Geology desk study offshore Bornholm, Baltic Sea

Windfarm investigations

Jørn Bo Jensen, Lasse Tésik Prins & Ole Bennike

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

G E U S

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Report for Energinet Eltransmission A/S

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G E U S

Contents

1. Summary

Energinet A/S has requested that GEUS undertakes a geological desk study of the Bornholm Offshore Wind Farms (OWFs) region. The study has resulted in a general geological description and establishment of a geological model. The study is based on existing data and is to be used as a background for future interpretations of new seismic data, geotechnical investigations, and an archaeological screening.

In this study we have used a combination of published work, archive seismic data and sediment core as well as CPT data to assess the general geological development of the Adler Grund area, including the planned Bornholm OWFs.

A geological description is provided, and a geological model has been developed.

As a result of the geological desk study, it has been possible to establish a relative late glacial and Holocene shore-level curve for the area and to describe the palaeo-development relevant for an archaeological screening.

The general geological description includes the complete geological succession from the pre-Quaternary framework, the pre-Quaternary surface, glacial deposits, the deglaciation, and late glacial and Holocene deposits.

The geological model of the south-western Baltic Sea region is based on sequence stratigraphical studies by Jensen et al. (1997, 1999, 2017) customized to the Bornholm OWFs.

The Integrated Ocean Drilling Program (IODP) Expedition 347 in October 2013 carried out a 73.90 m deep drilling at site M0065 in the Bornholm Basin. The obtained sediment succession (down to 49.21 m) was divided into three different lithostratigraphical units and description of lithology and downhole core logging were performed including physical parameters.

In 2013, Energinet conducted surveys on six offshore near coastal areas. One of these areas (Rønne Banke Site 6) is located about 10km south of Rønne. Site 6 data gives information about lateglacial sands, till and Upper as well as Lower Cretaceous sediment distribution and geotechnical parameters.

In the south-western part of the Baltic Sea, studies of late glacial and early Holocene shore-level changes formed the basis for evaluation of the potential to find submerged settlements in the wind farm areas. The shore-level curve, in combination with the present bathymetry, indicate that the shallowest parts of the wind farm areas 1 and 2 were dry land during two short time intervals at ca. 12800 and 11700 years ago. This corresponds to the Bromme/Ahrensburg/Maglemose cultures. During younger cultures, the wind farm areas were transgressed, and continued being submerged during the Ancylus Lake and later by the Littorina Sea.

In relation to geotechnical challenges, a number of focal points has been raised such as neotectonics, recent earthquakes, gas in sediments, thick weakly consolidated glaciolacustrine clay and Holocene mud with high organic contents.

2. Introduction

GEUS has been asked by Energinet to provide an assessment of the Bornholm Offshore Wind Farms (OWFs), consisting of the establishment of a geological model based on existing data. The report will serve as a background for future interpretations of seismic data and a marine archaeological screening (Figure 2.1).

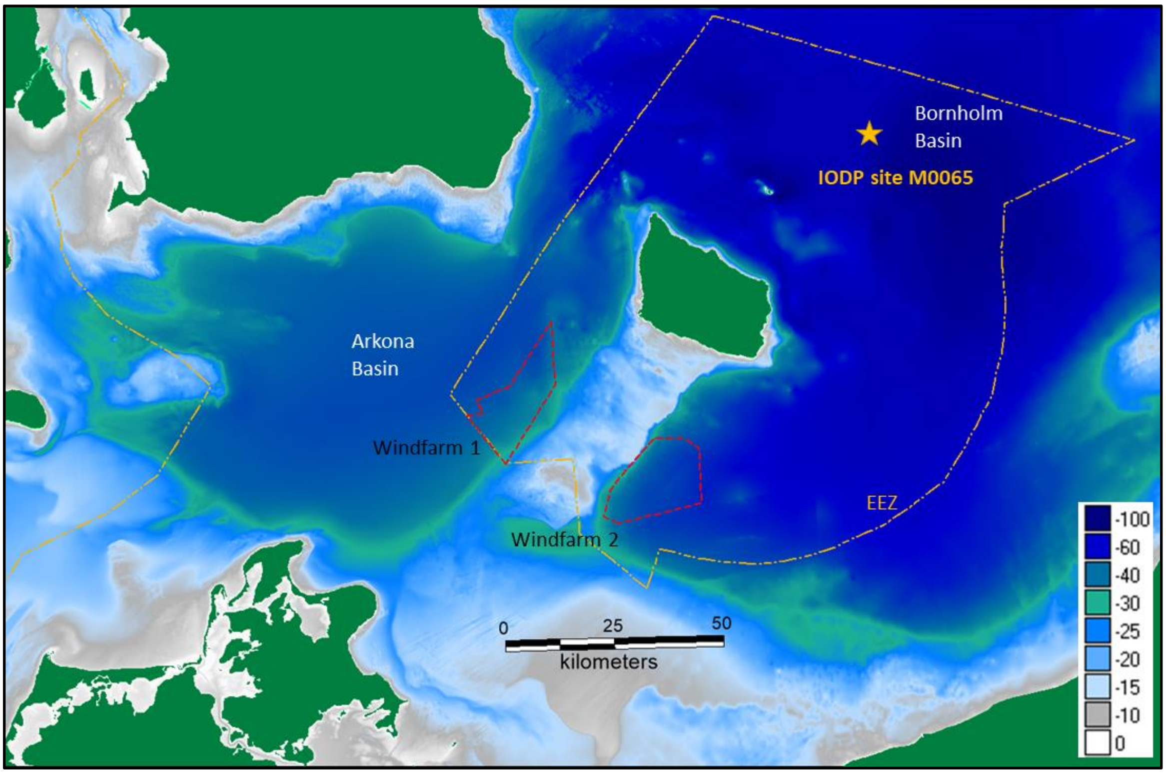


Figure 2.1. Overview map of the southwestern Baltic Sea with location of the Windfarm 1 and 2 study areas (polygons with red dashed lines). IODP site M0065 (yellow star). The yellow lines show the Exclusive Economic Zone. Bornholm Basin and Arkona Basin is indicated.

3. Data background

As a background for the desk study, deep seismic information has been compiled from scientific papers, but the seismic data are available from the GEUS Oil and Gas database (http://data.geus.dk/geusmap/?mapname=oil_and_gas&lang=en#baslay=baseMapDa&optlay=&extent=-741060,5683270,1783060,6766730), while the GEUS Marta database (https://www.geus.dk/produkter-ydelser-og-faciliteter/data-og-kort/marin-raastofdatabase-marta/) is the main supply of shallow seismic data and vibro-core data (Figure 3.1). In addition, available data from IOPD core M0065 have been included.

3.1 GEUS archive shallow seismic data and sediment cores

The Marta database includes available offshore shallow seismic data and core data in digital and analogue format (Figure 3.1). An increasing part of the seismic lines can be downloaded as SGY files from the web portal.

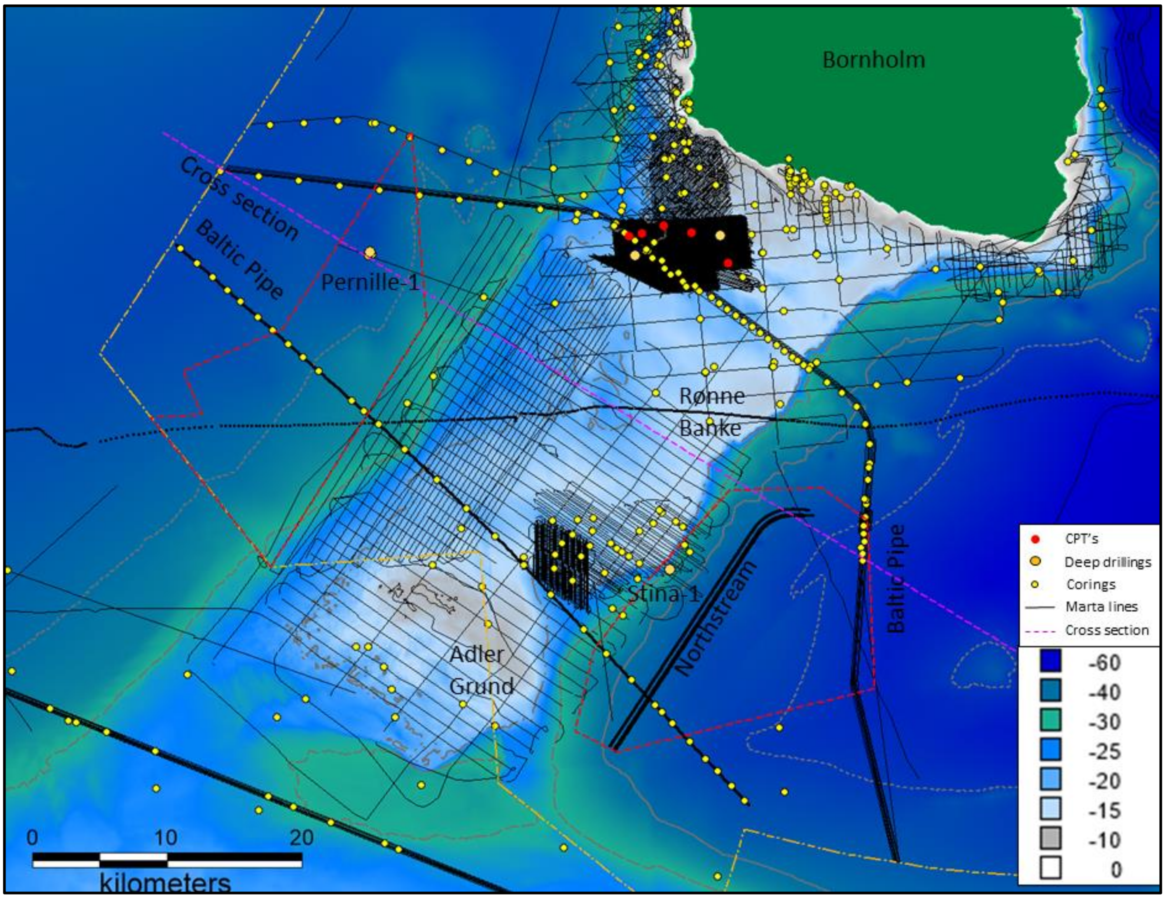


Figure 3.1. Distribution of Marta database seismic grid and core data southwest of Bornholm. The location of the proposed wind farms is indicated by polygons. The bathymetry is from Emodnet.

