, which appear to be related to glacial/interglacial cyclicity (Table 1, Fig. 7). The glide planes are found in seismically stratified units of hemipelagic deposits

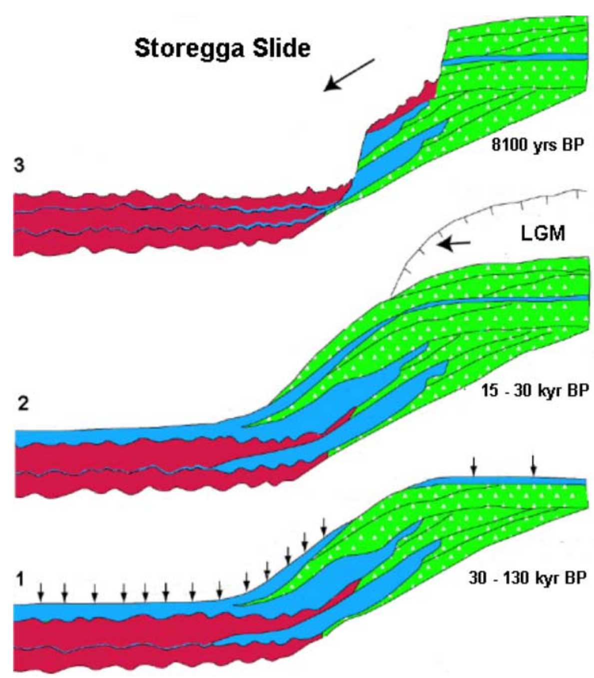

Fig. 7. Illustration of the cyclic deposition and slide processes in the Ormen Lange area. Green, glacial sediments; red, slide deposits; blue, marine sediments. (1) Last interglacial with deposition of soft marine clays. (2) Last glacial maximum (LGM) with the ice at the shelf edge and deposition of glacial sediments. (3) The Storegga Slide. The figure shows two older slide scars that are filled with marine clays.

and the thick infill of stratified sediments indicate a late glacial to early interglacial occurrence of slides (Rise et al., 2005; Solheim et al., 2005).

6. Slide scar morphology

The Storegga Slide has an upper headwall length of 320 km, and the slide narrows to a 60 km wide gateway in the opening between the Møre and Vøring volcanic highs (Fig. 3). In addition to the upper headwall, the Storegga Slide scar contains several headwalls and scarps (Fig. 8). The lowermost Headwall was probably formed in the Brygge formations by evacuation/mobilisation of oozes during the late Pliocene/early Pleistocene (Riis et al., 2005). The sediment thickness increases up slope and causes higher compaction and sediment strength. The scarps mark glide plane jumps to higher stratigraphic levels within the Naust Formation during the retrogressive slide development. Whereas the O and R headwalls are from the Storegga Slide, the S and lower headwalls were probably older features that were reactivated during the Storegga Slide.

The northern and southern parts of the slide failed in the marine clay layer of sub-unit O3 with a depth of less than 100 m below the pre-slide seabed (Fig. 8). Lateral spreads are the most common morphological feature observed in these areas. These features appear as parallel ridges and troughs and are formed by extensional displacement of the sediments overlying glide planes or a slip zone in the hemipelagic/contouritic sediments.

In the central part of the slide including the Ormen Lange area, the detachment has followed deeper sub-units. Failure has taken place in S2 below the lower headwall and R2 in

