The Lower Miocene Skade Formation in the northern North Sea

(Extent and thickness, age from fossil and strontium isotope correlations, lithology, paleobathymetry and regional correlation)

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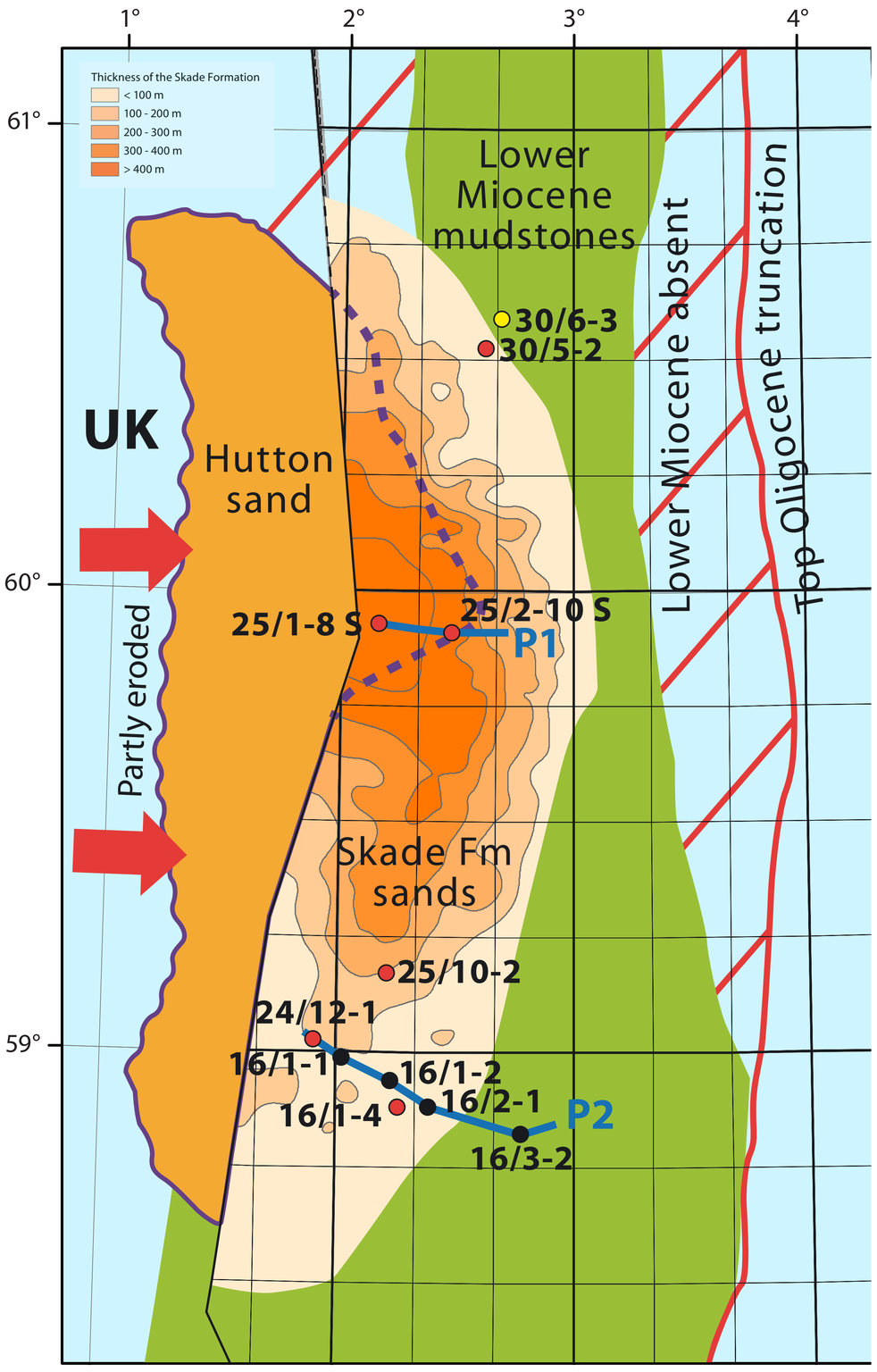
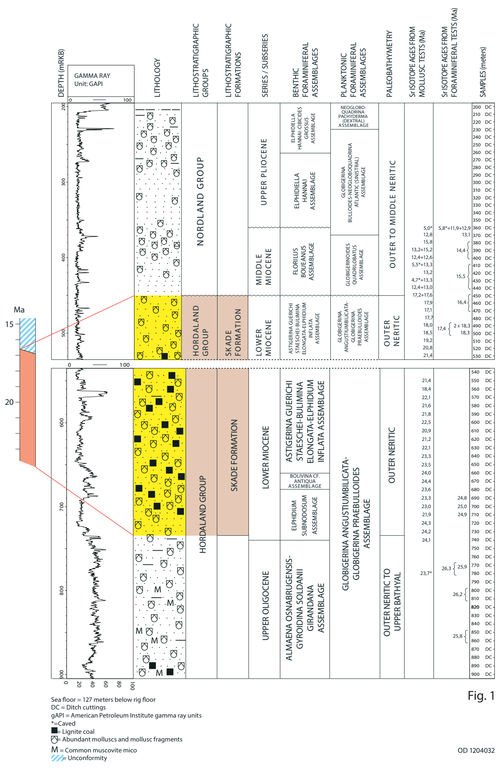
The deposition of the Skade Formation represents a southern shift in coarse clastic influx to the northern North Sea basin from the East Shetland Platform, relative to Oligocene time. We have investigated the Skade Formation in six wells and in most wells the deposits are turbiditic in origin and were probably deposited in quite deep parts of the shelf. The Skade sections in well 25/2-10 S and 25/1-8 S contain common mollusc fragments and lignite coal, and have probably been deposited in shallower water close to or as parts of a delta. According to the mapping of Gregersen & Johannessen (2007) these are wells situated in the distal part of the Hutton sand area. Hutton sand is an informal term used in British sector by several oil companies to describe all sands above the Lower Eocene Balder Formation in the Northern North Sea (British Geological Survey 2000). In some areas Hutton sand extends into the Norwegian sector and continues into the Skade Formation, but we prefer not to use the term Hutton sand in Norwegian waters.