The existing seismic lines crossing Windfarm 1 and 2 have been collected by the Baltic Pipe and the Northstream projects and consists of side scan, sediment echosounder and boomer data. Multiple turning lines can be observed in the western rim of Windfarm 2. These data have been collected by GEUS in relation to raw material mapping and includes side scan, sediment echosounder and sparker data.

Alle the mentioned data are digital data and can be requested from GEUS for a small administrative fee.

The existing coring's in Windfarm 1 and 2 are all (except Stina-1), vibrocorings with up to 6m penetration. Most of the vibrocores relate to the Baltic Pipe project. Core descriptions are available in the Marta database while no samples have been preserved.

3.2 IODP Site M0065 data types

Important information about the sediment types in the Bornholm Basin can be obtained from the nearby IODP core M0065 (Figure 8.6). Andrén et al. (2015) provided descriptions that can be downloaded from the IODP homepage (Site M0065 (iodp.org)). An overview paper of the drilling results is presented in Appendix A.

Descriptions of the drilling results include:

- Lithostratigraphy
- Biostratigraphy
- Geochemistry
- Physical properties
- Microbiology
- Stratigraphic correlations
- Downhole measurements

4. Pre-Quaternary geology

The south-western Baltic Sea is crossed by the 30-50 km wide WNW-ESE-trending Sorgenfrei–Tornquist Zone that separates the Baltic Shield, the Skagerrak-Kattegat Platform and the East European Precambrian Platform in the northeast from the Danish Basin in the southwest (Figure 4.1). The Sorgenfrei–Tornquist Zone has been active during several phases after the Precambrian. The lineament is characterised by complex extensional and strike-slip faulting and structural inversion (Liboriussen et al. 1987; Mogensen & Korstgård 2003; Erlström & Sivhed 2001). The old crustal weakness zone was repeatedly reactivated during Triassic, Jurassic and Early Cretaceous times with dextral transtensional movements along the major boundary faults.

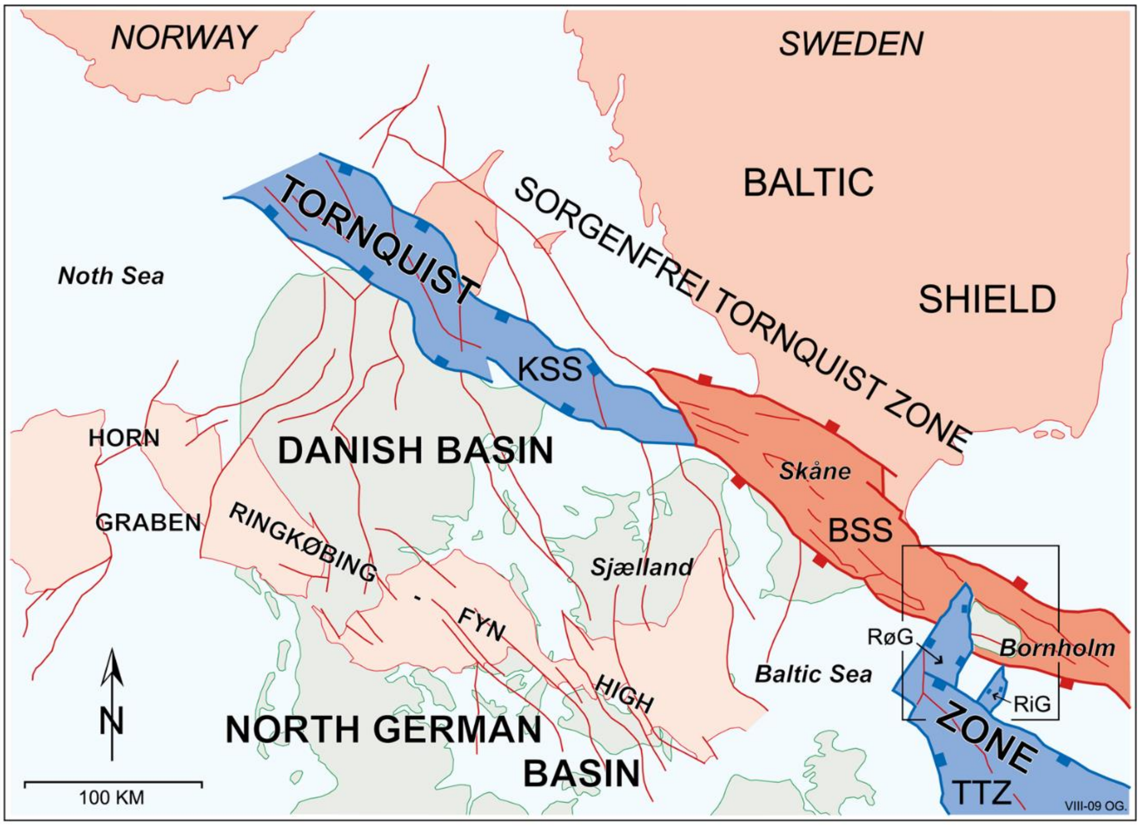


Figure 4.1. Position of the Bornholm area in the Tornquist Zone between the Baltic Shield/East European Platform and the Danish Basin/NW European craton (Graversen 2004, 2009).

In particular, the Rønne Graben (RøG) (Figure 4.2) has been studied in great detail, often in comparative studies along the Tornquist Zone (e.g. Liboriussen et al. 1987). Detailed descriptions were presented by Vejbæk (1985) and Graversen (2004, 2009) of the significant dextral wrench-faulting in the Late Carboniferous – Early Permian strike-slip pull-apart RøG basin, which was later lifted during the Late Cretaceous and early Tertiary regional inversion. The description of the block tectonics is based on deep seismic data and a few wells. In the shallow waters southwest of Bornholm, however, shallow seismic data have been used to describe in detail the inversion structures of the RøG basin (Jensen & Hamann 1989).

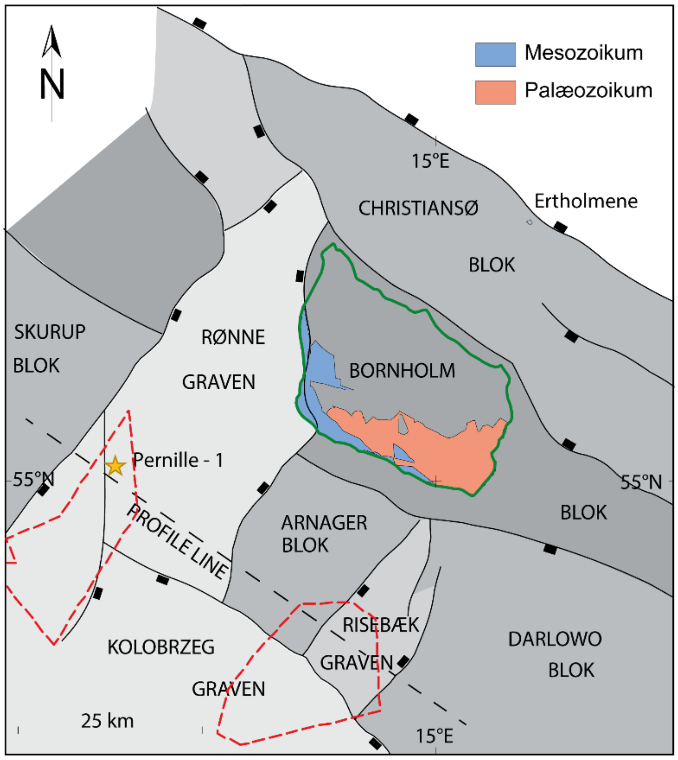


Figure 4.2. Major fault blocks of the Bornholm region. The fault pattern is based on Vejbæk & Britze (1994) and Vejbæk (1997). Profile line of Figure 4.3 is shown.

The tectonic history of the Tornquist Zone dates back to the Early Palaeozoic and repeated tectonic overprint characterizes the complex development of the zone. Changes in the stress field orientations through time resulted in shifting transtensional and transpressional strike-slip movements between the crustal blocks, where reactivation of old basement deep-seated fault zones caused dextral movements along the major boundary faults of the Tornquist Zone (Mogensen & Korstgård 2003).

In the Bornholm region, the RøG and the Bornholm Basin represent sedimentary basins, whereas Bornholm acts as a rigid diamond shaped block in the Tornquist Zone around which deformation was focused (Deeks & Thomas 2012).

Late Carboniferous – Early Permian large-scale intraplate tension resulted in dextral strike-slip faulting along the Tornquist Zone. The right stepping release step-over (Wu et al. 2009) resulted in the development of the NE–SW-orientated RøG pull-apart basin (Figure 4.2 and Figure 4.3) between opposing normal faults.

Expansion of the basins continued through the Triassic, Jurassic and Early Cretaceous (Vejbæk et al. 1994).

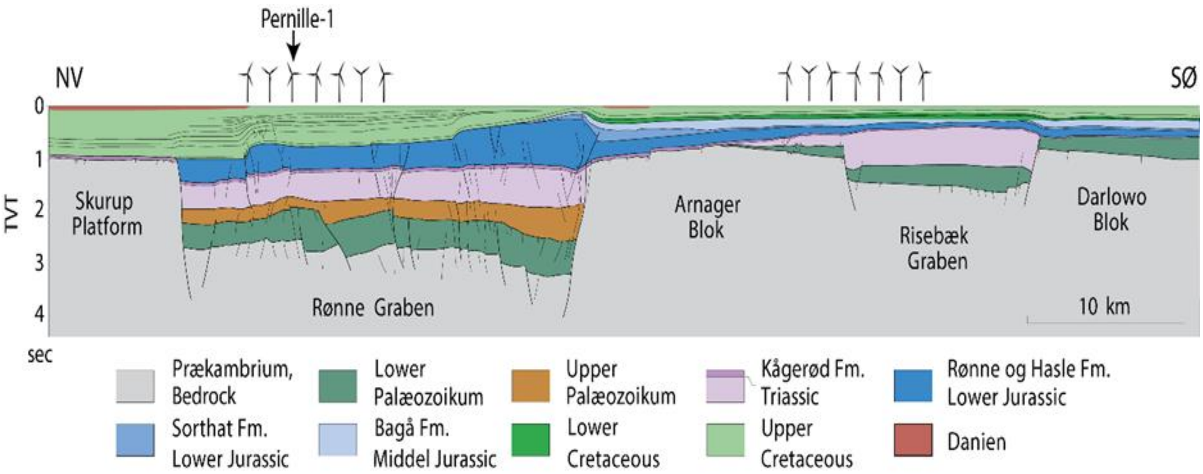


Figure 4.3. Cross section of the Sorgenfrei–Tornquist zone in the middle of the Bornholm OWFs (Mogensen & Korstgård 2003). The location of the section is indicated on Figure 4.2 and Figure 4.4

The following Late Cretaceous inversion phase that was associated with intraplate thrusting in central Europe (Kley & Voigt 2008) resulted in transpressional strike-slip tectonics along the Tornquist Zone during the Late Cretaceous and early Tertiary (Ziegler 1990). The Bornholm region was strongly affected by inversion tectonism caused by compressional strikeslip movements. This resulted in reverse faulting, uplift and erosion of former basin areas as described by Graversen (2004, 2009). The Rønne Graben is a key example of basin inversion (Figure 4.2, Figure 4.3 and Figure 4.4), with reactivation of faults and development of anticline flexure folds. Detailed studies of the near-surface part of the Rønne Graben (Jensen & Hamann 1989) revealed the presence of a number of en-echelon reverse faults approximately perpendicular to the main north–south reverse faults. The main fault can be classified as a dextral wrench fault with a reverse component. The presence of anticlinal flexural folds adjacent to the main fault requires a compressive component to the fault, which indicates that the system involved compressive dextral strike-slip movement.

