Aarhus Area

Overview of geological conditions in Aarhus and surrounding areas

GeoAtlas Live Documentation
Report 1, 2018-07-12

This report gives a brief overview of the geological setting and interpretation of the geological model for Aarhus and the surrounding area.

The pre-Quaternary and Quaternary stratigraphy and the structural setting of the area is presented by maps and profiles illustrating the complexity of the area.

The mapped layers in the Aarhus model are briefly described by occurrence, thickness and sedimentology.

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Report 1, 2018-07-12

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1 Introduction

This note gives a brief overview of the geology of the Aarhus area. All available geological datasets (drillings. Geophysical surveys, maps) have been imported into the modelling software GeoScene-3D and visualized in Geos web based GeoAtlas Live platform. For more information, see here (Danish) or here (English).

The extend of the model area is illustrated below see Figure 1.

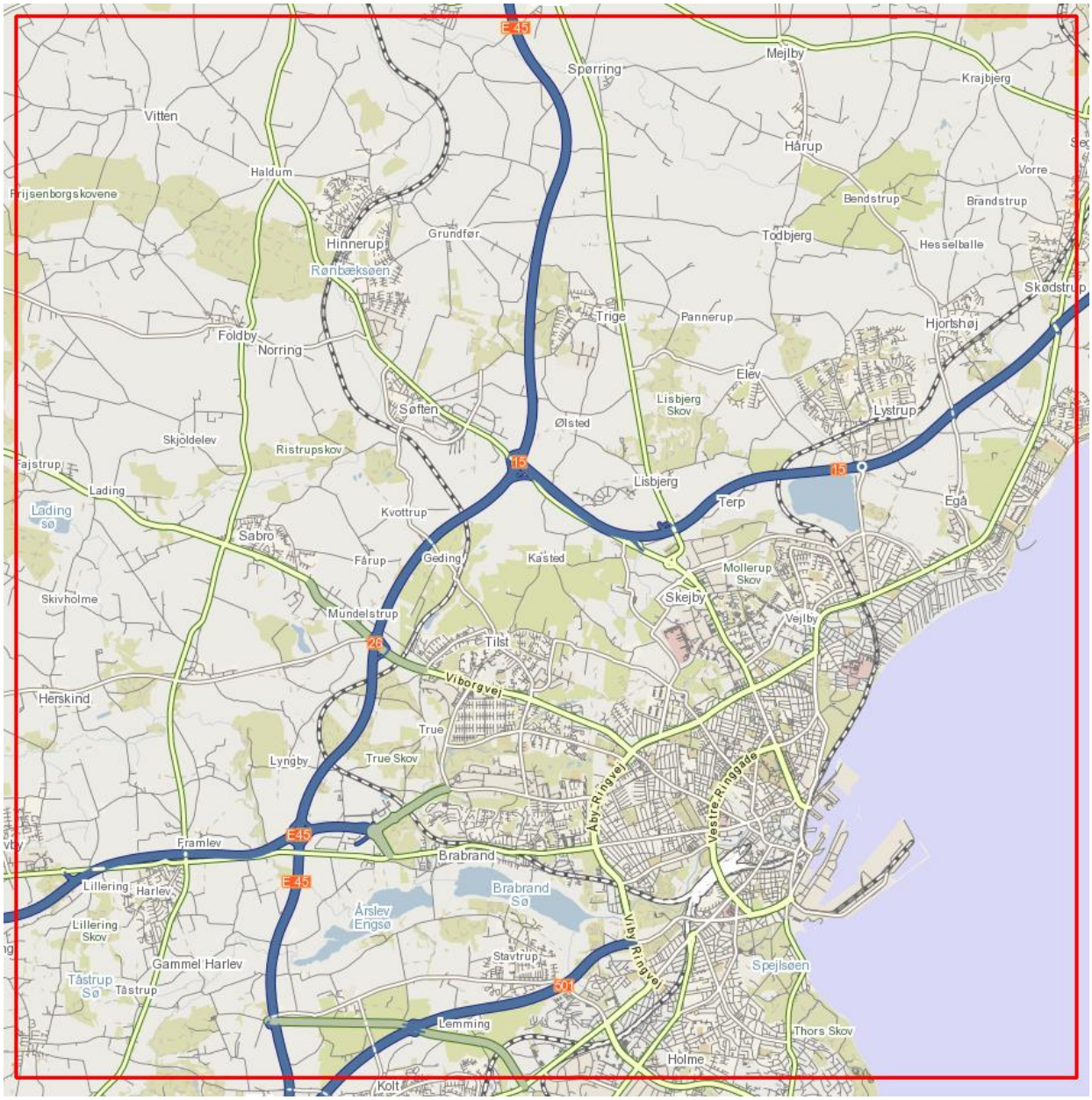

Figure 1. Extent of the Aarhus Model Area.