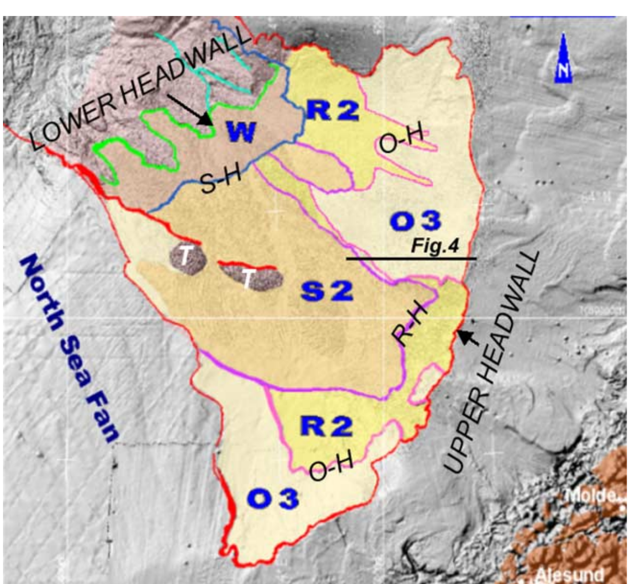

Fig. 8. Distribution of the main failure layers (O3, R2 and S2, Fig. 4) and location of the main headwalls (O–H, R–H and S–H) in the Storegga Slide. T, outcrop of Tampen Paleoslide.

the Ormen Lange area (Fig. 8). Blocky debris flows dominate the morphology in the central slide scar with laterals spreads towards the upper headwall. The R-headwall may have reached 500 m height in the Ormen Lange area during the slide, based on a reconstructed pre-slide topography.

Compression ridges of varying sizes are present over large parts of the central slide area, but the most prominent compression zone is in the north-western part of the North Sea Fan (Figs. 2 and 8). The main detachment was in the S2 sub-unit with a region of shallow compression in the O3 sub-unit at the perimeter towards the North Sea Fan. The compression zone is most likely the result of collapse of the Saalian glacial fan built out in the Ormen Lange area.

The history of previous sliding and evacuation events (Riis et al., 2005) left old slide scars with headwalls that provided locally steep slopes in the lower to mid slope region, which probably only had a thin drape of sediments prior to the Storegga Slide. Further upslope, the old slide scars and headwalls were deeply buried by subsequent sedimentation.

The slide scar and the lateral spreads have similarities with onshore slides in quick-clay or liquefied sandy/silty sediments. The observed pattern in the Storegga Slide scar is related to the strain softening behaviour of the marine clays and numerical modelling has demonstrated that a retrogressive slide process is likely, even at the low slope gradients ($\sim 1°$) in the Storegga area (Kvalstad et al., 2005).

7. Slope destabilisations and slide triggers

7.1. Overview

All potential triggers and destabilising factors prior to the Storegga Slide have been evaluated with regards to the repeated sliding and to evaluate the significance of these triggers today. Included are effects of high sedimentation rates during peak glaciations, gas hydrate melting, gas charging of shallow sediments, diapirism and earthquakes. A common factor for such processes is that they all increase the pore pressure of the sediments and decrease the effective soil strength.

7.2. Sediment loading

During the last peak glaciation (the LateWeichselian), the sediment input to the Storegga area was modest, reaching approximately 100 m in the upper part of the slope, whereas approximately 500 m accumulated in the depocenter of the North Sea Fan (Fig. 9). During the Saalian glaciation, the main depocenter for the glacial sediments seem to have been in the Ormen Lange area (Fig. 9). A similar thickness was probably deposited in the North Sea Fan, but later partly eroded by the Tampen Slide (Solheim et al., 2005). The distal parts of the Storegga Slide area are