The resulting present distribution of pre-Quaternary deposits in domino-shaped blocks and basins as a major puzzle of different ages is illustrated in Figure 4.4.

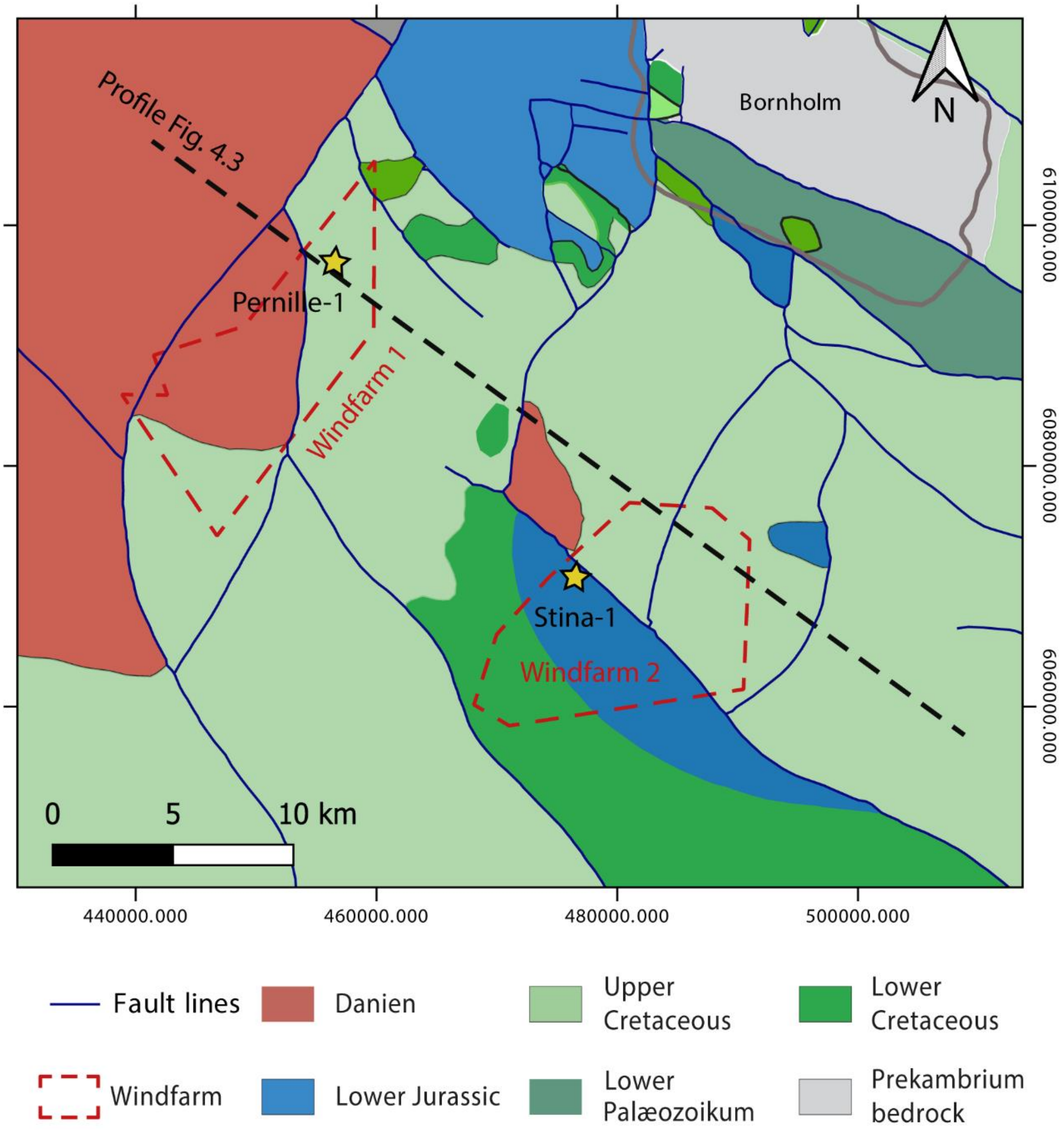


Figure 4.4. Major faults and pre-Quaternary stratigraphic units southwest of Bornholm. The stars indicate deep wells.

5. Earthquakes

Records of recent earthquake activity along the Fennoscandian Border Zone and the relationship to recent geological motion shows that the border zone is still an active zone (Gregersen et al. 1996). However, only few earthquakes have been recorded in the south-western Baltic Sea (Figure 5.1 Earthquake activity in southern Scandinavia (Gregersen & Voss 2014). The red dots show modern well-located earthquakes of the last 75 years, and green dots show the most important relatively larger earthquakes in 1759, 1841, 1904, 1985, 2004, 2008 and 2010. Danish observations of earthquakes through hundreds of years show no signs of greater earthquakes in the Sorgenfrei – Tornquist Zone than outside. The only exception to this is an area in the Kattegat region.

All observed earthquakes in the Danish and the Swedish part of the Sorgenfrei – Tornquist Zone are small and harmless, and only few can be felt by humans. It happens however, at yearly intervals. It is important to emphasize that the noticeable earthquakes occur more often outside the Sorgenfrei – Tornquist Zone than in the zone itself.

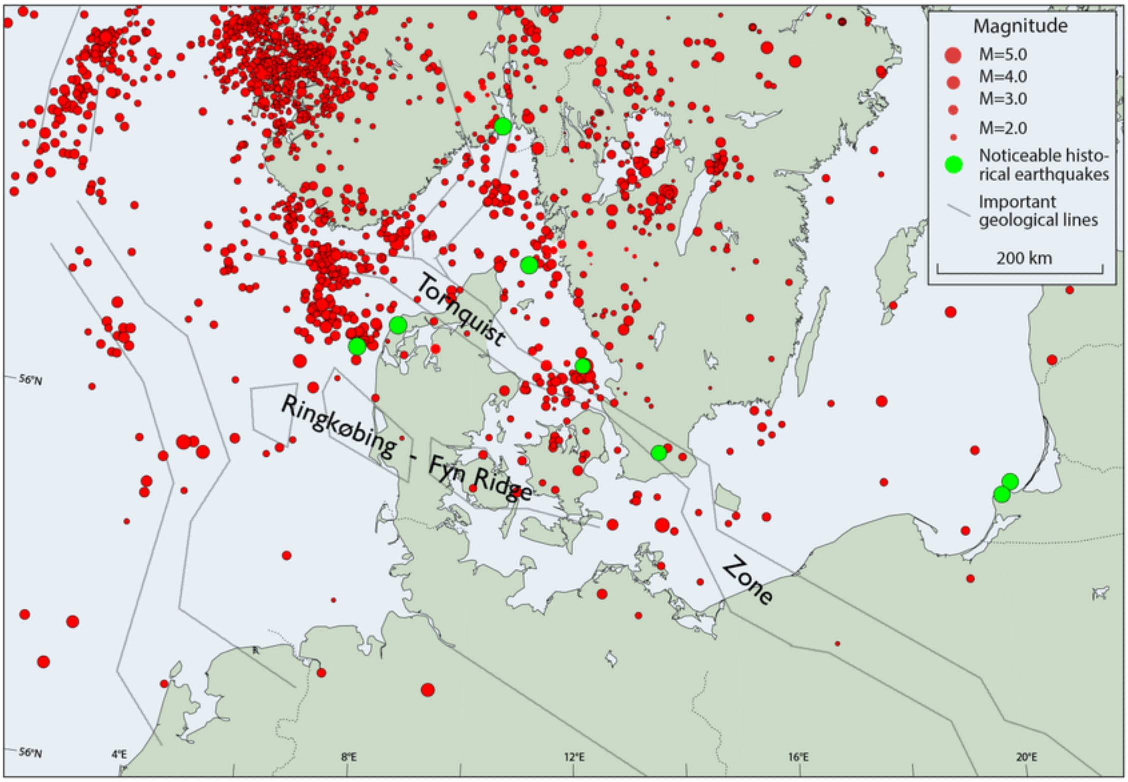


Figure 5.1 Earthquake activity in southern Scandinavia (Gregersen & Voss 2014). The red dots show modern well-located earthquakes of the last 75 years, and green dots show the most important relatively larger earthquakes in 1759, 1841, 1904, 1985, 2004, 2008 and 2010.

6. Pre-Quaternary surface

The general geological development of the study area has resulted in a characteristic pre-Quaternary morphology (Binzer & Stockmarr (1994; Figure 6.1). The major faults reflect the transtensional motions within the fault blocks.

