Sønderborg Area

Overview of the geological conditions in the Sønderborg model area

GeoAtlas Live Documentation
Report 1, 2018-02-21

This report gives a brief overview of the geological setting and conceptual interpretation of the Sønderborg Model Area. The Sønderborg model was interpolated as a 10m grid cell model.

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

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

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1 Introduction

This note gives a brief overview of the geology of the Sønderborg model 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 Sønderborg model was interpolated as a 10m grid cell model.

The extend of the model area is illustrated in Figure 1.

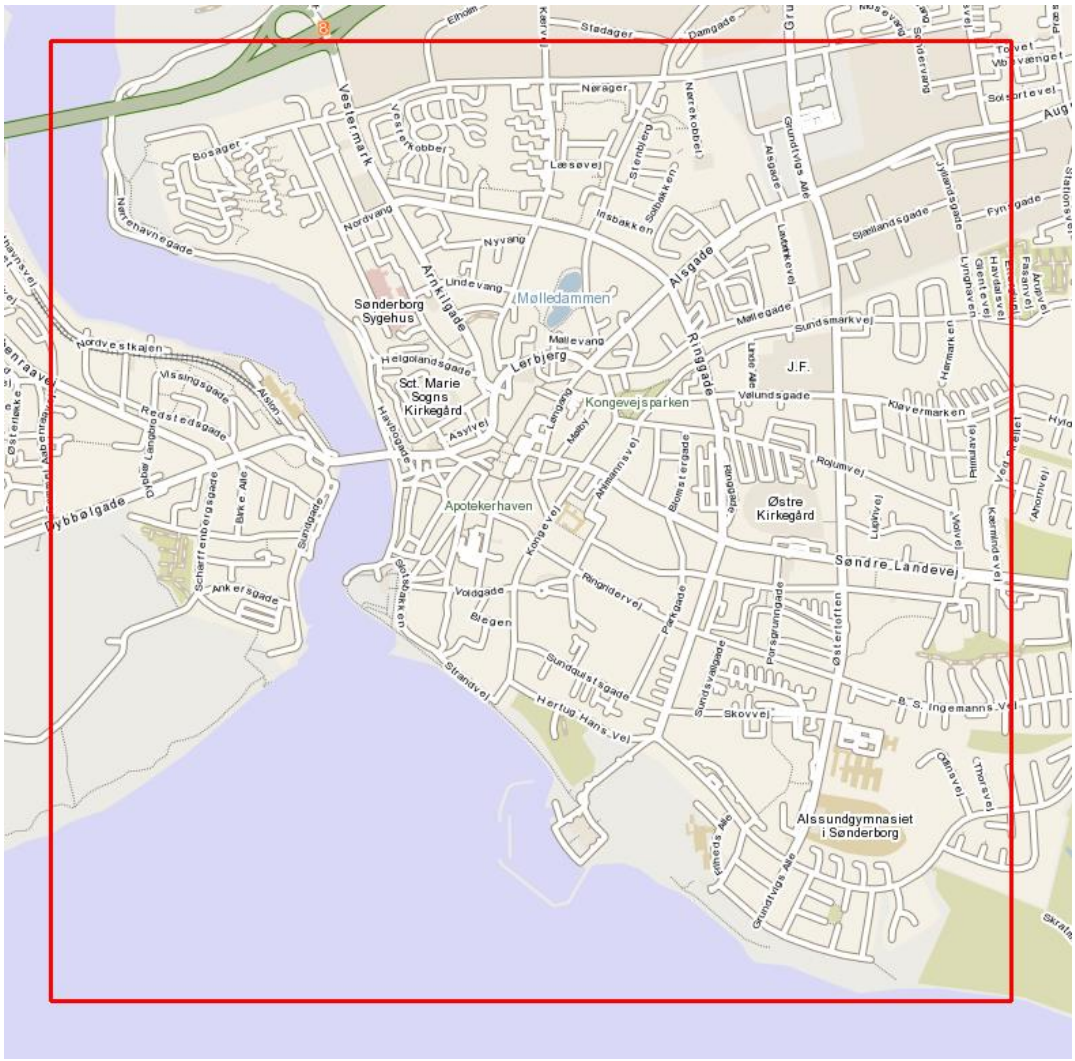

Figure 1. Extend of the Sønderborg Model Area (10m) extending from Broager (Jutland) in the west in the eastern part of Sønderborg. Red square marks the extend of the model area.