The lithological units present in the area were interpreted and correlated on a regional scale based on the depositional history and urban development

The sedimentary units interpreted in the conceptual geological model were setup in the modelling software. The layers were interpolated with a 25m cell size in order to ensure a high standard of accuracy.

2 Geological setting

The geological setting in the Aarhus area is a result of the pre-Quaternary stratigraphy and the elevation of the pre-Quaternary surface as well as the depositional and erosional history during the glaciations in the Quaternary epoch.

The geological setting and depositional history are briefly described below:

2.1 Pre-Quaternary deposits and elevation of the pre-Quaternary surface

The pre-Quaternary deposits in the Central Jutland area are generally dipping towards the SW due to the overall tectonic settings in the Danish Basin. The pre-Quaternary stratigraphy in the area thereby constitute a sequence where the oldest deposits are found to the east and the youngest deposits are found towards the west due to erosion of the strata.

Oligocene and Miocene deposits primarily represent the pre-Quaternary sediments in the Aarhus area. Deposits of Danien age are locally found in Brabranddalen due to salt-tectonic influence, which has caused uplift of the sediments.

The deposits of Oligocene, Miocene and Eocene age are primarily made up by marine clays with high to very high plasticity, but the Miocene deposits also contain sand layers.

The distribution of the pre-Quaternary deposits is shown in Figure 2.