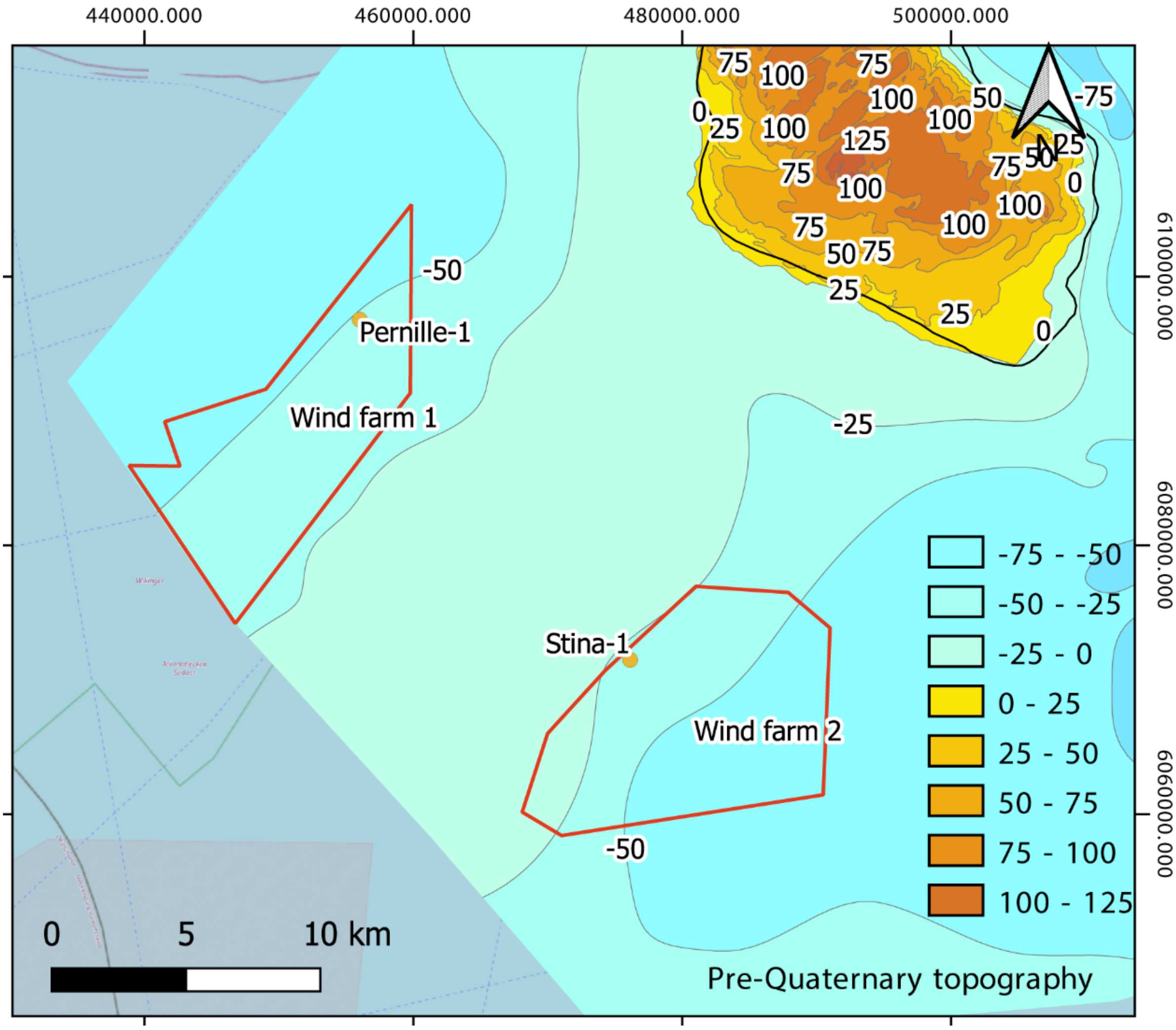


Figure 6.1. Pre-Qaternary morphology (Binzer & Stockmarr 1994). The location of the Bornholm OWFs is indicated.

In a combined presentation of present bathymetry, major faults, and pre-Quaternary morphology (Figure 6.1 and Figure 6.2Figure 6.2) the close relationship between the wrench system faults and the depocenters is obvious. It is seen that the Bornholm OWFs crosses deep faults and pull-apart basin depocenter in the northern parts of the wind farms influenced by the Late Cretaceous and early Tertiary compressive dextral strike-slip inversion. The combined present bathymetry and pre-Quaternary surface morphology shows that only a thin Quaternary top unit of a few metres to about 30 m thickness can be expected. The seabed sediment map in Figure 11.2 shows that large areas expose pre-Quaternary sediments at the seabed.

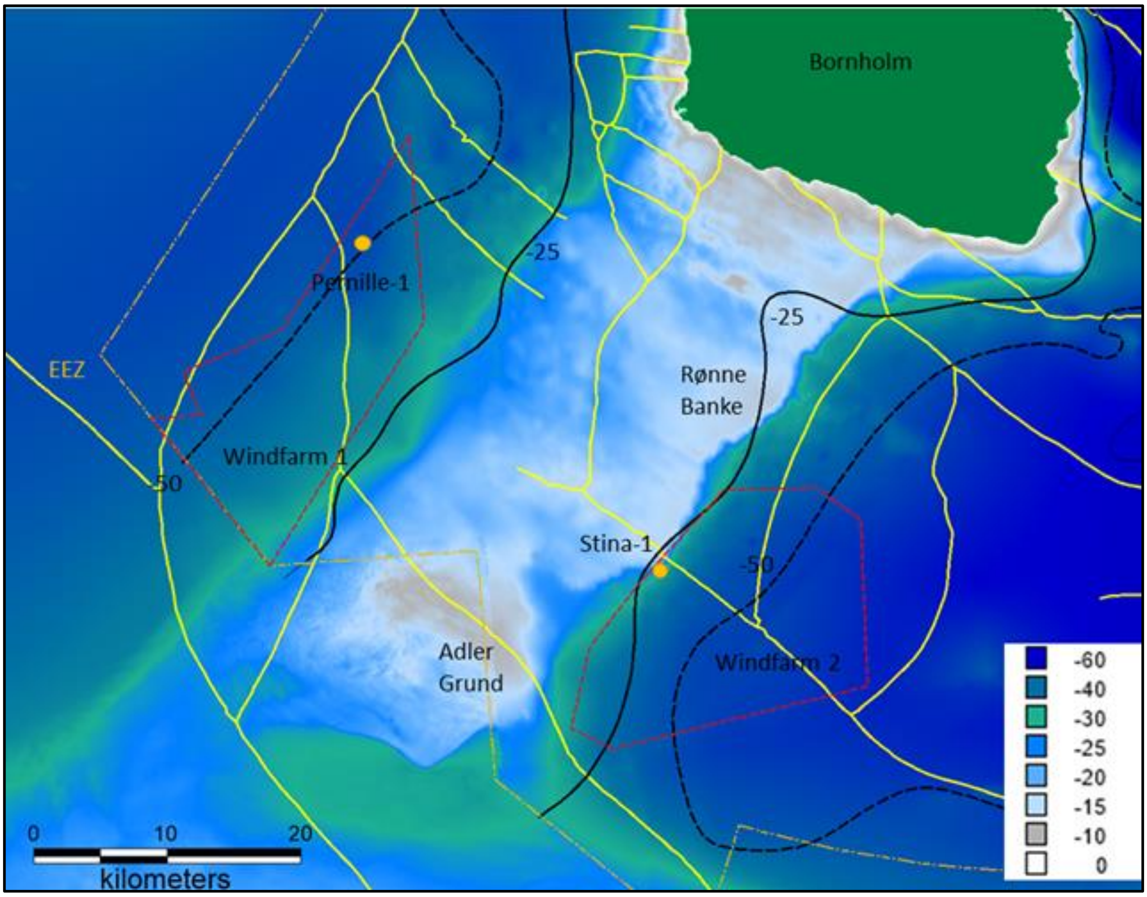


Figure 6.2. Present bathymetry, major faults (yellow lines) and Pre-Quaternary surface morphology curves -25 m and -50 m. The locations of the Bornholm OWFs are indicated.

7. Deep wells

Two deep wells, Pernille-1 and Stina-1 have been drilled in the windfarm areas.

- Pernille-1 is located in Windfarm 1, in the Rønne Graben (Figure 4.2). It mainly penetrated Mesozoic deposits (Figure 4.3 and Figure 4.4). Below about 16 m of Quaternary sandy to silty clay, the Pernille-1 well penetrated about 800 m of limestone from the Upper Cretaceous Chalk Group and Lower Jurassic Hasle and Rønne Formations sandstone, siltstone, mudstone and coal (Figure 7.1).

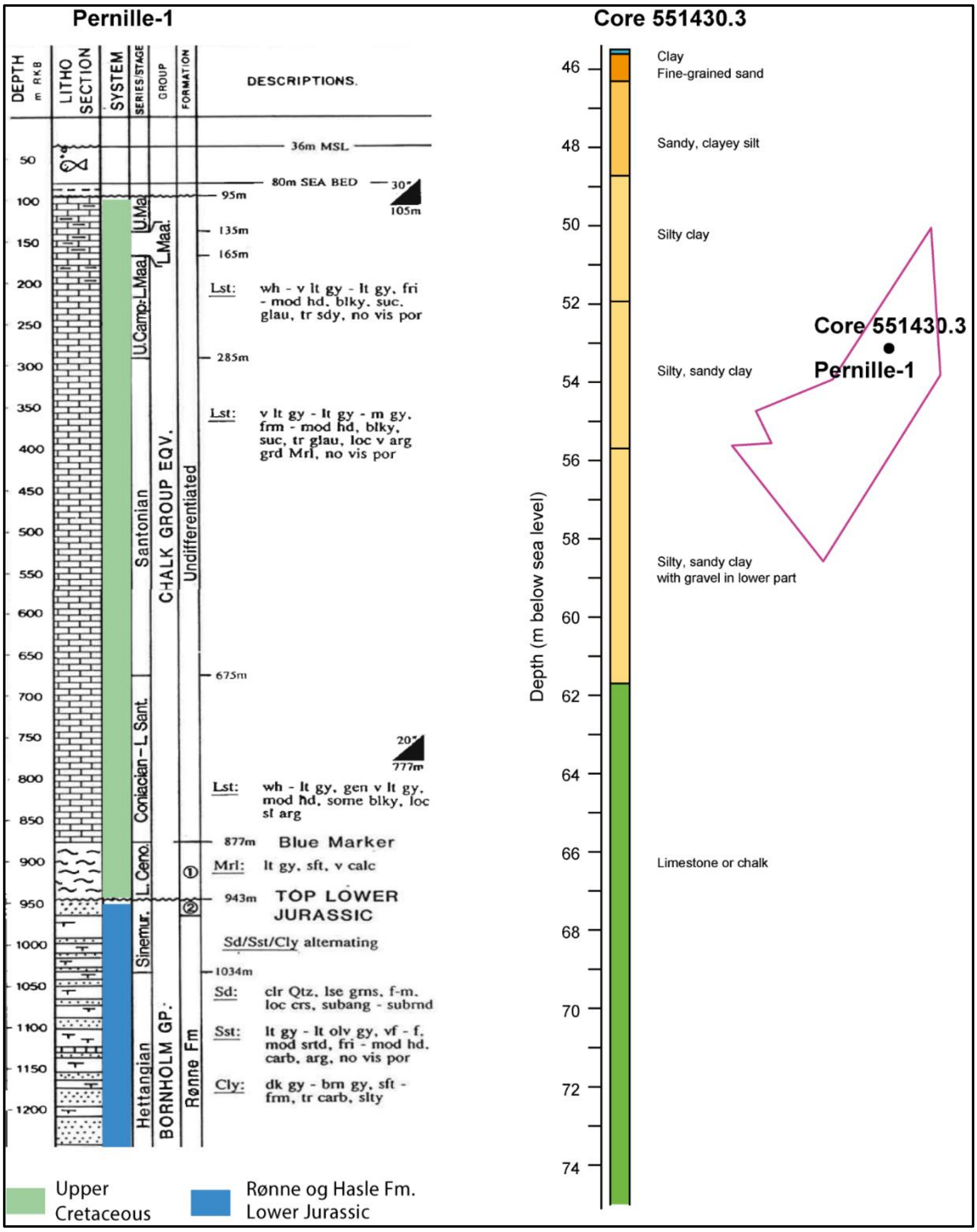


Figure 7.1. Lithological logs of deep well Pernille-1 (log report Appendix B) and a shallower core 551430.3 from the same position.