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 geology were setup in the modelling software. The surfaces were interpolated with a 10m cell size in the regional model area in order to ensure a high standard of accuracy.

2 Geological setting and history

The geological setting and depositional history are briefly described below:

2.1 Pre-Quaternary structural geology and deposits

Structurally, the model area is positioned in the Northern-German Basin along the southern margin of the Ringkøbing-Fyn High (RFH). The RFH is a structural ridge orientated NW-SE consisting of elevated crystalline bedrock.

To the west of Sønderborg, several fault systems are orientated NW-SE forming the Tønder Graben. The fault systems extend along the Flensborg Fjord towards Sønderborg.
Another system of fault lines trending N-S extends from Northern Germany towards the model area. This marks the northern extention of the Glückstadt Graben system /1/.

The pre-Quaternary deposits in the area consist of Paleogene (Eocene/Oligocene) and Neogene (Miocene) marine sediments. The Miocene sediments consist of silty clay deposits belonging to the Klintinghoved Formation and possibly the Vejle Fjord Formation, overlaying Oligocene Clay (Viborg Ler) and Eocene clay with very high plasticity (Lillebælt Ler).

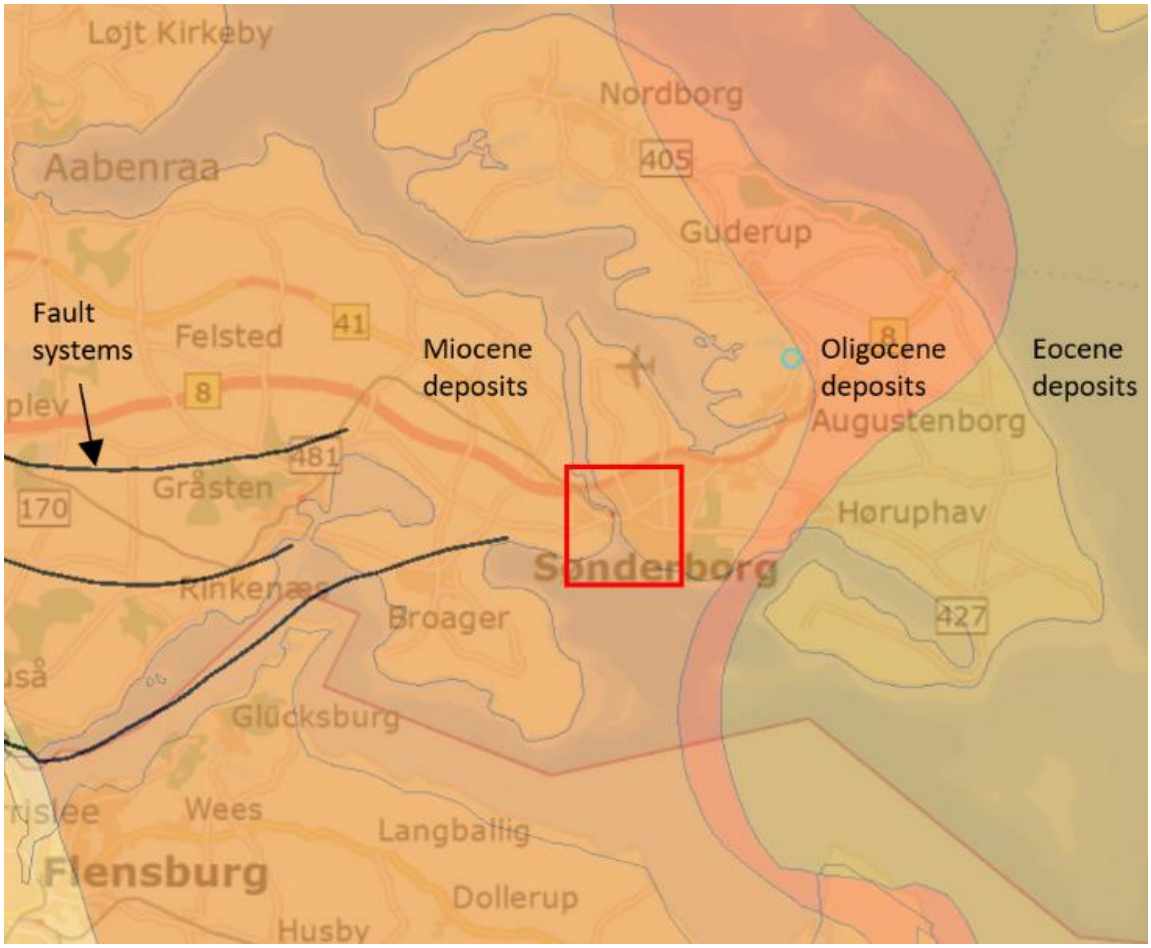

Figure 2. Distribution of the pre-Quaternary deposits in the Sønderborg model and surrounding area. Note the fault lines to the west, that may extent into the model area The fault system to the south is not illustrated in this map. Model area is shown with red square. From /2/

2.2 Eocene deposits

The Eocene deposits are not interpreted as a separate layer in the model but are part of the pre-Quaternary layer.
The Eocene deposits consist of Lillebælt Clay (Lillebælt Ler) that were deposited in a marine environment. It consists of very high plasticity- to silty clay with minor volcanic ash-layers. The Lillebælt Clay rests on Danien limestone at about level -320 and the top of the clay is found at level -160.