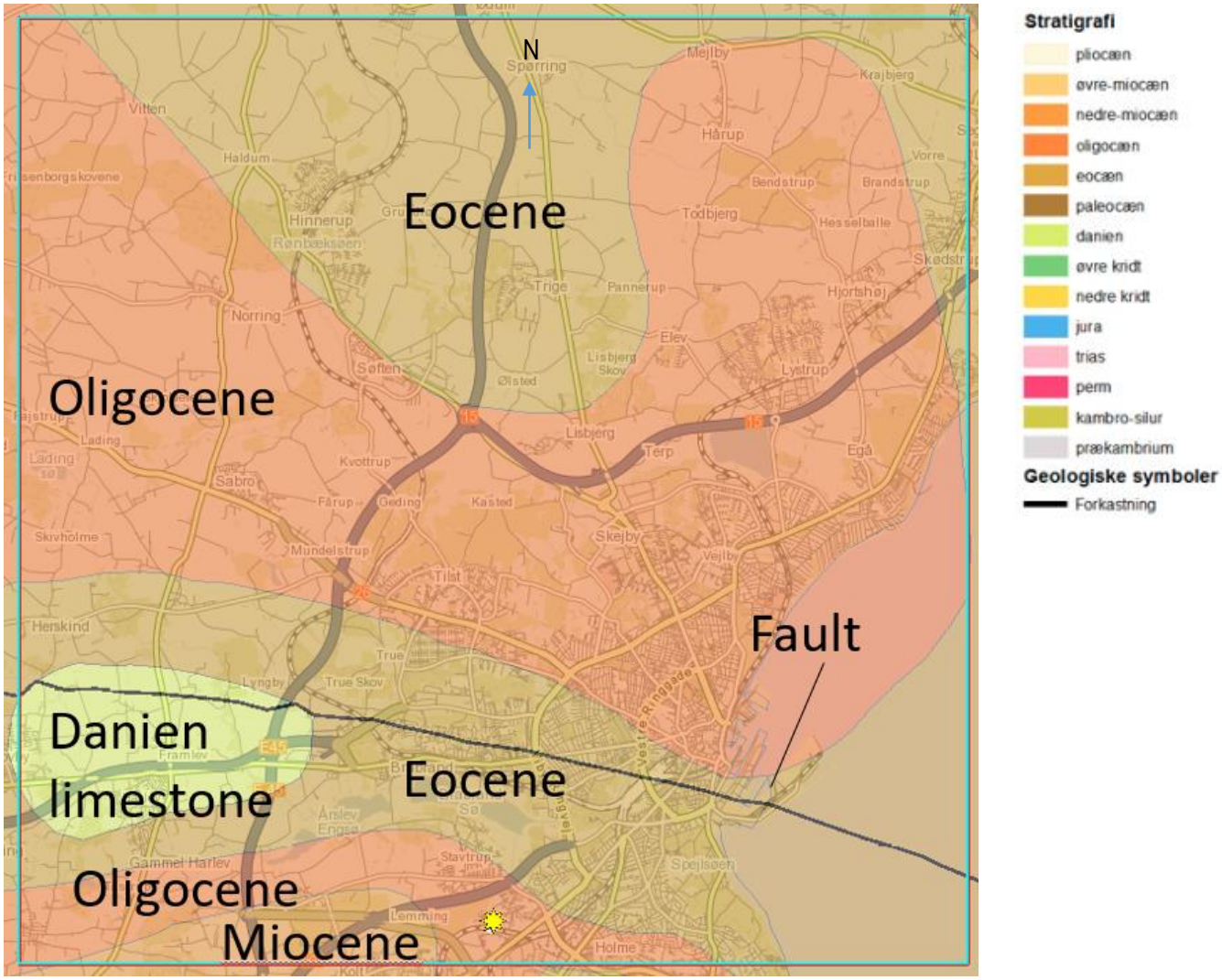

Figure 2. Distribution of Oligocene, Miocene, Eocene and Danien deposits at the pre-Quaternary surface, the sediments are primarily marine clay with high to very high plasticity and minor sand layers. Note the occurrence of Danien Limestone in the Brabrand valley and the fault line following the course of valley. From /1/

The pre-Quaternary surface is transsected by multiple, deeply incised valley-systems, that probably represent the orientation of fault lines in the area. The fault lines have been prone to erosion during the Tertiary and Quaternary from fluvial and glacial mechanisms thus creating the valley systems in the pre-Quaternary deposits. A map showing the elevation of the pre-Quaternary surface is shown in Figure 3