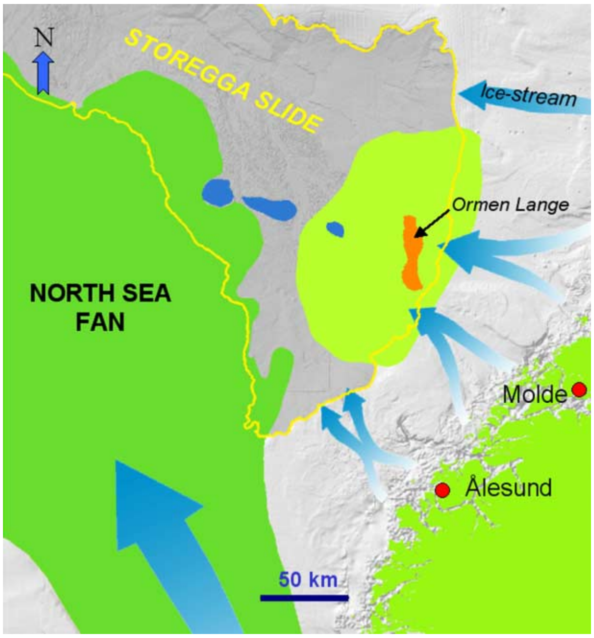

Fig. 9. Outlines of the Weichselian (last glaciation) deposits in the North Sea Fan and the Saalian (penultimate glaciation) deposits in the Ormen Lange area. T, outcrops of Tampen paleoslide. Yellow line represents the outline of the Storegga Slide.

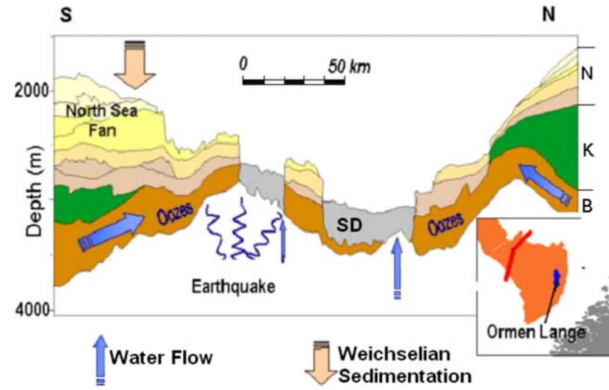

Fig. 10. Cross-section of the lower part of the Storeggea slide. The load from the Weichselian sedimentation in the upper part of the North Sea Fan caused build-up of excess pore pressure, which may have been transferred to lower parts of the Storegga Slide area, where the overburden was thin and locally steeper slopes existed. N, Naust Formation; K; Kai Formation, B, Brygge Formation.

assumed to have experienced low sedimentation rates during the last 300 ky.

Rapid loading of sediments with low permeability may cause development of excess pore pressure when the length of drainage path increases faster than the time required for consolidation. Thus, pore overpressure was created in the contouritic marine clays and oozes Kai and Brygge Formations), with the highest over-pressure in and close to the glacial depocenters. Modelling indicate potential excess pore pressures in the order of 20–30% due to loading in the upper slope and shelf edge at the time of the Storegga Slide (Kvalstad et al., 2005). The measured recent excess pore pressure 2 km behind the upper headwall was 15–17% (Tjelta et al., 2002).

Numerical modelling of possible load effects from the glacial deposits in the North Sea Fan was carried out to evaluate the transfer of excess pore pressure to a proposed initiation area for the Storegga Slide, approximately 150 km downslope from the Ormen Lange gas field (Fig. 10). The results of the simulations showed development of high excess pore pressure that spread laterally towards the Storegga Slide area (Kvalstad et al., 2005). In an area with low deposition rate, as in the distal part of the Storegga Slide the transferred pore pressure can be higher than the increase in overburden stress and result in swelling and unloading. The swelling will introduce a delay in peak pore pressure response. This effect was demonstrated numerically with finite element (FE) analyses and shows that the most critical conditions may develop with a considerable time lag compared with the deposition history and offset the pore pressure build-up in the Storegga Slide into the early Holocene.

7.3. Earthquakes

The glacio-isostatic rebound following the deglaciation of Scandinavia was responsible for strong earthquakes and magnitudes 7+ are assumed from onshore faults in northern Norway (Bungum and Lindholm, 1998; Fjeldskaar et al., 2000; Bungum et al., 2005). Sealevel curves show that the uplift changed from a fast and exponential to a slow and linear movement ca. 8000 years ago (Mörner, 1990). It is reasonable to relate the period with strong earthquakes with rapid rebound and the triggering of the Storegga Slide. Recent modelling shows that the seismic energy can induce ground shaking that lasts longer than previously assumed in the deep sedimentary Møre basin (Lindholm et al., 2005). In the Storegga region the isostatic deformation and reactivation of Late Jurassic–Early Creteaous faults because of sediment loading on the North Sea Fan probably caused an elevated earthquake level. At present there is still a higher earthquake activity around the Quaternary depocentres than elsewhere along the Norwegian continental margin (Byrkjeland et al., 2000). An earthquake of magnitude *M* 5.4 was recorded in the distal part of the North Sea Fan as late as 1988 (Bungum et al., 2005).