The Skade sands pinch out to the east. The sandy system has a maximum gross thickness in excess of 300 m. According to our investigations, the sands were deposited between approximately 23.5 and 15.5 Ma. It has been suggested that they are a result of uplift of the East Shetland Platform, possible associated with a renewed compressional tectonic phase along the northwest European margin (Lundin & Dore 2002, Boldreel & Andersen 1994).

The climate was probably warm temperate during the Early Miocene and culminated with a subtropical climate in the early Middle Miocene (see Fig. 4).



WELL 25/1-8 S

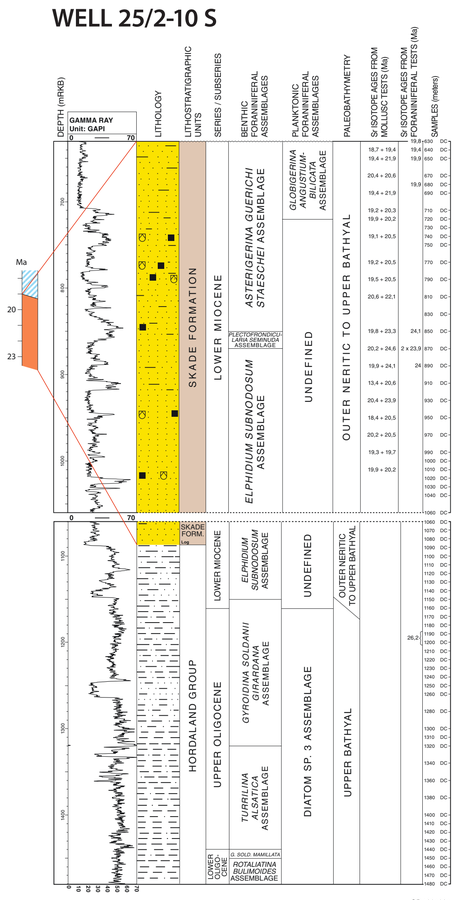


Sea floor = 127 meters below rig floor
DC = Ditch cuttings
gAPI = American Petroleum Institute gamma ray units
*=Caved
= Lignite coal
= Abundant molluscs and mollusc fragments
M = Common muscovite mica
= Unconformity