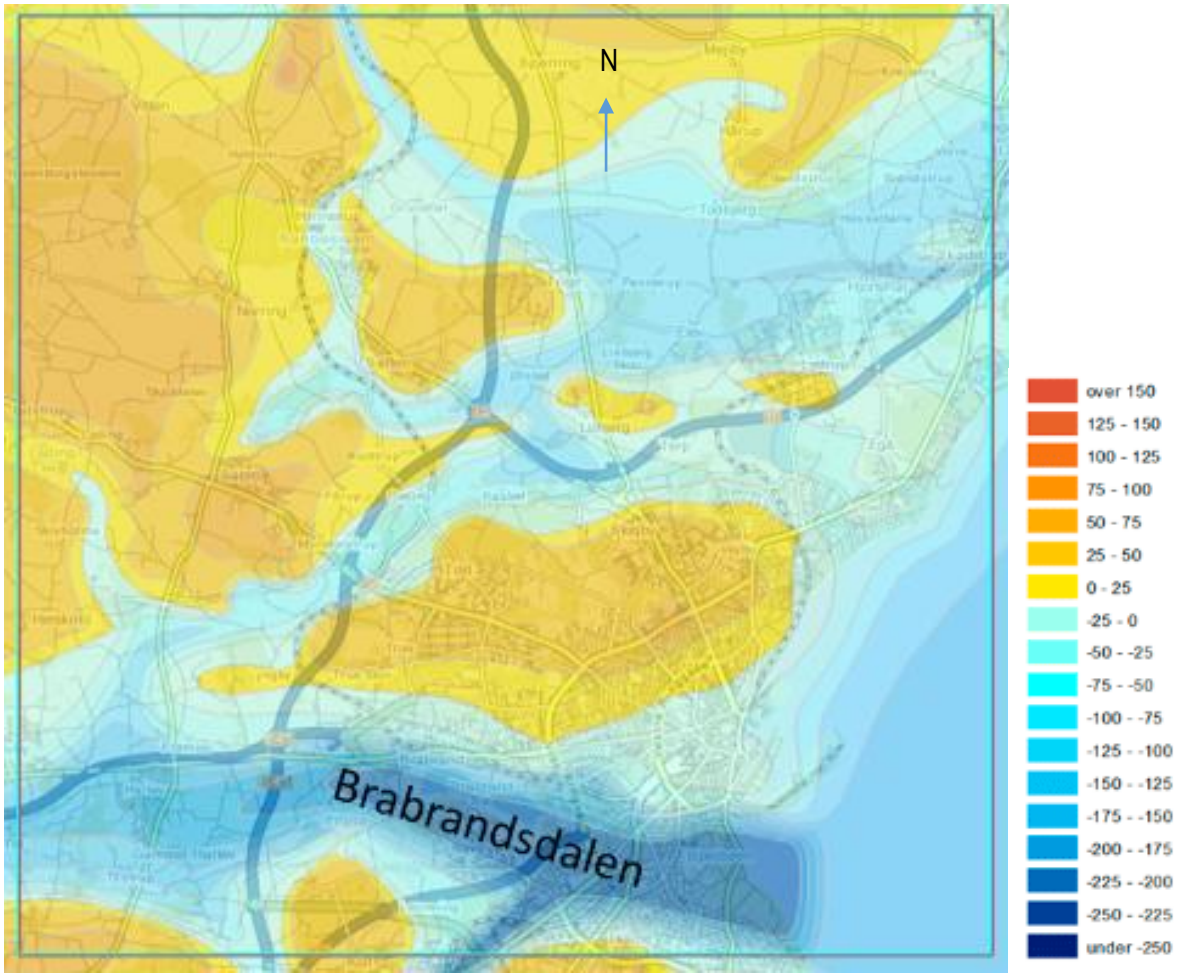

Figure 3. Elevation of the pre-Quaternary surface in the Aarhus model area, a major valley system (Brabranddalen) extends in an E-W direction along a fault system shown in Figure 2. Other valley systems are orientated SW-NE. The valley systems coincide with the buried valley systems in the area. Note the rise in elevation towards the west. From /1/.

2.2 Quaternary deposits and landscapes

The quaternary landscape has primarily been developed during the last glaciation in the area, the Weischselian Glaciation.

During the Weischselian stage, glaciers first advanced from a NE direction. A later advance from a SE direction replaced this advance. Both glacial advances deposited layers of Till and meltwater sediments, developed ice marginal lines/complexes and eroded deep systems of subglacial valleys in the area.

The advance of the glacial ice sheet from the NE produced ice marginal lines with a NW-SE orientation and tunnel valleys with an SW-NE orientation. The valley systems developed by the NE-ice may be partially or completely covered by glacial sediments from the following advance from the SE.

The final advance of ice during the Weischselian came from the SE. This advance had its maximum extend to the east and north of Aarhus and produced concave ice marginal lines with SW-NE orientation. Meltwater valleys related to this advance are orientated N-S or NW-SE. During the retreat of the ice sheet towards the

east, major glacial lakes were created in the western part of the deep valley systems dammed by pre-Quaternary sediments/ice marginal lines to the west and the retreating ice to the east.

The extent of the NE-advance and the SE-advance is shown in Figure 4.