- The Stina-1 well was drilled on an inversion anticline, where a Jurassic package is identified directly below about 60 m of Quaternary sediments. The about 500 m of Jurassic sediments is interpreted as the Sorthat Formation on top of Hasle Formation and Rønne Formation in a succession of sandstones, siltstones, mudstones, and coals. Thick units of Triassic sediments are located below (Figure 7.2).

The stratigraphy of the wells was described by Graversen (2004) and log reports are attached as Appendix B and C.

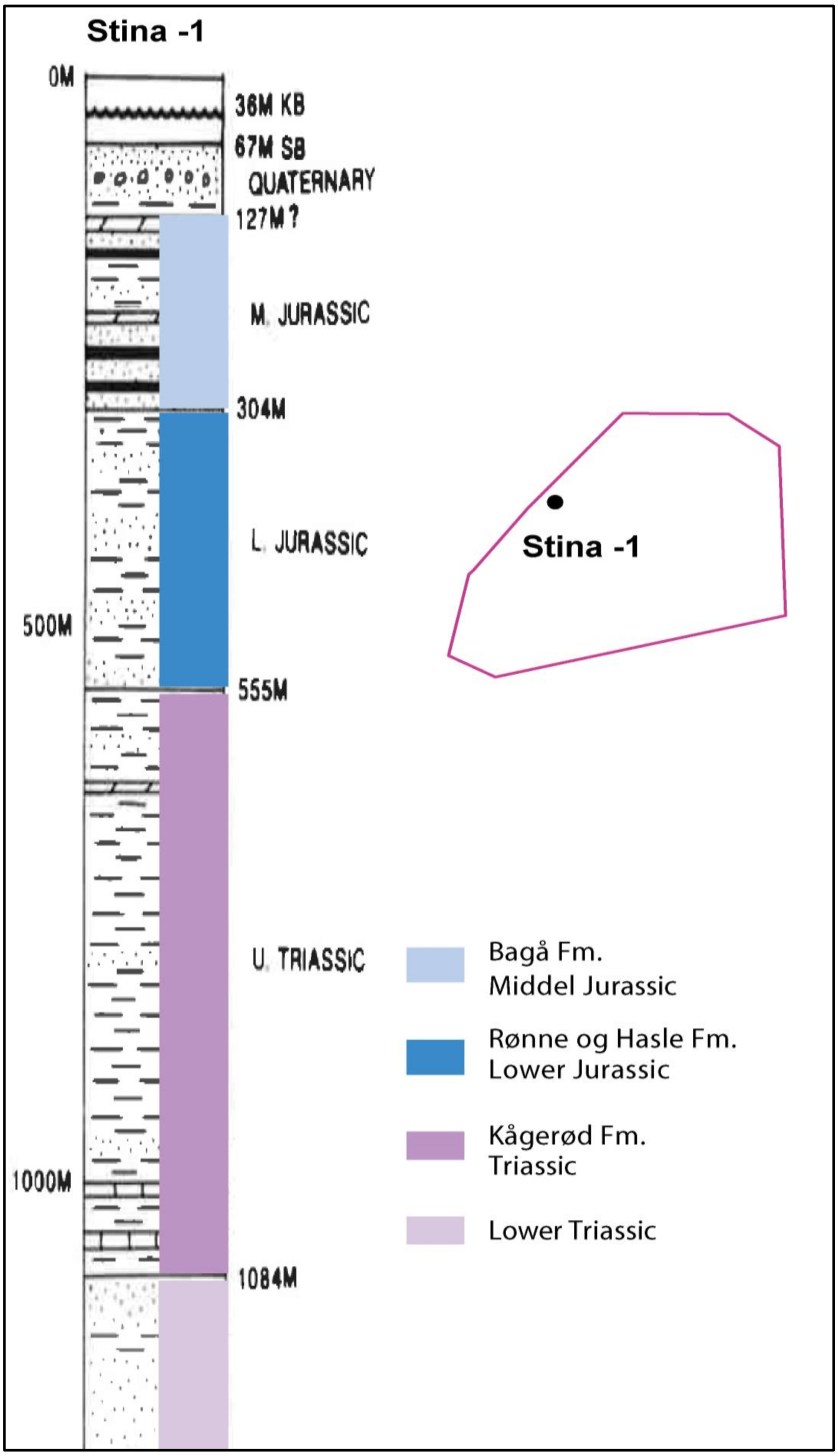


Figure 7.2. Lithological log of the deep well Stina-1 (log report Appendix C).

8. Quaternary geology of the Bornholm region

Four Late Saalian to Late Weichselian glacial events, each separated by periods of interglacial or interstadial marine or glaciolacustrine conditions, have been identified in the southwestern Baltic region. The thickness of Quaternary sediments in the region can exceed 100 m in the basins (Jensen et al. 2017). The Scandinavian Ice Sheet reached its maximum extent in Denmark about 22000 years BP followed by stepwise retreat.

The Bornholm region was probably deglaciated shortly after 15000 years BP. Moraine ridges on Rønne Banke and Adler Grund trending parallel to the former ice margin resemble ridges reported southeast of Møn (Jensen 1993). They may mark short-lived re-advances during the winter, formed during the general retreat of the ice margin. After the deglaciation, a glaciolacustrine environment, the Baltic Ice Lake, was established with ice bergs (Figure 8.1).

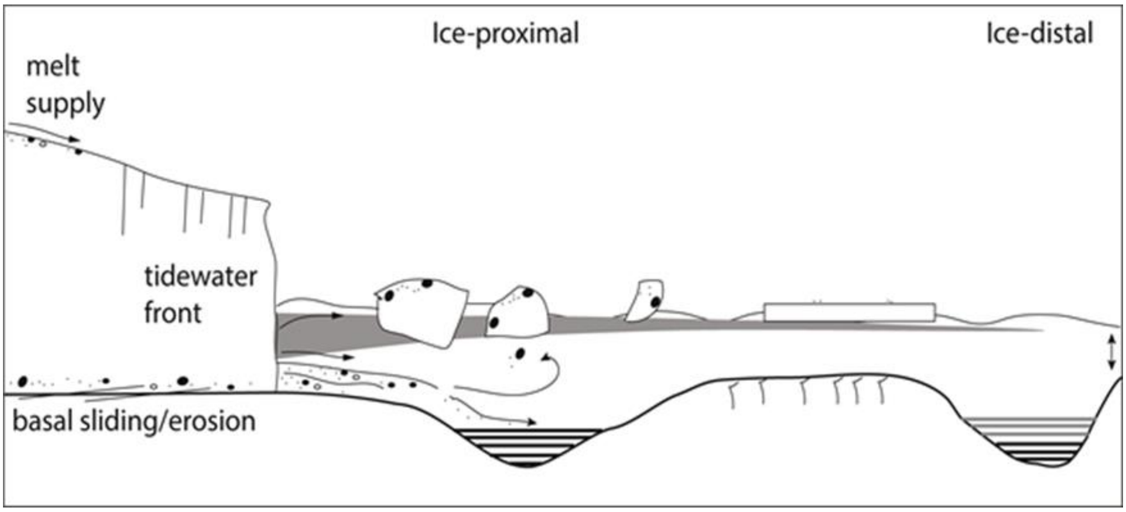


Figure 8.1. Illustration of a glaciolacustrine depositional environment.

Quaternary sedimentation in the Arkona and Bornholm Basins, has been intensively studied in relation to the development of the Late- and Postglacial Baltic Sea phases, because of the well-preserved Baltic Ice Lake clay and the Yoldia Sea and Ancylus Lake clay as well as the brackish to marine Littorina Sea clay and mud deposits. The Holocene history was documented by Andrén et al. (2000).

8.1 The geological model

The Quaternary geological model for the region, builds on a network of seismic data recovered during the last few decades, mainly in connection with the EU BONUS project: Baltic Gas. A seismic stratigraphy was developed, and core positions were selected and followed by an Integrated Ocean Drilling Program (IODP 347).

At Expedition 347 in October 2013, cores were recovered at Site M0065 (Figure 8.3, Figure 8.4, Figure 8.5 and Figure 8.6) in the Bornholm Basin, with an average site recovery of 99%. The water depth at the coring site was 84.3 m, with a tidal range of <10 cm. A total depth of

73.9 m b.s.f. was reached, at that depth bedrock was encountered. Piston coring was used to recover the clay lithologies before switching to a combination of open holing and hammer sampling to maximize recovery in the sandier lithologies. No samples were recovered from the lower part and only the upper 49.2 m could be described.

The obtained sediment sequence was divided into three lithostratigraphical units (Andrén et al. 2015). Description of lithology and downhole core logging was performed with physical parametres illustrated in Figure 8.6.

A combined geological model based on seismic data and core data was established by Jensen et al. (2017) and will briefly be presented in the following sections.