OD 1204032

Fig. 1

WELL 25/2-10 S

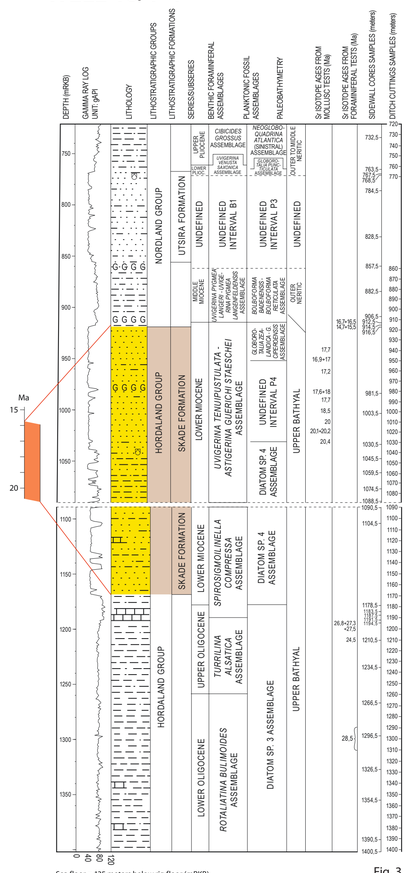


Sea floor = 141 meters below rig floor (mRKB)
DC = Ditch cuttings
gAPI = American Petroleum Institute gamma ray units
G = Abundant glauconite
= Lignite coal
= Abundant Molluscs and mollusc fragments
= Unconformity

OD 1204034

Fig. 2

WELL 16/1-4



Sea floor = 135 meters below rig floor (mRKB)
gAPI = American Petroleum Institute gamma ray units
= Abundant molluscs or mollusc fragments
G = Abundant glauconite
= Lignite coal
= Limestone

OD 1204031

Fig. 3

Late Paleogene and Neogene lithostratigraphy

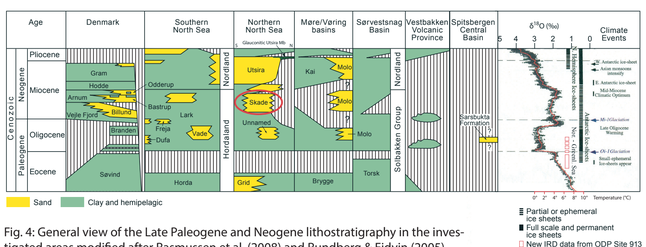
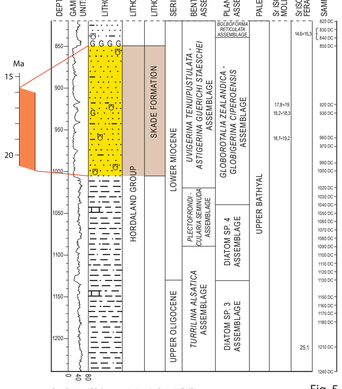


Fig. 4: General view of the Late Paleogene and Neogene lithostratigraphy in the investigated areas modified after Rasmussen et al. (2008) and Rundberg & Eidvin (2005). On the right hand side of the diagram there is added some paleoclimatic data including a global deep-sea oxygen curve, bottom-water paleo-temperatures in the world's oceans and periods with ice-sheets in the Antarctica and northern hemisphere (after Zachos et al. 2001). Periods with deposition of IRD at ODP Site 913 (off East Greenland) are also indicated (Eldrett et al. 2007).

WELL 24/12-1

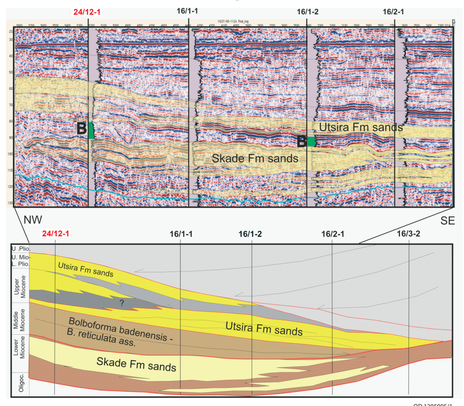


Sea floor = 138,5 meters below rig floor (mRKB)
gAPI = American Petroleum Institute gamma ray units
= Abundant molluscs or mollusc fragments
G = Abundant glauconite
DC = Ditch cuttings
* = Caved