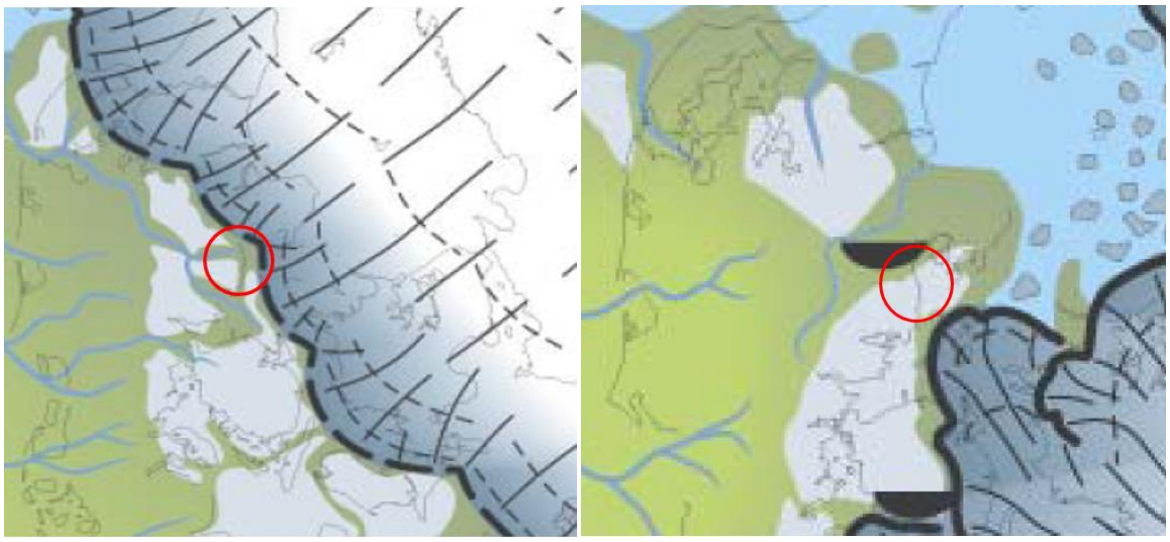

Figure 4. A) Distribution of the NE-ice sheet close to its maximum extend in Jutland, note the NW-SE orientation of the ice marginal lines. B) Distribution of the SE-ice sheet during its advance towards the Aarhus area and Eastern Jutland. The model area is marked by red circles. From /2/.

3 Conceptual model

A conceptual model has been set-up, based on the interpretation of the geological setting and all available datasets. The conceptual stratigraphy of the Aarhus geological model is divided into a Quaternary sequence and a pre-Quaternary sequence and the resulting interpretation resulted in a 19-layer model consisting of 9 pre-Quaternary layers and 10 Quaternary layers.

An overview of the stratigraphy is given in Table 1.

The geological structures and stratigraphy of the area is illustrated by two profiles, a regional (S-N) and a local (W-E) transecting the city centre and harbour area. See Figure 5 and Figure 6.

Table 1. Overview of the stratigraphy for the Aarhus area. The stratigraphy includes Paleocene, Eocene, Oligocene, Miocene and Quaternary sediments as well as postglacial organic sediments and Recent fill deposits.

No	Name	Lithology	Chronology
1	Fill	O, S-O, S-L, ,S,L	Recent
2	Postglacial_Organic	P, T, FP, FT	Postglacial
3	Sand_1	DS, GS, HS, S, G	Late glacial
4	Clay_1	ML, DL, DI, i, I	Late glacial
5	Sand_2	DS, DG,S,g,MS, MG	Glacial
6	Clay_2	ML, DL, DI, I, i	Glacial
7	Sand_3	DS, DG,S,g,MS, MG	Glacial
8	Clay_3	ML, DL, DI, I, i	Glacial
9	Sand_4	DS, DG,S,g,MS, MG	Glacial
10	Clay_4	ML, DL, DI, I, i	Glacial
11	Glimmersand (Micra-sand)	GS, KS, KG	Miocene
12	Glimmerler (Micra-clay)	PS, PK, PL, s	Miocene
13	Viborg ler (clay)	VL, IL	Oligocene
14	Kysingmergel (marl)	KM, IL	Eocene
15	Moesgårdler (clay)	MO, IL	Eocene
16	Søvindmergel (marl)	SL, IL	Eocene
17	Lillebæltler (clay)	IL	Eocene
18	Stollenklint, Ølst, Holmehus (clay)	PL	Paleocene
19	Bryozoan Limestone	BK, KK, LK, K	Paleocene/Danien