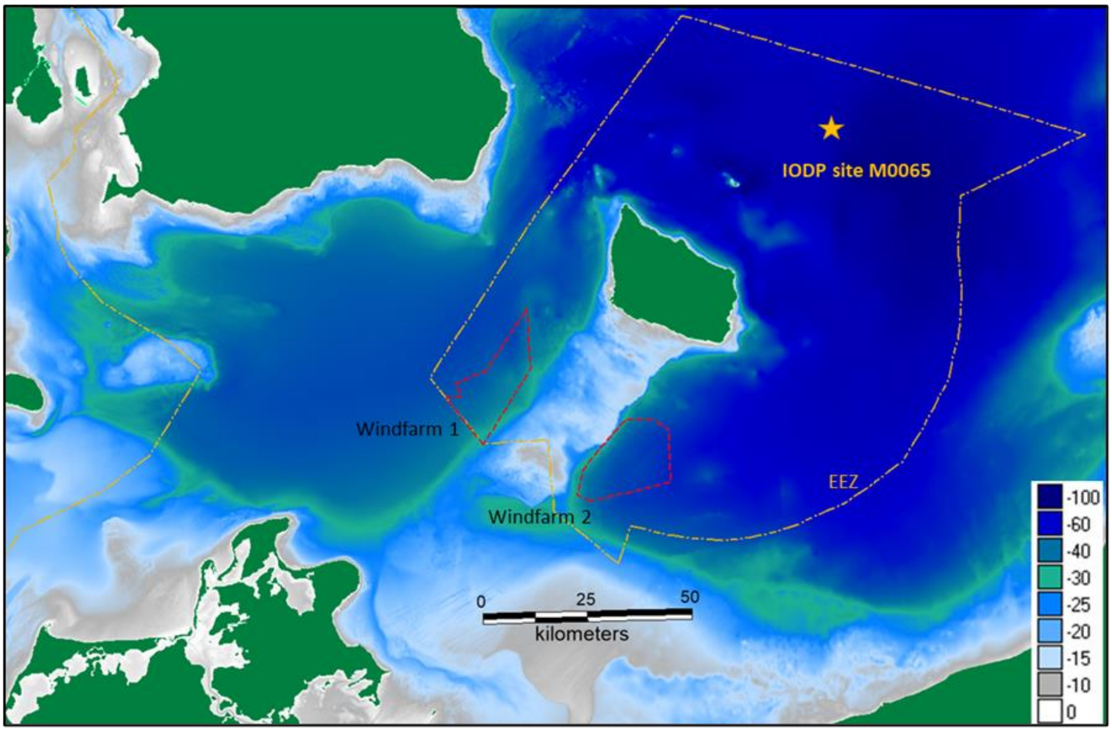


Figure 8.2. Map of the southwestern Baltic Sea with location of IODP sire M0065 (yellow star) in relation to the Windfarm 1 and 2 study areas (polygons with red dashed lines). EEZ yellow lines.

Six seismic units were described all separated by unconformities (Figure 8.3).

The Crystalline basement and Sedimentary bedrock Unit V as well as the Glacial Unit IV were mainly identified on deeper seismic airgun data, whereas details of the late- and postglacial softer deposits are best seen on the sediment echo-sounder profiles (Figure 8.4).

The late- and postglacial Units III–I were deposited in basins with a changing shore level, well known in the southwestern Baltic Sea (Figure 8.3) (Uscinowicz 2006) and a close match can be expected between shore-level lowstands and allostratigraphical unconformities.

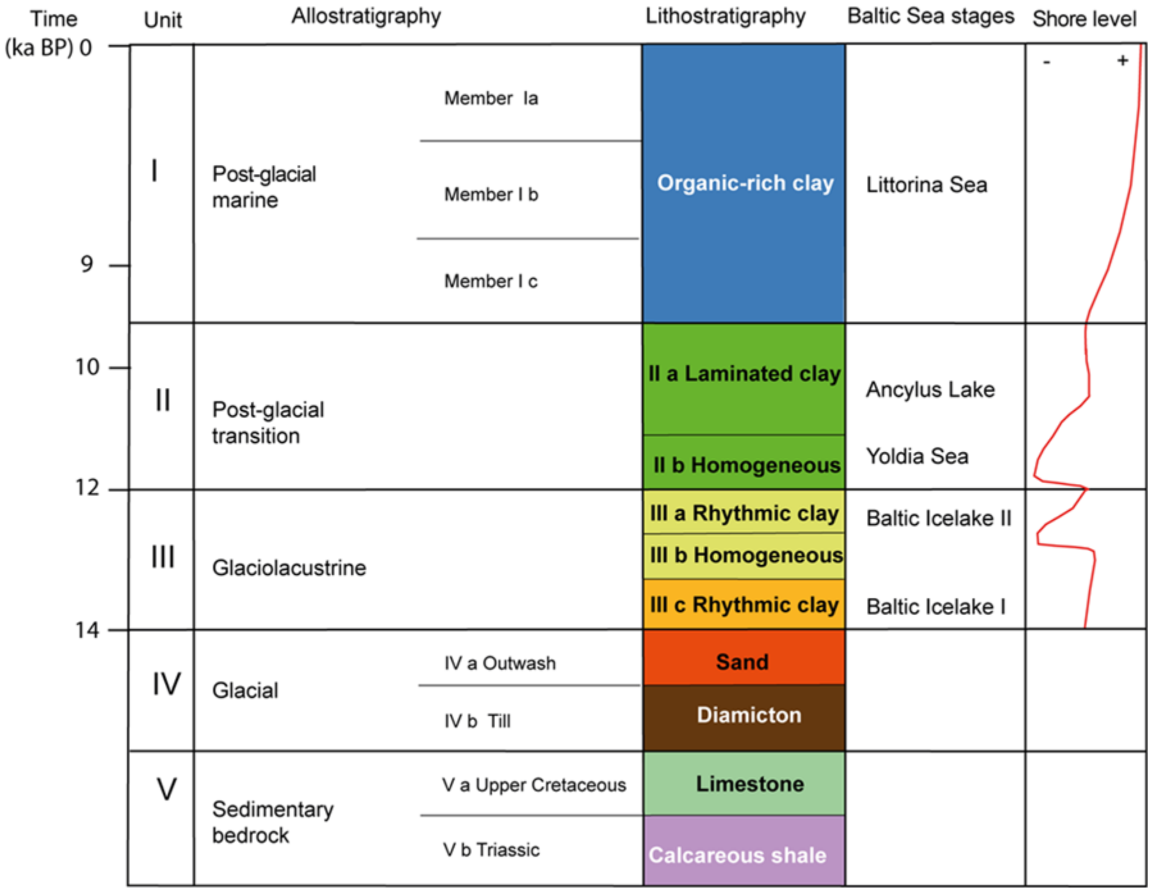


Figure 8.3. Stratigraphical subdivision of the Bornholm Basin (Jensen et al. 2017). The seismic Units I–VI represent allostratigraphical formations, some of which are divided into members, all bounded by unconformities. Mappable lithostratigraphical formations (informal) are identified within the allostratigraphical framework and Baltic Sea stages as well as the general Baltic Sea shore-level changes are correlated with the established allostratigraphy.

8.1.1 Unit IV Glacial deposits

The glacial deposits drape the pre-Quaternary irregular surface. Unit IV is usually 10–20 m thick, but in the Christiansø Ridge zone, crystalline basement rocks are sometimes found at the seabed, whereas the unit is more than 50 m thick in the strike-slip fault basins. The upper reflector is an irregular unconformity, and the internal configuration is mostly chaotic except in some of the strike-slip fault basins, where internal unconformities exist. The glacial deposits consist of diamicton and glacial outwash sediments, as documented in the IODP 347 sites (Figure 8.4) and Andrén (2014).

The distribution of glacial sediment facies is in general chaotic with alternating sections of clast-rich muddy diamicton and parallel-bedded, medium grained sand with cm to dm-scale laminated silt and clay interbeds as seen in IODP site 66. However, IODP site 65 is in a strike-slip fault basin, where there is a clear subdivision into a lower diamicton member (IVb) and an upper outwash member (IIIa), separated by an unconformity.

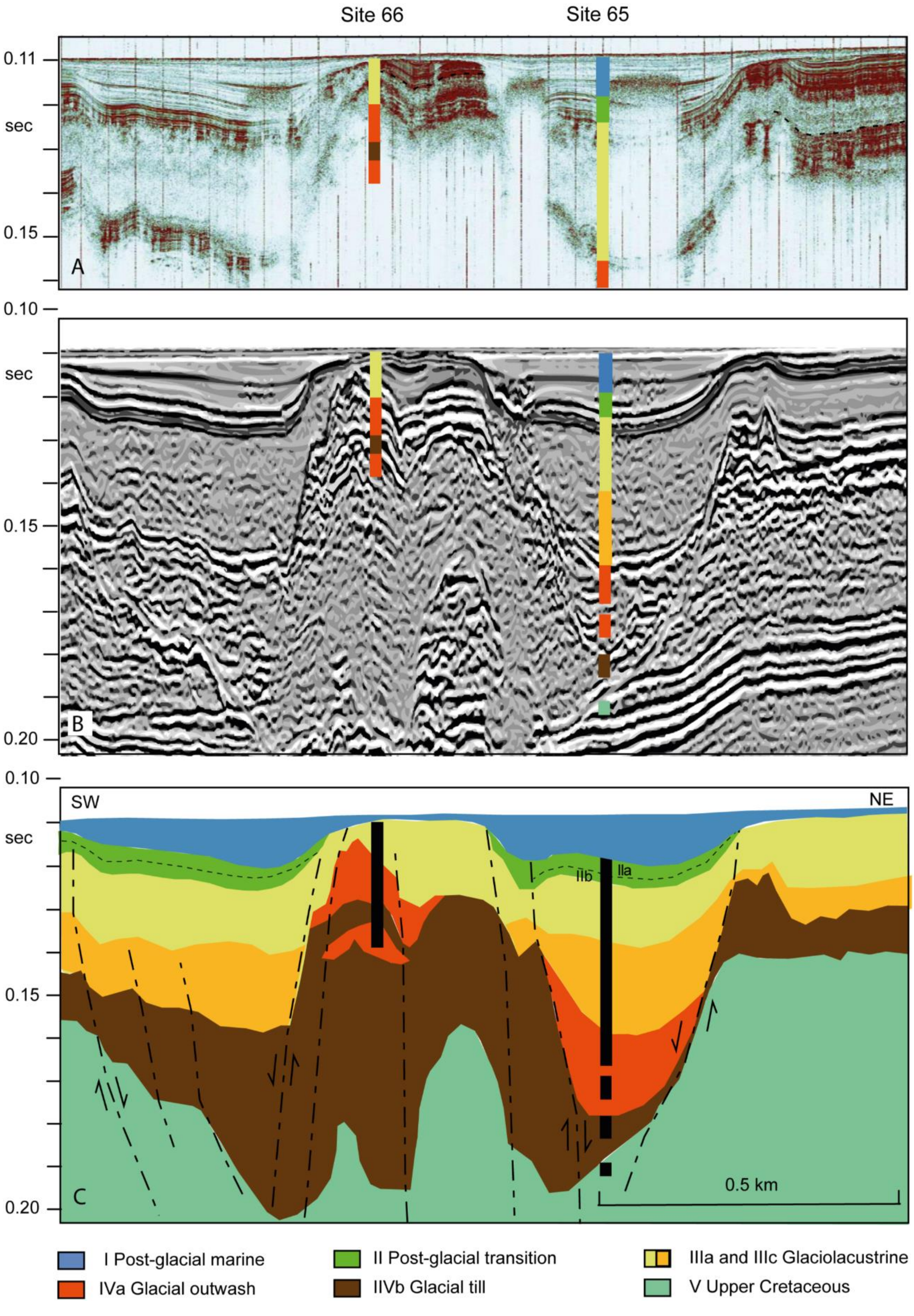


Figure 8.4. Seismic Line across Site M0065 (Jensen et al.2017). Original interpretation of the seismic transect: Airgun (A) and Atlas parasound (B) data (Andrén 2014), as well as sediment documentation for sites 65 and 66. The interpretation (C) follows the classification in seismic units described in Figure 8.3. The location of the IODP sites is shown in Figure 8.2.