2.3 Oligocene deposits

The Oligocene deposits are not interpreted as a separate layer in the model but are part of the pre-Quaternary layer.
The Oligocene deposits consists of Viborg Clay (Viborg Ler) that were deposited in a marine environment. It consists of silty clay that may contain mica or glauconite minerals. The Viborg Clay rests on Lillebælt Clay at about level -160 and the top of the clay is found at level -120.

2.4 Miocene deposits

The Miocene deposits are not interpreted as a separate layer in the model but are part of the pre-Quaternary layer, where it makes up the upper part of the layer. The Miocene deposits consist of silty- to sandy, micaceous clay from the lower Miocene and is probably part of the Vejle Fjord Formation. The Vejle Fjord FM. was deposited in a marine environment. The Miocene deposits rest on Viborg Clay at about level -110nd the top of the Miocene clay is found at levels between -70 and -55.

2.5 Quaternary deposits

The Quaternary deposits are represented by three clay tills and two layers of meltwater sand, however minor sand layers or lenses may be interbedded with the till layers.

The two upper till layers are interpreted to represent three ice-advances during the Weichselian Glaciation, namely the Mid Danish Till deposited during the main glacial advance from the NE and two advances from SE during the East Jutland advance (East Jutland Till) and the Bælthav advance (Bælthav Till).
The extent of the glacial ice sheets during the Weichselian is shown in Figure 3.

The lowermost till is interpreted to represent the Lillebælt Till deposited during the Saalian Glaciation thus making the sand layer separating the lowermost till from the two upper tills of Eemian age (interglacial), this would be partially in accordance with the interpretation of the stratigraphy at the nearby location of Stensigmose at Broagerland /4/.