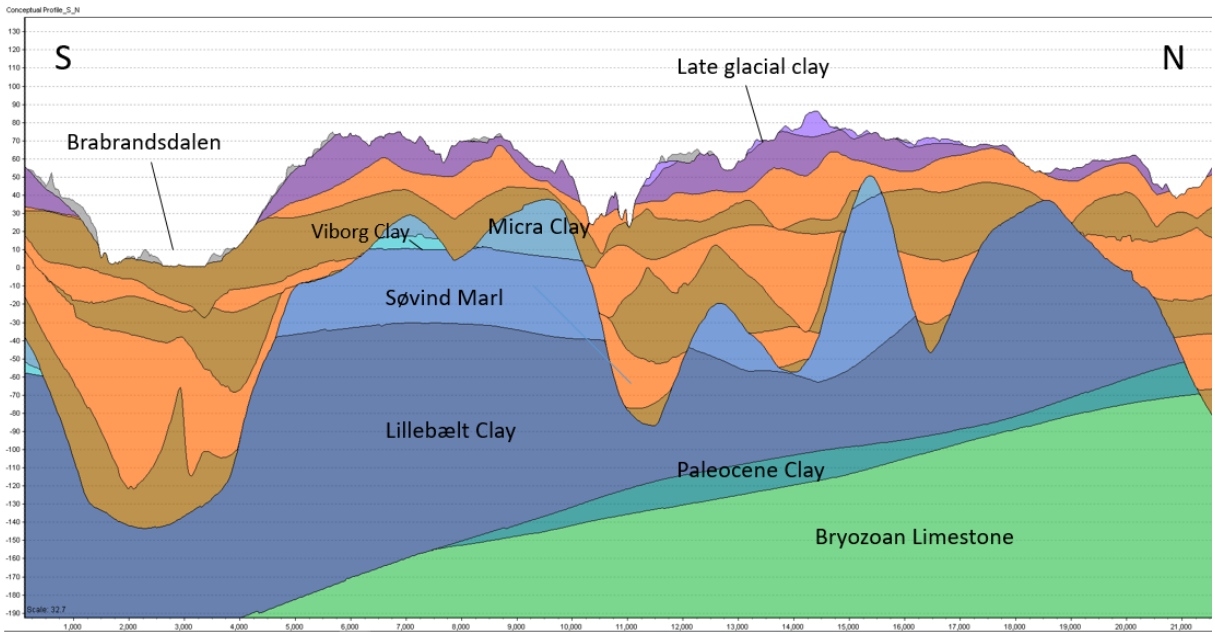

Figure 5. Profile orientated S-N transecting the model area. The stratigraphy includes pre-Quaternary deposits dipping towards the SW and Quaternary deposits (orange and brown layers) infilling and partially covering deep valley systems (buried valleys) that transect the pre-Quaternary strata.

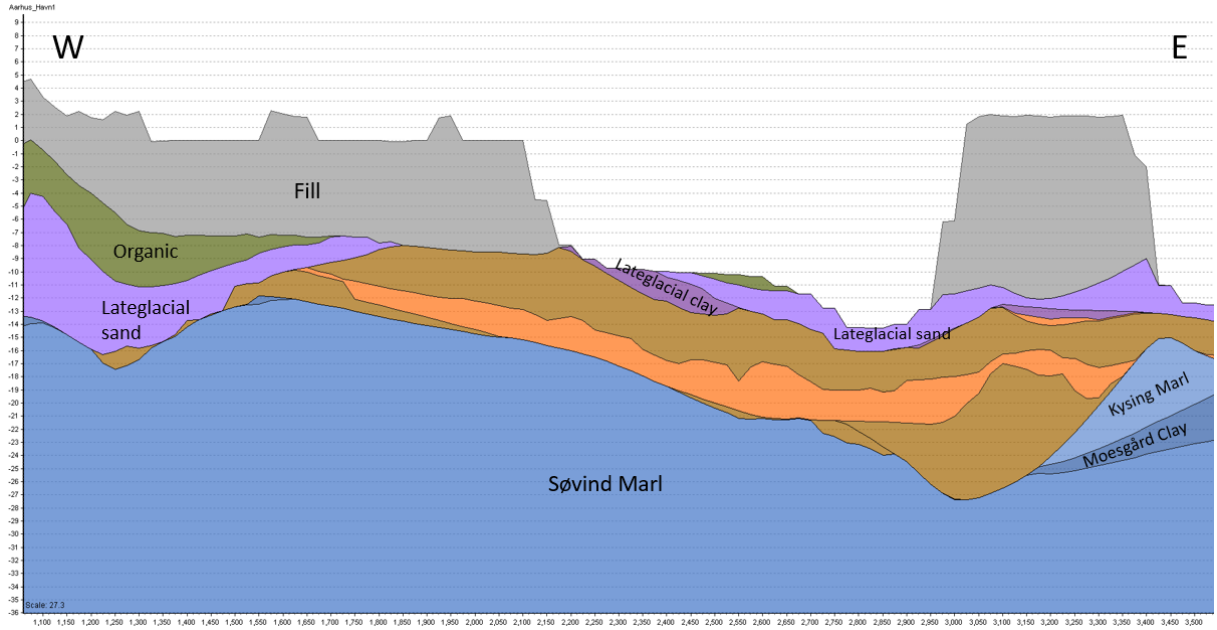

Figure 6. Profile orientated W-E transecting the Aarhus harbor area. Note the occurrence of organic sediments, late glacial sand/clay and the pre-Quaternary deposits of Kysing Marl, Moesgård Clay and Søvind Marl.