7.4. Gas hydrate melting

Temperature changes caused by warm water influx after the last deglaciation were limited to water depths shallower than about 700 m and thus limited to the upper slide area. The potential melting front along the base of the gas hydrate stability zone does not follow the stratigraphy and thus not the observed slip surfaces. However, gas hydrate models show good correlation to the position of the headwall in the north-eastern part of the slide (Mienert et al., 2005). Destabilisation of gas hydrates may locally have influenced the pore pressure and contributed to the slope failure.

8. Slide initiation area

The combined effects of excess pore pressure, exposure of ooze, relative steep slopes 10–20° and to the vicinity of potential earthquake centres favour an initial slide in the distal area (Fig. 10). Here the relatively thin sediments draping pre-existing scarps may have been destabilised by excess pore pressure transferred through the Brygge oozes or by failure in the ooze sediments. An initiation of shallow slide higher upslope is not excluded, but it has been difficult to find support for this model in the geotechnical analysis and modelling (Kvalstad et al., 2005).

9. Slide process and development

A submarine slide development like the Storegga Slide, involves material transition from a solid to a liquefied state. The slide development is generally described as three main phases: initial failure and formation of blocks and slabs, debris flows, and finally turbidity currents (Fig. 11). The seabed morphology and seismic facies of the Storegga Slide indicate that the main slide developed by a headwall retreating upslope with unloading at the toe as the main driver (retrogressive slide). Most of the slide debris was transported into the Norwegian basin as gravity flows possible combined with hydroplaning and turbidity currents. High mobility of the slide sediments is needed to explain the sediment transport out of the slide area for the main slide phases. The development of an erosion channel in the central scar may have enabled channelized flow and increased velocity of the debris flows (Fig. 13). During the last stages the headwalls were modified giving slide lobes that did not move very far (lateral spreads).

The process of retrogressive sliding required that unloading of the headwall caused strain concentrations and strength loss in the base layer (strain softening behaviour) and that failure started to propagate upslope along the base marine clay layer. The less sensitive unit above was exposed to expansion and accelerated into the slide scar under gravity loading with the formation of a new headwall. Modelling of the process shows that the slide blocks develop a high velocity (10–20 m/s) and a high pressure near the front (Kvalstad et al., 2005). The remoulded clay combined with 'lubrication' by water entrapment and hydroplaning may explain the high mobility and transition to a liquefied state of the slide sediments.

This retrogression continued to develop upslope as long as sufficient debris mobility existed and soil conditions were favourable. The last stages of the slide involved retrogression of lateral spreading that in general slowed as the sediments became stronger close to the shelf where they had been influenced by glacial compaction. The process stopped when the headwall met the horizontally layered and overconsolidated glacial deposits on the shelf and the mobility of the slide blocks decreased. In the last phase the slide blocks became support to the headwall.

The combined analyses of the slide scar morphology, seismic stratigraphy and seismic facies have enabled a possible sequence of events to be established for the evolution of the Storegga Slide.

1. A strong earthquake triggered an initial failure in the relatively steep slopes that existed in oozes of the Brygge formation in the distal part of the Storegga Slide area (Fig. 12). The preslide slope inclination as well the pore pressure was most likely higher in this distal area than elsewhere in the Storegga area at that time.