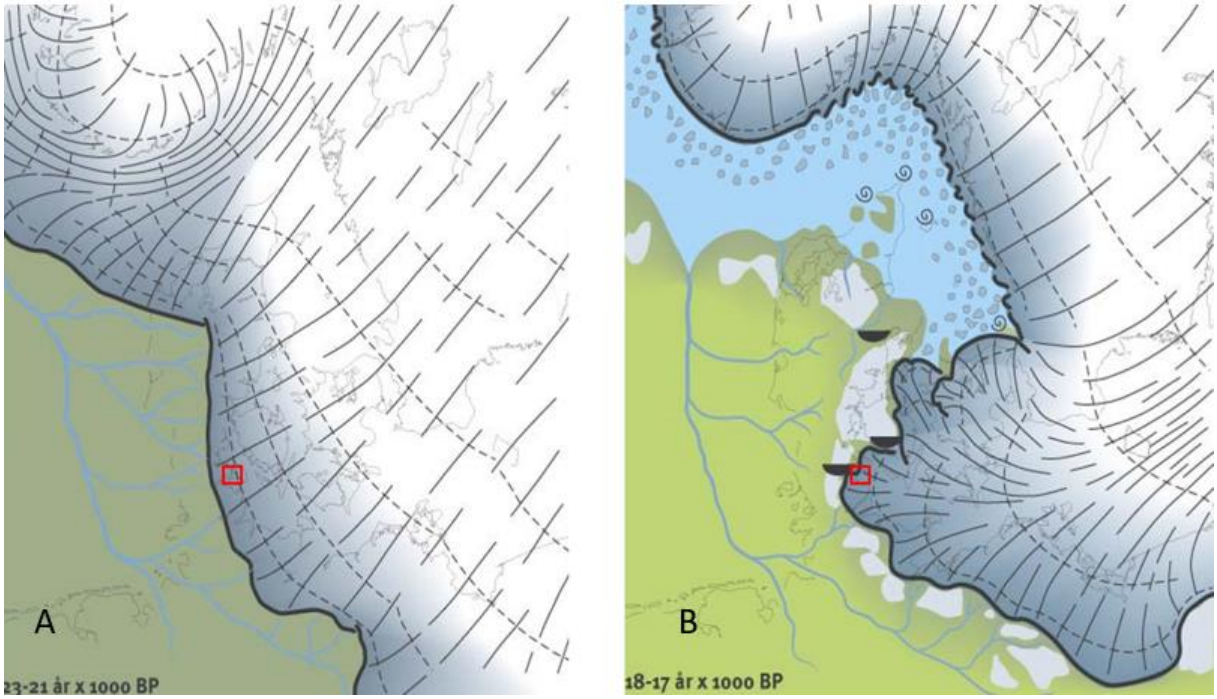

Figure 3. Extent of the glacial ice sheets during the A) Main advance from the NE associated with the intermediate till, B) Ice advance from a SE direction associated with the upper till. From /3/.

2.6 **Late-glacial, Postglacial and Recent deposits**

The Late-glacial and Postglacial deposits are not interpreted in separate layers but are included in the upper till and fill layers. The distribution of the deposits are shown in Figure 4.

Late-glacial meltwater sand deposits occur locally in the area, especially in the western part. Sand-deposits also occur as Postglacial deposits along and in the strait separating the island of Als from Broagerland (Jutland) to the west.
Postglacial organic deposits occur locally, especially to the SE in minor depressions.

Recent fill deposits occur primarily within the urban area of Sønderborg.

Figure 4. Distribution of Lateglacial and Postglacial deposits, primarily sand and organic deposits (red/green colors). Older glacial deposits are shown with brown colors. From /2/.

3 Conceptual geology

The stratigraphy of the Sønderborg area is divided into a glacial Quaternary sequence and pre-Quaternary layer. The resulting interpretation resulted in a 7-layer model consisting of one Recent layer, 5 Quaternary layers and 1. Pre-quaternary layer.

An overview of the stratigraphy is given in Table 1.

