Geological evaluation of observed vertical terrain movements in the Esbjerg test site

A contribution to the ABRATE/Terrafirma project

Peter Roll Jakobsen



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND MINISTRY OF CLIMATE AND ENERGY

Geological evaluation of observed vertical terrain movements in the Esbjerg test site

A contribution to the ABRATE/Terrafirma project

Peter Roll Jakobsen



GEOLOGICAL SURVEY OF DENMARK AND GREENLAND MINISTRY OF CLIMATE AND ENERGY

Contents

0.	Resume and conclusions	2
1.	Introduction	3
2.	Regional geology of the Esbjerg region	4
2.1	Quaternary	
2.2	Pre-Quaternary	
2.3	Recent seismic activity	6
3.	Interpretations of some of the vertical movements	7
3.1	Vertical movements along the railroad	7
3.2	Vertical movements on Fanø and north of Skallingen	
3.3	Vertical movements in the habour	9
3.4	Vertical movements in the dump area at Måde	
4.	References	11

0. Resume and conclusions

The aim of this investigation was to link the observed vertical movements to the geology in the Esbjerg test area, and if possible to give a geological explanation of the movements. The evaluation is based on existing data and maps.

No recent seismic activity has been recorded in this region and the study area is considered tectonically stable. Tectonic generated movements in the area, is not likely to occur.

Along the railroad from Esbjerg and to the East, there are several locations, where vertical movements are seen. In most of these locations the rail road crosses low areas with unconsolidated postglacial deposits. It is most likely that the load of the railroad construction has caused the deposits to settle.

On the island of Fanø and in the area north of the Skallingen peninsula, sporadic vertical movements occur. In these areas the vertical movements is probably caused by settling of unconsolidated marine and aeolian deposits.

In the harbour area in Esbjerg relatively large vertical movements are seen, which probably is due to settling of the filled material, which built up the harbour area.

In the western outskirt of Esbjerg relatively strong movement are seen in an area which is a former dump. The vertical movements are most probably a consequence of settling of the filled material.

1. Introduction

In the Esbjerg area satellite data of vertical movements of the terrain has been retrieved during the ABSRATE/Terrafirma project(Figure 1.1). GEUS was asked to give a geological evaluation of the observed relative vertical movements.

The aim of this investigation was to link the observed vertical movements to the geology in the Esbjerg test area, and if possible to give a geological explanation of the movements. The evaluation is based on existing data and maps.



Figure 1.1. Location of the Esbjerg test site.

2. Regional geology of the Esbjerg region

2.1 Quaternary

The area in question is situated in the south-western part of Jutland. The surface deposits in the area are Quaternary glacial deposits, postglacial freshwater deposits, marine deposits and aeolean deposits. The main geological and morphological features are the hilly islands, the meltwater plains, the marine marsh foreland, the aeolean dune landscape and the barrier islands.

The hill islands consist of glacial till and meltwater sand and clay of Saalian or older age, as the glaciers of the Weichselian glaciation did not reach this area. The meltwater plains surrounding the hill islands are sandy sediments, deposited by meltwater rivers during the Weichselian glaciation.

In postglacial time freshwater sediments and peat are deposited along rivers/streams and in lake basins. Along the west coast of Jutland, marine tidal sediments are deposited and they build up the marsh flats.



Figure 2.1. Geological map of the area (Pedersen, 1989).

2.2 Pre-Quaternary

The Pre-Quaternary deposits in the area in question are of Miocen age (Rasmussen, 1956). They consist of marine sand and clay. The level of the Pre-Quarternary surface is shown on fig. 2.2. It seems that there is no clear connection between the pattern of vertical movements and the prequaternary surface.



Figure 2.2. Map showing the level of the Prequaternary surface within the area (Binzer & Stockmarr, 1994).

2.3 Recent seismic activity

The seismic activity in Denmark in the period from 1929 to 2007 is shown in fig. 2.3. The major seismic activity is along the Sorgenfrei-Tornquist Zone and just south of it and in the North Sea in the central graben.

The Study area is situated on the Ringkøbing –Fyn High and on the southern edge of it. No recent seismic activity has been recorded in this region and the study area is considered tectonically stable, which means that tectonic generated movements in the area, is not likely to occur.



Figure 2.3. Earthquakes in Denmark, and adjacent areas. Location and magnitude of earthquakes are indicated. (modified from Gregersen et al., 1998).

3. Interpretations of some of the vertical movements

3.1 Vertical movements along the railroad

Along the railroad from Esbjerg and to the East, there are several locations, where vertical movements are seen (Figure 1.1 and 3.1). On figure 3.1 7 locations are outlined. The location numbers 1, 2, 5 and 7 are situated in areas with postglacial freshwater deposits. Location 3 is situated in an area with postglacial marine deposits.

Both postglacial freshwater deposits and postglacial marine deposits are unconsolidated, and it is very likely that the load of the railrod construction has caused the deposits to settle.

There is no immediate explanation of the vertical movements at locations 4 and 6.



Figure 3.1. Uppermost: location of vertical movements along the railrod. Middle: Geological map with the located points (same legend as fig. 2.1). Lowermost: Map of the are with the located points.

3.2 Vertical movements on Fanø and north of Skallingen

On the island of Fanø and in the area north of the Skallingen peninsula, sporadic vertical movements occur.

In both regions the geology consists of postglacial marine deposits overlain by eolian dunes and cover sand. The postglacial marine and eolian deposits are unconsolidated. It is therefore likely that the vertical movements are caused by settling of the unconsolidated deposits.



Figure 3.2. The vertical movements on Fanø and North of Skallingen (indicated with red circles) occur in areas with postglacial marine deposits overlain with eolian deposits.

3.3 Vertical movements in the habour

In the habour area in Esbjerg relatively large vertical movements are seen. The habour area consists largely of filled material.

The vertical movements seen in the harbour area are probably due to settling of the filled matarial which built up the habour area (Figure 3.3).



Figure 3.3. Vertical movements in the habour area in Esbjerg.

3.4 Vertical movements in the dump area at Måde

Måde is situated in the western outskirt of Esbjerg (Fig. 3.4). In this area a former clay pit has subsequently been used as a dump. The former clay pit is now filled and covered with soil. Within this area relatively strong movement are seen, and it is most probably a consequence of settling of the filled material.



Figure 3.4. The upper and the lower picture have the same delimitation. The upper picture shows vertical movements in the Måde area, and the lower picture is a map of the area. The grey area is a former clay pit, which subsequently has been used as a dump.

4. References

Binzer, K. & Stockmarr, J., 1994: Geological map of Denmark 1:500.000. Pre-Quaternary surface topography of Denmark. Geological Survey of Denmark. Map Series no. 44.

Gregersen, S., Hjelme, J. & Hjortenberg, E., 1998: Earthquakes in Denmark. Bulletin of the Geological Society of Denmark, Vol. 44, 2, pp. 115-127.

Pedersen, S.A.S., 1989: Jordartskort over Danmark 1:200.000. Sydjylland og Fyn. Danmarks Geologiske Undersøgelse.

Rasmussen, L.B., 1956: The Marine Upper Miocene of South Jutland and its Molluscan Fauna. Geological Survey of Denmark, II series, No. 81, pp. 166.