OD 1204020

Fig. 5

Southern Viking Graben - 59°N

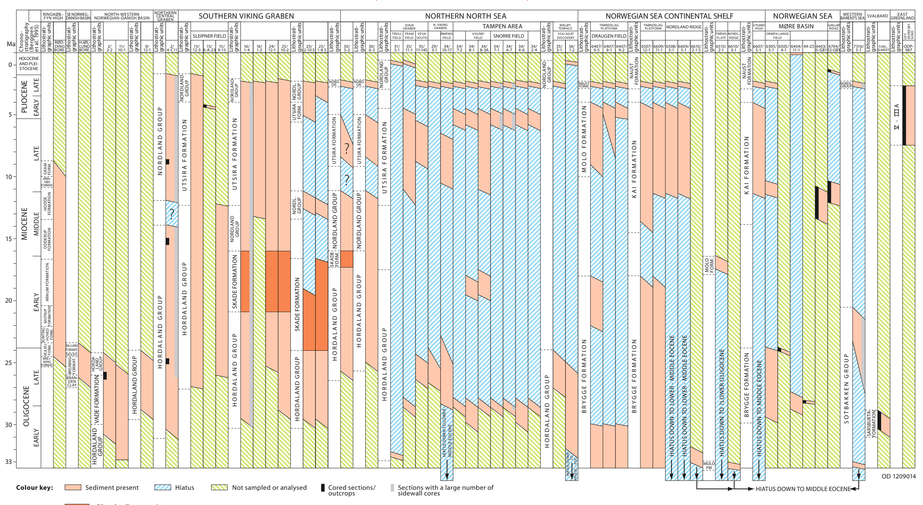


OD 1205005/1

Profile 2: (a) Seismic line through wells 24/12-1, 16/1-1, 16/1-2 and 16/2-1 across southern Viking Graben showing Skade and Utsira formations. Green-coloured part of gamma ray logs denotes Middle Miocene Bolboforma badenensis and Bolboforma reticulata assemblages. (b) Interpretation of seismic line shown in Profile 2 (a) (extended towards east through well 16/3-2. Well 24/12-1, where the Skade Formation is investigated, has red number (after Rundberg & Eidvin 2005).

Geochronology of studied wells, boreholes and outcrops

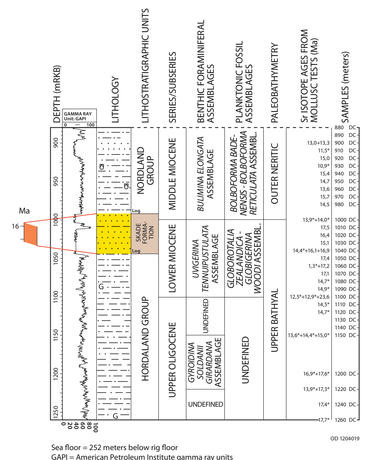
(The Skade Formation is in dark red)



OD 1209014

Fig. 6: Geochronology of all studied wells including the six wells with the Skade Formation.

WELL 30/5-2



Sea floor = 252 meters below rig floor
GAPI = American Petroleum Institute gamma ray units
DC = Ditch cuttings
G = Abundant glauconite
= Abundant molluscs and mollusc fragments
* = Caved

OD 1204019

Fig. 8

Thickness of the Lower Miocene Skade Formation

with the extent of the hutton sand and Lower Miocene mudstones

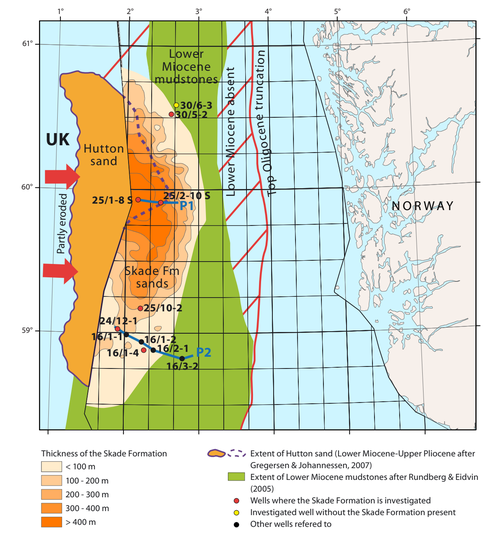


Fig. 7: Distribution of Lower Miocene sediments in the northern North Sea with a thickness map of the Skade Formation according to NPD (2011), outline of the Miocene-Upper Pliocene Hutton sand according to Gregersen & Johannessen (2007) and outline of Lower Miocene mudstones according to Rundberg & Eidvin (2005). After Eidvin et al. (work in progress).