8.1.2 Unit III Late glacial glaciolacustrine deposits

The glaciolacustrine sediments cover the irregular unconformity of the glacial deposits in the Bornholm Basin, except in the topographically high Christiansø Ridge area, where Unit IV is truncated or absent, indicating erosion. In the basin areas, a strong upper reflector marks the top of the glaciolacustrine deposits, which in general drape the underlying topography with a thickness of 10–20 m. An increased thickness of more than 50 m is found in the minor strike slip fault basins (Figure 8.4). The internal reflection configuration also varies through the basin.

Unit III is sub-divided into three subunits:

- IIIc is the lowest unit characterized by greyish brown clay with weak lamination by colour and few silt laminae in mm scale, large intervals dominated by massive to contorted appearance; numerous interspersed, grey clay/silt intraclasts of mm to cm scale, very well sorted.
  Unit IIIc corresponds to Baltic Ice Lake deposited in front of the retreating Weichselian glacier and represents an early stable phase of the glaciolacustrine environment. The parallel reflectors and rhythmically layered clay, seen all over the Bornholm Basin, are interpreted as varved glaciolacustrine clay. The upward decrease in grain size from silty clay to clay and the decreasing frequency of sand laminations indicate that the ice front became more and more distal to the Bornholm Basin.

- IIIb unit consists of dark grey, homogenous clay. It is a basin-wide intermediate zone consisting of homogeneous clay that can be related to the first Baltic Ice Lake drainage that occurred during the late Allerød (Figure 8.5). This drainage led to a 10-m drop in water level and to the formation of unconformities in the shallow parts of the south-western Baltic Sea (Jensen et al. 1997; Bennike & Jensen 1998, 2013; Uscinowicz 2006). The relatively deep Bornholm Basin was covered by water even after this drainage event and the unconformity seen in shallow areas is replaced by a basin correlative conformity. However, the water level drop in the Bornholm Basin is reflected in the changes in internal reflector configurations and the lithological shift to homogeneous clay.

- IIIa is the upper unit and consist of greyish brown, silty clay with parallel lamination, downwards coarsening to fine- to medium-grained sand with laminated silt; lowermost few metres massive, medium-grained sand with few dispersed pebbles, detrital carbonate in all grain sizes up to fine gravel. The indistinct lamination in formation IIIa, combined with homogeneous and contorted sedimentary structures as well as clay intraclasts may indicate slumping in an unstable sloping environment with high sedimentation rates. This could be due to piano key neotectonics (Eyles & McCabe 1989) that led to reactivation of minor, along-basin, strike-slip faults.

The sediments in unit III are barren of diatoms, foraminifers or ostracods and the depositional environment is interpreted as a glacio-lacustrine environment. The sandy sediments in the lowermost part of the retrieved succession represents a proximal glacio-lacustrine environment.

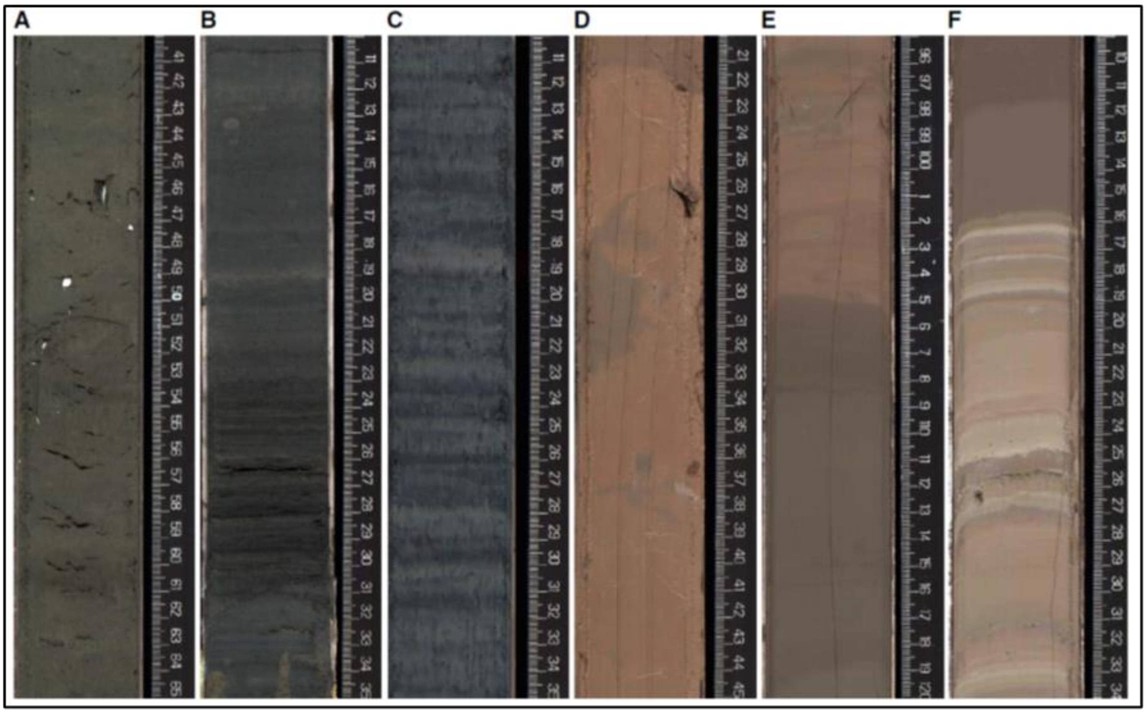


*Figure 8.5. Examples of lithostratigraphic units, Hole M0065A. A. Unit I. B. Unit I. C. Unit II. D. Subunit III*c. *E. Subunit IIIb. F. Subunit III*a.

8.1.3 Unit II Early postglacial transition clay

Unit II conformably drapes the glaciolacustrine sediments in the Bornholm Basin with a rather constant thickness of about 4 m. The seismic characteristics of Unit II are closely spaced parallel reflectors with upward decreasing amplitude. A strong reflector is seen at the upper boundary. In the minor strike-slip fault basins, local thickening of the unit, on-lapping and erosional truncation is observed. This is probably due to synsedimentary down-faulting of the basins and relative uplift of the margin (Figure 8.4).

At IODP site 65, which is in one of the minor strike-slip fault basins (Figure 8.4), Unit II is 4 m thick and consists of grey to dark grey clay. In the lowermost part (formation IIb) homogeneous brown clay is observed, gradually upwards changing to grey clay with intervals of black spots and specks. The uppermost part of the clay (formation IIa) is laminated by colour with very fine dark grey iron sulphide-rich, 2–3 mm thick lamina. The density of laminae decreases downwards. The basin-wide clay drape indicates accumulation of Unit II in a deep-water basin with only weak bottom currents. Previous studies in the Bornholm Basin (Kögler & Larsen 1979; Andrén et al. 2000b) documented the same lithological sequence; it has been interpreted to represent deposition in the Yoldia Sea (the lowermost homogeneous part) whereas the Ancylus Lake clay (AY) is represented by the uppermost laminated part. Sulphide migration downwards from the upper organic-rich sediments is a likely explanation for the diagenetic iron sulphide enhanced laminations.

8.1.4 Unit I Mid- and late postglacial marine mud

In the central Bornholm Basin, northeast of the Christiansø Ridge, the basin infill of the youngest Unit I have an asymmetrical external wedge shape and the sediment echo-sounder data show complex internal reflection patterns (Figure 8.4). Frequent low amplitude, concave and internal on-lap parallel reflectors dominate the major synsedimentary down-faulting zone. In the minor strike-slip fault basins, we established three allostratigraphical members (Ic, Ib and Ia; Figure 8.3). These members show asymmetrical bundled on-lap infill of the basins and the bundles are bounded by reflectors representing internal unconformities and-correlative conformities.

The complex reflection pattern indicates that late postglacial down-faulting resulted in episodic, synsedimentary deposition in the strike-slip basins and that sub-recent to recent sedimentation is still asymmetrical with sedimentation in the southern central basin and erosion at the north-eastern margin of the basin. Transport of sediments from the Arkona Basin west of Bornholm into the Bornholm Basin and along the southern basin margin is a likely process to have provided sediment deposited as a wedge-shaped contourite.

In IODP 65, Unit I is ~7 m thick (Figure 8.4). The unit consists of well-sorted, dark greenish grey, organic-rich clay with indistinct colour lamination due to moderate bioturbation. The general stratification is overprinted by intervals of black layers with sharp bases. Scattered shell fragments are found down to the lowermost transition zone to Unit II, where about 10 cm of non-bioturbated clay with prominent mm-thick laminae is found. Organic debris is common (possibly algal or plant debris) and large centric diatoms are found. Some silt and sand are also present. The boundary to Unit I is gradual. The organic-rich clay, with bioturbated indistinct lamination and intervals of black layers, indicates more oxic conditions during the mid- and late Holocene in the Bornholm Basin than in the central Gotland Basin. The lowermost laminated transition zone may represent an initial anoxic phase, similar to the anoxic phases reported in the Gotland Deep (e.g., Zillen et al. 2008).

8.1.5 Physical properties

This section summarizes some of the preliminary physical property results from Site M0065. Gamma density was measured at 2 cm intervals (Figure 8.6). Gamma density increases progressively from the core top to the base of lithostratigraphic Subunit IIIb. Gamma density exhibits a shift to higher values in Subunit IIIc and remains generally high (~2 g/cm^3) throughout lithostratigraphic Subunit IIIc.