The conceptual interpretation is illustrated in a conceptual profile orientated W-E showing the general geological settings and structures of the Sønderborg Model (10m), Figure 5.

Table 1. Overview of the stratigraphy in the Sønderborg Model Area. The stratigraphy includes glacial Quaternary sediments and a pre-Quaternary layer of Miocene/Oligocene age.

No.	Name	Lithology code (DK)	Age	Description	Occurence in model
1	Fill	o,s, tg,b, fs	Recent/postglacial	Fill, Postglacial	Urban area
2	Clay 1	ml, ms, mi, dl,di, l,v	Weichselian	Till and meltwater clay	Regional
3	Sand 1	ds, dg, s, g	Weichselian	Sand and gravel	Regional
4	Clay 2	ml, ms, mi, dl,di, l,v	Weichselian	Till and meltwater clay	Regional
5	Sand 2	ds, dg, s, g	Eemian	Sand and gravel	Regional
6	Clay 3	ml, ms, mi, dl,di, l,v	Saalian	Till and meltwater clay	Regional
7	Prequaternary	ol, vl, v, pl	Miocene/Oligocene	Micaous clay and sand	Regional

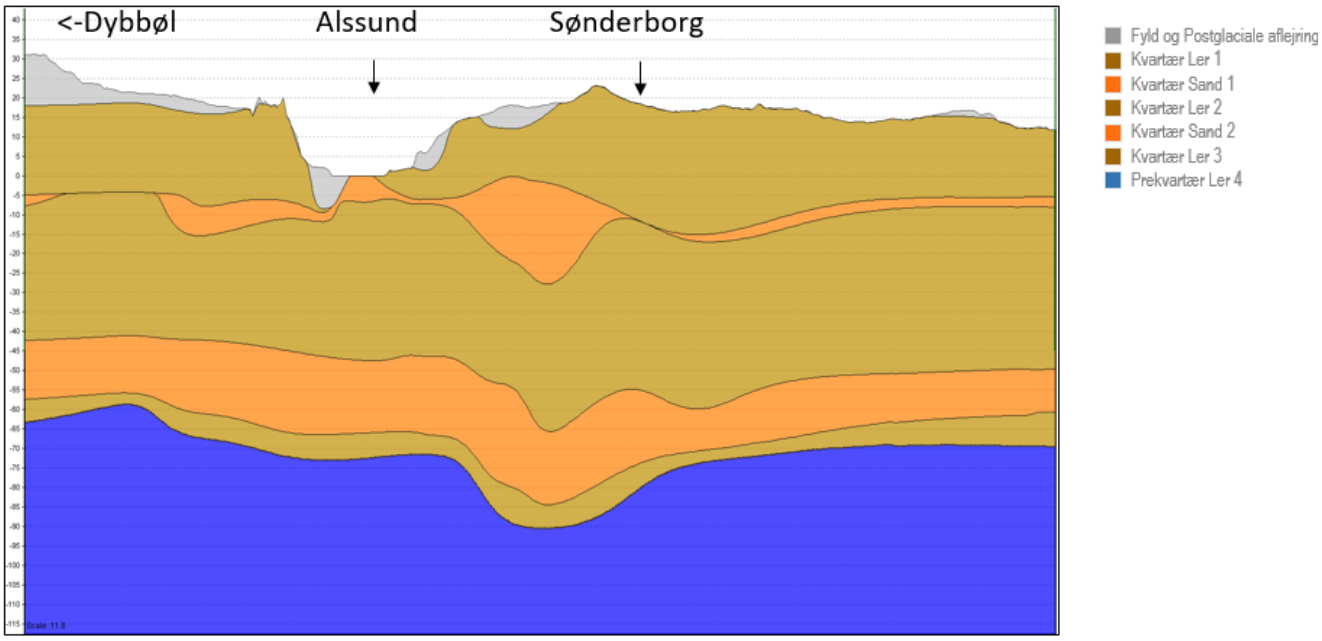

Figure 5. Conceptual profile W-E transecting the regional geological model (10m) for the Sønderborg Area

4 Description of the Pre-Quaternary surface

The pre-Quaternary sediments in the model area consists of Miocene deposits. The top of the pre-Quaternary sediments show a pattern of valley structures probably related to fault zones in the pre-Quaternary sediments and later the development of buried valley- and tunnel valley systems during the Quaternary glaciations.