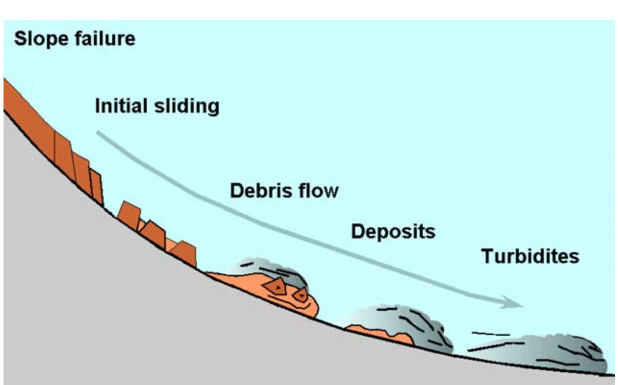

Fig. 11. Schematic representations of the different stages of a slide from slope failure to turbidite.

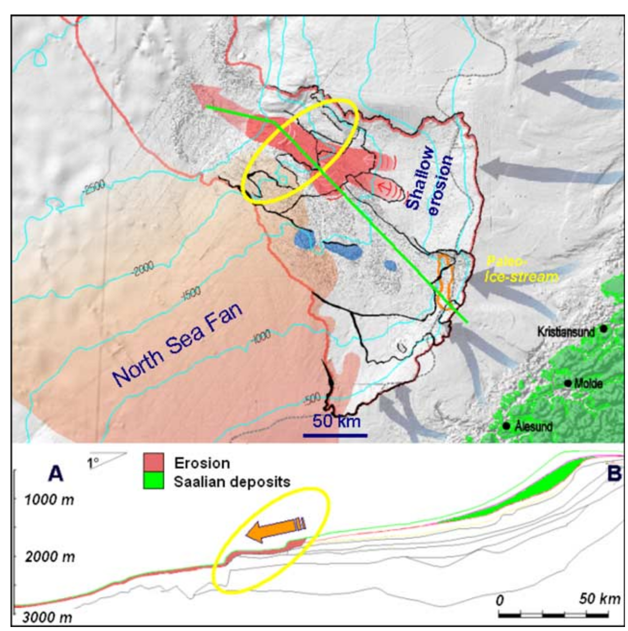

Fig. 12. Initiation of the deeper slide at the lower headwall, indicated by ellipse. The red area indicates the first retrogression of the failure. The profile A–B indicates a failure in the S1/S2 layer.

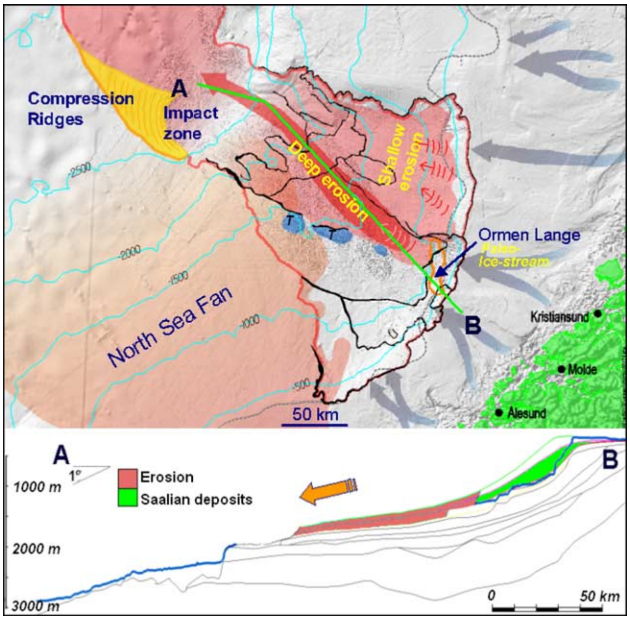

Fig. 13. The slide developed rapidly as shallow failures in the northern part and more slowly as a deep failure in the central scar. The blue line on the cross-section represent the present seabed.

2. The initial slide removed the toe support and the shear strain increased to a critical level in strain concentration zones. As a result, progressive failure developed in deeper sediment layers (S2) in the central sector (Fig. 13). The rate of failure progress depends on the depth of the glide planes with shallow sliding retrogressing more quickly than the deeper ones. The effect of this difference is observed in morphological analysis that shows the main part of the northern slope failed in the sub-unit O3 before the deep failures in central upper slope area.