4 Description of the pre-Quaternary sediments

The pre-Quaternary deposits consist of Palaeocene limestone of Danien age (Bryozokalk), marine clay of Palaeocene, Eocene, Oligocene and Miocene age with high to very high plasticity. The Miocene layers does, however, include sand layers in the upper part.

The pre-Quaternary layers are generally dipping towards the SW, but are locally influenced by tectonics and the distribution of incised valley/buried valley systems that may influence the distribution and/or the elevation of the layer.

4.1 Glimmersand (mica-sand) and Kvartssand (Quarts-sand)

The mica-rich sand is here attributed to the Brejning FM (Øksnerade MB) and/or the Vejle Fjord FM that was deposited during the latest part of the Oligocene period.

The mica-rich sand consists of grey-dark, fine-grained sand, often with organic content.
The layer occurs in minor areas in the central part of the area to the north of the Brabranddalen valley and in minor areas in the southernmost part of the model area, the thickness varies between 10-30m.

Quarts sand is typically coarser grained and consist almost exclusively of well-rounded quarts grains.

4.2 Glimmerler (mica-clay)

The mica-rich clay is here attributed to the Brejning FM (specifically the Brejning Clay) and the Vejle Fjord FM that were deposited during the latest part of the Oligocene period.
The clay is brownish with medium-high plasticity to silty-sandy. It is rich in mica, with organic content and no carbonate content.

The layer occurs in the central part of the model area north of the Brabranddalen Valley and in the southernmost area. The thickness varies between 10-30m.

4.3 Viborg ler (-clay)

The Viborg Clay was deposited during the Oligocene period.
The deposits consist of clay with very high plasticity with some silt specs. The upper part may contain fine sand specs. The sediment contains a slight amount of mica, some organic material but no carbonate.
The layer occurs in the central part of the model area north of the Barabranddalen valley and to the south of the valley. The layer is generally between 10-30m in thickness.

4.4 Kysing mergel (-marl)

The layer is an internal layer in the Late Eocene Søvind Marl FM.
The marl consists of light-grey marl with very high plasticity and is similar to the Søvind Marl.
Due to data coverage, the layer is only interpreted in the Aarhus Harbour area where it occurs with a thickness about 2m

4.5 Moesgård ler (-clay)

The layer is an internal layer in the Søvind Marl FM and was deposited during the Late Eocene.
The Moesgård clay is a dark layer with very high plasticity and a low carbonate content.
Due to data coverage, the layer is only interpreted in the Aarhus Harbour area where it occurs with a thickness about 10m.

4.6 Søvind mergel (-marl)

The Søvind marl was deposited during the Late Eocene.
The marl consists of light-grey marl with very high plasticity with minor layers or laminae of clay. The uppermost part has a high carbon content and is almost white in colour.
The layer occurs in the central and NW-SE part of the area, it is absent in the NE and SW part and at the deep valley systems. It has a thickness about 40-50m.

4.7 Lillebælt ler (-clay)

The Lillebælt clay was deposited during the Eocene period.
The clay deposits consist of laminated clay with very high plasticity, that may contain minor layers of marl or ash layers. The layers are dark grey, greenish to reddish in colour. It may contain iron or carbonate concretions.
The layer occurs with an average thickness about 40-50m, but considerable larger thicknesses occurs in the Aarhus city area. It is absent in the northernmost part of the area and in parts of the deep valleys.

4.8 Palaeocene clay (Holmehus, Stollenklint, Ølst-)

The Palaeocene clay is comprised of layers deposited during the Selandien or Early Eocene.
They consist of clays with high to very high plasticity that except from the Holmehus FM contain no carbonate. The Holmehus FM is massive to laminated with greenish to reddish layers, the Stollenklint and Ølst FM are dark-grey laminated clay. Numerous ash layers are seen in Ølst FM.