The pre-Quaternary surface shows a distinct pattern of buried valley structures with two orientations namely SW-NE and NW-SE probably relating to the glaciations during the Weichselian from the NW and the SW respectively.

An interpretation of the morphology of the pre-Quaternary surface is shown in Figure 6.

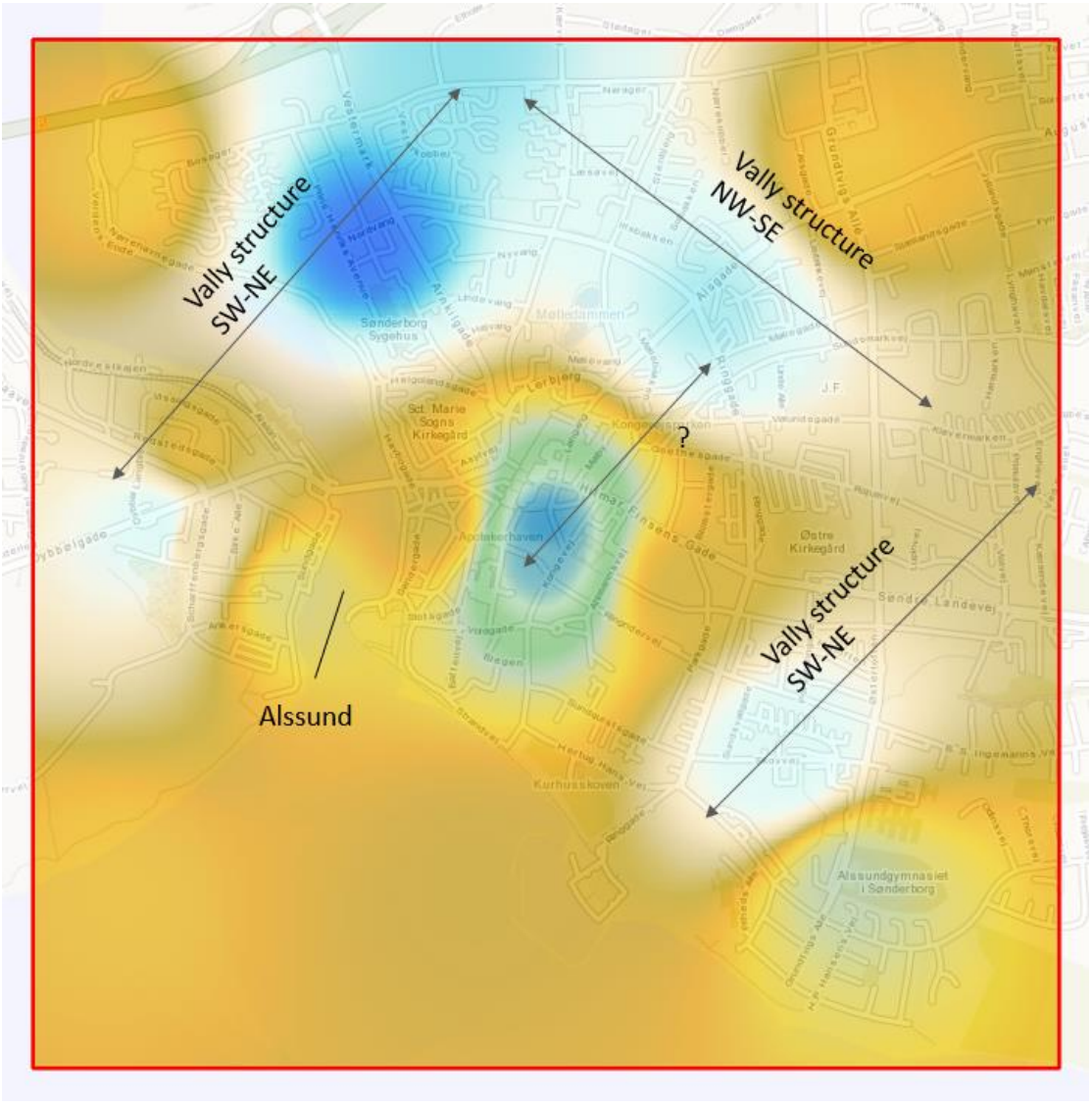

Figure 6. Morphology of the pre-Quaternary surface in the Sønderborg model area. Note the valley structures orientated SW-NE and NW-SE respectively and the orientation of the Alssund strait. Brown colours: high elevation, green and blue colours: lower elevations.

5 Description of the Quaternary sediments

The Quaternary stratigraphy of the Sønderborg model area consist of a glacial sequence that comprises two layers of meltwater deposits of mainly sand and gravel interbedded with three layers of glacial till, the glacial sequence rests mainly on top of Miocene deposits.

5.1 Fill deposits

The fill deposits consist of both clay and sand sediments, mixed with building materials.
The fill occurs in the build-up areas of Sønderborg, primarily in the central parts, along the harbor and infrastructure and in the easternmost part of the model area at Dybølgade.

The thickness of the fill is generally between about 1-5m. In the easternmost part of the area it may reach 10m.

5.2 Clay-1 (Upper clay till)

The upper till unit is interpreted to have been deposited during an ice-advance from the SE.
The layer consists of sandy- gravelly clay till and is widely distributed in the glacial landscape but is not found or is very thin in the Alssund (-strait) area.

The thickness generally varies between 20-30m but in the in the strait- and Fjord area, the layer is between 1-5m.

5.3 Sand-1

The unit is interpreted to have been deposited by an advancing ice sheet from the SE.