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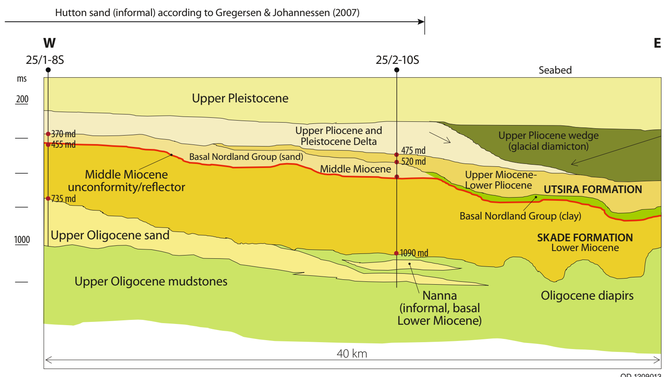
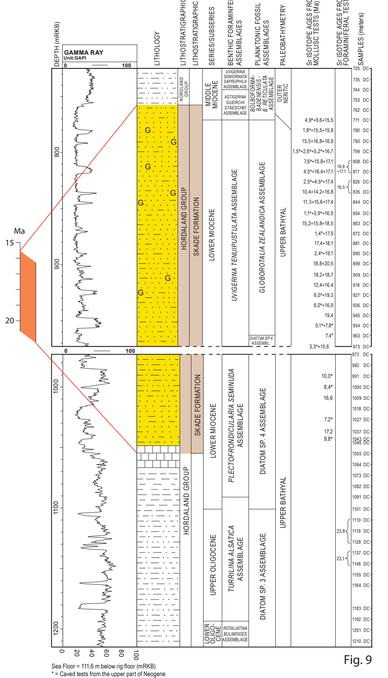
Hutton sand (informal) according to Gregersen & Johannessen (2007)



OD 1209013

Profile 1: This geo-section illustrates how four different delta sands, which constitute the outer delta front of the Hutton sand system (informal name used only in UK waters) are deposited. In Norwegian waters the Lower Miocene Skade Formation is turbitic in origin and overlays Oligocene mudstones. The Utsira Formation overlays a mud prone, distal Middle Miocene unit and thins out west from the delta front towards the 25/1-8S area. An Upper Pliocene delta builds on top of the Utsira Formation in the 25/2-10S area, modified after Gjeldvik et al. (2011).

WELL 25/10-2

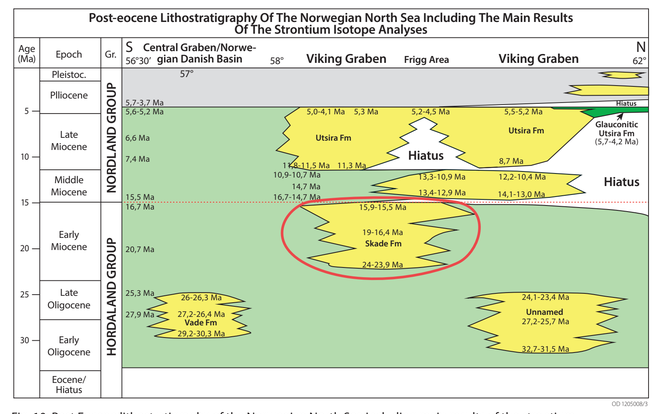


Sea Floor = 111,6 m below rig floor (mRKB)
* = Caved tests from the upper part of Neogene
= Limestone
G = Abundant glauconite

OD 1204033

Fig. 9

Post-eocene Lithostratigraphy Of The Norwegian North Sea Including The Main Results Of The Strontium Isotope Analyses



OD 1205008/3

Fig. 10: Post Eocene lithostratigraphy of the Norwegian North Sea including main results of the strontium isotope analyses based on fossil tests interpreted to be in situ (after Eidvin et al., work in progress 2).

PROPOSED POST-EOCENE STRATIGRAPHY OF THE NORTHERN NORTH SEA

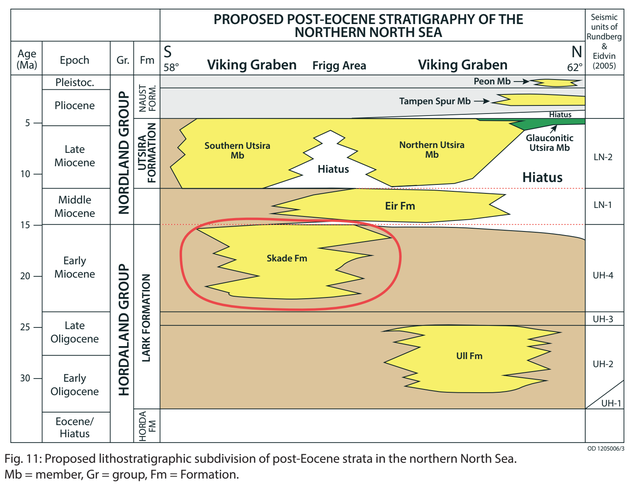


Fig. 11: Proposed lithostratigraphic subdivision of post-Eocene strata in the northern North Sea. Mb = member, Gr = group, Fm = Formation.

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If not stated otherwise all figures and text are according to:
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