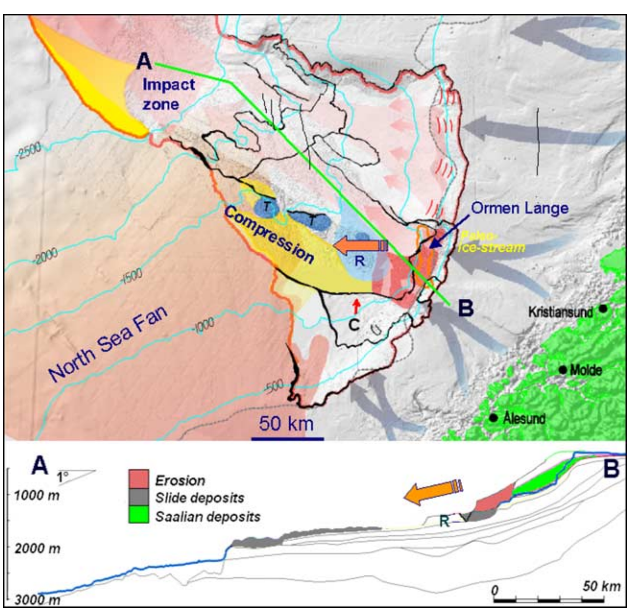

Fig. 14. The deep central erosion created space and allowed the retrogression to continue to the east of the Tampen Slide remnants and the height of the collapsing headwall increased rapidly in the Saalian deposits. The failure of the Saalian glacial deposits in Ormen Lange area generated the tsunami and the deep impact from the failure pushed the slide block R to the west and initiated the compression. The last major phase was the failure of the southeastern branch (C). The blue line on the cross-section represent the present seabed.

3. When the slide reached the Ormen Lange area, the headwall height increased to about 500 m with the break up of the Saalian glacial fan. The volume and energy released by the deep failures in this area produced the tsunami and generated compression and shear zones at the western flank (Fig. 14). The shearing was followed by extension along the southern R Headwall and the southern sector failed in a south to north direction.
4. The last stages of the slide development include final shaping and filling of the debris flow channels in a southeast to northwest direction and development of the embayments in the central sector head scarp.

10. Conclusions

Slides of similar type and size as the Storegga Slide have occurred in the same region on a nearly regular basis (100–200 ky interval) during the last 0.6–0.5 My, with a strong relation to the glacial–interglacial climate cyclicity and occurring mainly after peak glaciations.

The predisposition for sliding in the Storegga region is due to the regional geological setting with

- The long term gateway to the deep ocean between the volcanic bedrock highs under the distal North Sea Fan and the outer Vøring Plateau.
- The depressions on the margin creating accumulation areas of along slope sedimentation drifts (contourites).
- The location in front of troughs on the shelf where ice streams gave rapid accumulation of glacial deposits.

The preconditioning of the slides is closely related to cyclic variations in sedimentation rate and type. The laterally extensive glide planes are in the marine clays (hemipelagic/contouric deposits) with strain softening behaviour. The main depocentre of the last glaciation was in the North Sea Fan and the load from these sediments caused compaction of the thick ooze deposits and resulted in a water flow to the Storegga Slide area. The relatively steep slopes in the distal part of the Storegga Slide have the highest exposure to destabilisation by these combined effects.

The triggering of the slides is closely related to reactivation of deep Late Jurassic–Early Createaous fault system. The sediment load and deglaciation generate earthquakes of length and magnitude that add dynamic loads and excess pore pressure which are sufficient to initiate failure in the marine clay layers.

The break up of the sediments is a retrogressive process which continues until the soil strength slows down the process and the mobility of the slide blocks is reduced to a level where they start blocking the following wedge. In the Ormen Lange the slide has stopped in the overconsolidated glacial clays on the shelf. The mobilised sediments are remoulded to a liquefied state and transported out of Storegga Slide scar as debris flows and turbidites.

The removal of 250–450 m of sediments means that the remaining sediments in Ormen Lange area are overconsolidated with high slope stability safety factors.

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