The layer occurs with a general thickness about 30m. It is absent in the NW and SE part of the area.

4.9 Bryozoan limestone

The bryozoan limestone was deposited during the Danian period.
The limestone is a marine sediment deposited in a deep-water environment. It consists of sand to silt sized skeletal fragments of bryozoans mixed with subordinate amounts of lime mud and clay. The limestone contains substantial amounts of silicifications and flint occurs as both light grey or black irregular nodules of various sizes.
The limestone only occurs at the pre-Quaternary surface in Brabranddalen but is distributed in the entire model area.

5 Description of the Quaternary sediments

The Quaternary stratigraphy of the Aarhus area consist of a glacial and late/post glacial sequence comprising a layer of recent fill, postglacial organic sediments, two late-glacial layers of clay and sand and three layers of clay till interbedded with three layers of meltwater sand and gravel.

5.1 Fill deposits

The fill consists of a mixture of different lithology's including organic deposits, sand, gravel and/or clay sometimes mixed with building materials of various kind.
The fill layer is generally between 1-5 meters in the central part of Aarhus, greater thickness is reached in the harbour areas with a thickness between 10-15m.

5.2 Postglacial organic deposits

Postglacial organic deposits are widely distributed in the former tunnel valleys and marine surfaces, they are widespread around the lake systems in Brabranddalen and central parts of Aarhus with a thickness about 5-10m and in an area east of Egå Engsø to the north with a thickness about 10-15m.
The postglacial deposits consist of both marine and freshwater deposits, mostly gyttja or peat.

5.3 Sand_1 (late glacial)

This unit consists of late-glacial sand deposited in both marine and freshwater environments.
The sand deposits consist mainly of fine to coarse-grained unconsolidated sand and can be with some organic content. The layer occurs with a thickness about 1-5m in the central part of Aarhus and in isolated areas to the west, in an area to the west of Egå Engsø the thickness is about 10-15m

5.4 Clay_1 (late glacial)

This unit consists of late-glacial-unconsolidated clay deposits, mostly top-till deposits but also includes meltwater clay and silt.

The unit is widely distributed in the elevated parts of the glacial landscape, but is absent in the tunnel valleys and the coastal areas. The thickness varies between 10-30m.

5.5 Sand_2 (glacial)

The unit consists of meltwater sand, -silt and -gravel with minor amounts of sandy Till or silty Till. The unit is consolidated and occurs as a widely distributed layer below Clay_1. This means that it occurs in the elevated parts of the glacial landscape but is absent in most tunnel valleys.
The thickness varies between 10-30m. The thickest deposits occurs in valley systems in the northern part of the model area.

5.6 Clay_2 (glacial)

The unit is widely distributed in the model-area and is only absent in parts of the deepest valley systems. It consists mostly of consolidated clay till with minor amounts of meltwater-clay.
The thickness varies between 10-40m, locally the thickness is about 50m

5.7 Sand_3 (glacial)

The unit consists of meltwater sand- and gravel, it occurs in intermediate levels confined to the tunnel- and buried valleys, primarily in the SW-NE orientated valley systems. It is absent in the remaining part of the glacial stratigraphy.
The thickness varies greatly within the valleys between 20-60m.

5.8 Clay_3 (glacial)

This unit consists of glacial till and meltwater clay, it occurs in intermediate levels in the buried valleys of all directions, and especially in the Brabranddalen valley.
The thickness varies greatly within the valley systems, for the most part between 10-60m, but locally it reaches 100m.

5.9 Sand_4 (glacial)

This unit is confined to the deepest levels if the buried wally-systems. It consists mostly of meltwater sand and -gravel. It is present in smaller parts of the SW-NE orientated valleys with thicknesses about 40-50m, but in Brabranddalen and a buried valley-system to the extreme NE, it occurs with a thickness up to 110m.

5.10 Clay_4 (glacial)

This unit is confined to the deepest parts of the buried valleys.
It consists of meltwater clay and glacial till, it occurs primarily in the Brabranddalen valley and in a deep valley system to the extreme N and NE.

6 References

/1/ Jacobsen, GEUS, map service.

/2/ Houmark-Nielsen, M. et al., 2005: De seneste 150.000 år I Danmark, istidslandskabet og naturens udvikling. Geoviden, GEUS.