The layer consists of fine-medium grained sand and is distributed primarily in area of Alssund or as a discontinuous layer in the buried valley systems.

In the Alssund area and the buried valleys, the layer may locally reach 30m, but else the thickness is between 1-5m. The layer is absent in the fjord area

5.4 Clay-2 (Intermediate till)

The unit is interpreted to have been deposited by an ice-advance from the NE.
The layer consists of sandy clay till and is distributed in the entire model-area.

The thickness of the layer varies between 40-50m in in the central urban area and parts of the NE area, thinning out towards the NW and SE to between 10-20m.

5.5 Sand-2

The layer is interpreted to have been deposited by the NE-ice sheet.
The layer consists of fine-medium or gravelly sand, and is distributed in most of the model area, the layer reaches a thickness between 20-30 m in the urban part of the model, stretching in an elongated form from Dybbølgade in the west to Ørstedgade in the east. The layer is thinning to between 1-10m to the north of Helgolandsgade and in the fjord area.

5.6 Clay-3 (Lower clay till)

The lower till unit is interpreted to have been deposited during an ice-advance during the Saalian Glacialtion.

The layer consists of sandy- gravelly clay till and is distributed in most parts of the model area. The thickness reaches 40m locally in the central part of the urban area, but in the remaining part of the area, the thickness varies between 5-10m, thinning further towards the north and south.

6 References

/1/ Vejbæk, V.O., (1997): Dybe strukturer I danske sedimentære bassiner.

/2/ GEUS, map service.

/3/ Houmark-Nielsen, M. et al., 2005: De seneste 150.000 år I Danmark, istidslandskabet og naturens udvikling. Geoviden, GEUS.

/4/ Gravesen, P. et al., (2003): Det sydlige Jylland, Stensigmose (lok.112a). GEUS.