P-wave velocity was also measured at 2 cm intervals (Figure 8.6). P-wave velocity exhibits low and relatively constant values (~1000 m/s) from the core top to ~18 m b.s.f. Values are higher and highly variable in the middle interval of lithostratigraphic Subunit IIIa (~18–32 m b.s.f.). The lower interval of lithostratigraphic Subunit IIIa, Subunit IIIb, and the upper interval of Subunit IIIc are all characterized by generally more constant values (~1500 m/s). From ~39 mbsf to the bottom of Hole M0065, P-wave velocity values are overall higher (>1600 m/s) than the upper section. However, there is a slight decreasing trend from ~39 to ~43 m b.s.f., where P-wave velocity increases again to the bottom of the hole to a high of ~1800 m/s.

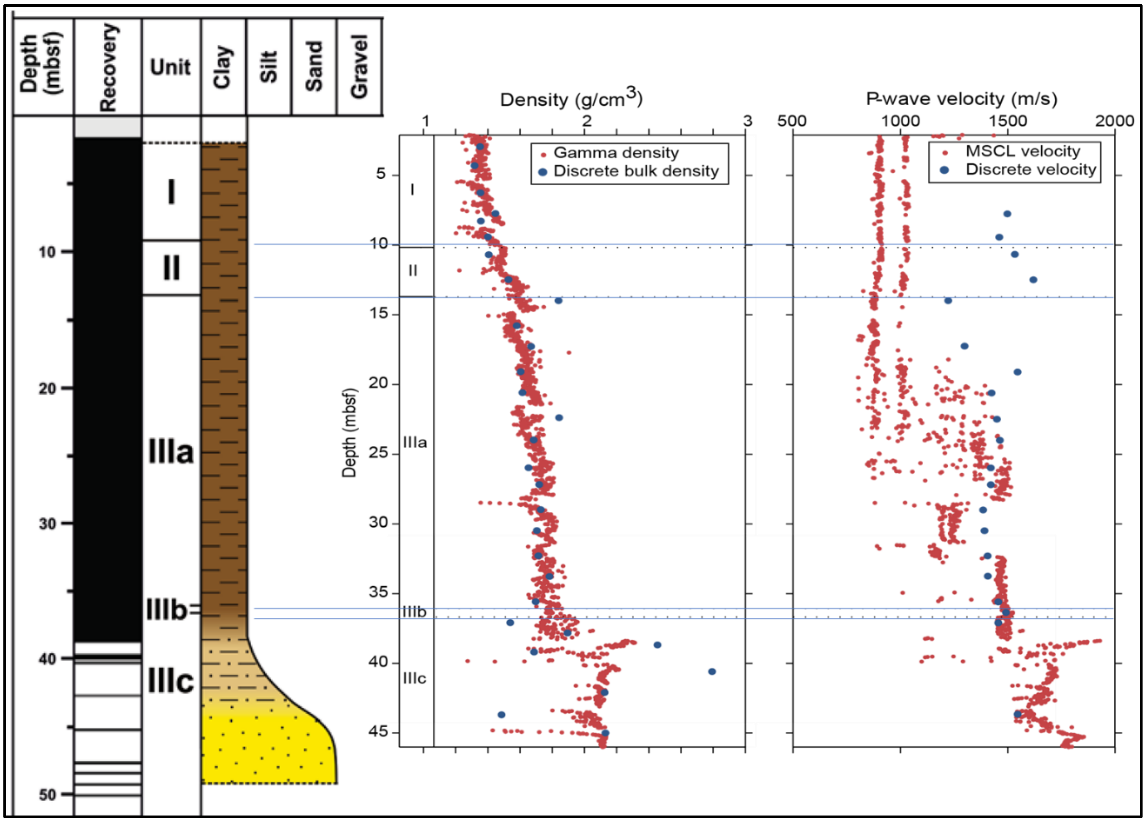


Figure 8.6. IODP Site M0065 core lithology, density and P-wave velocity. For details see Appendix A.

9. Palaeogeography of the deglaciation of Denmark

The Scandinavian Ice Sheet reached its maximum extent in Denmark about 22000 years BP followed by stepwise retreat.

During the general deglaciation, an ice stream re-advance from the Baltic moved westward and reached the East Jylland ice marginal line. The Bornholm region was probably deglaciated shortly after 15000 years BP. Moraine ridges on Rønne Banke and Adler Grund trending parallel to the former ice margin resemble ridges reported southeast of Møn (Jensen 1993). They may mark short-lived re-advances during the winter, formed during the general retreat of the ice margin. After the deglaciation, a glaciolacustrine environment, the Baltic Ice Lake, was established with ice bergs (Figure 8.1).

The knowledge about the general deglaciation and postglacial history of the southwestern Kattegat and the western Baltic can be presented in a series of palaeogeographical maps

Figure 9.1. a and b.

- About 18000 years ago, the deglaciation from the largest glacier extension (Main Stationary line) in Jutland had reached a stage where the ice margin roughly followed the Swedish west coast, the present Zealand northern coastline, extending southward along the western part of the Great Belt and with the distal margin found in the northernmost part of Germany. In this early phase the deglaciated Kattegat region still was not isostatically adjusted and the relative sea-level was high, and the sea covered major parts of northern Jutland.
- At the next stage, about 16000 years ago, the ice margin had retreated to the Øresund region and the western part of Skåne leaving an ice lobe that covered the southern part of Zealand and followed the present southern coastline of the Baltic Sea. The ice margin was directly connected by a broad meltwater channel to the Kattegat marine basin, which at this stage was affected by an initial relative sea-level regression, while local lakes were under development along the ice margin in the south-westernmost Baltic Sea.
- A controversial stage of the deglaciation was reached about 15000 years ago, as the ice marginal retreat had reached central Skåne. For this stage only limited information has so far been available about the present offshore area, but investigations in Polish waters combined with data from German and Danish waters show that the ice margin must have been situated west of Bornholm and a large lake must have been dammed in front of the ice sheet with connection through the Great Belt to the Kattegat, which at that time was increasingly affected by a regression. Apart from meltwater flow from the glacier area west of Bornholm, major meltwater contributions were provided by German and Polish rivers as proved by the existence of major late glacial delta deposits.
- After the initial damming of The Baltic Ice Lake two phases of damming occurred followed by major discharge events. The last and most extensive damming was at its maximum about 12000 years ago, when minor channels drained the lake through the Great Belt and Øresund and only a small land bridge separated the Baltic Ice Lake from the sea in south-central Sweden. Further retreat resulted in a catastrophic discharge event in south-central Sweden and the lake level dropped by about 25 m.

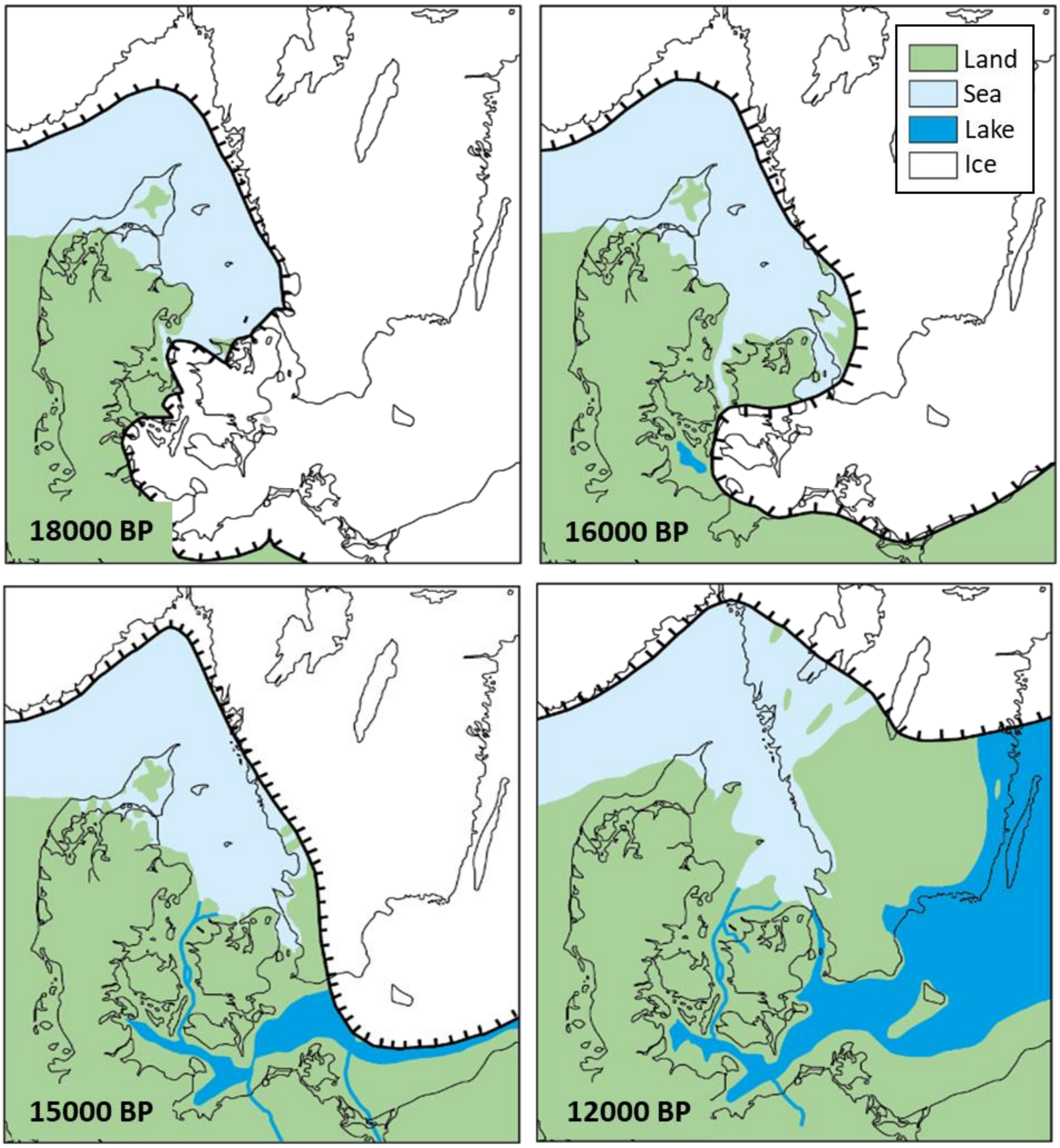
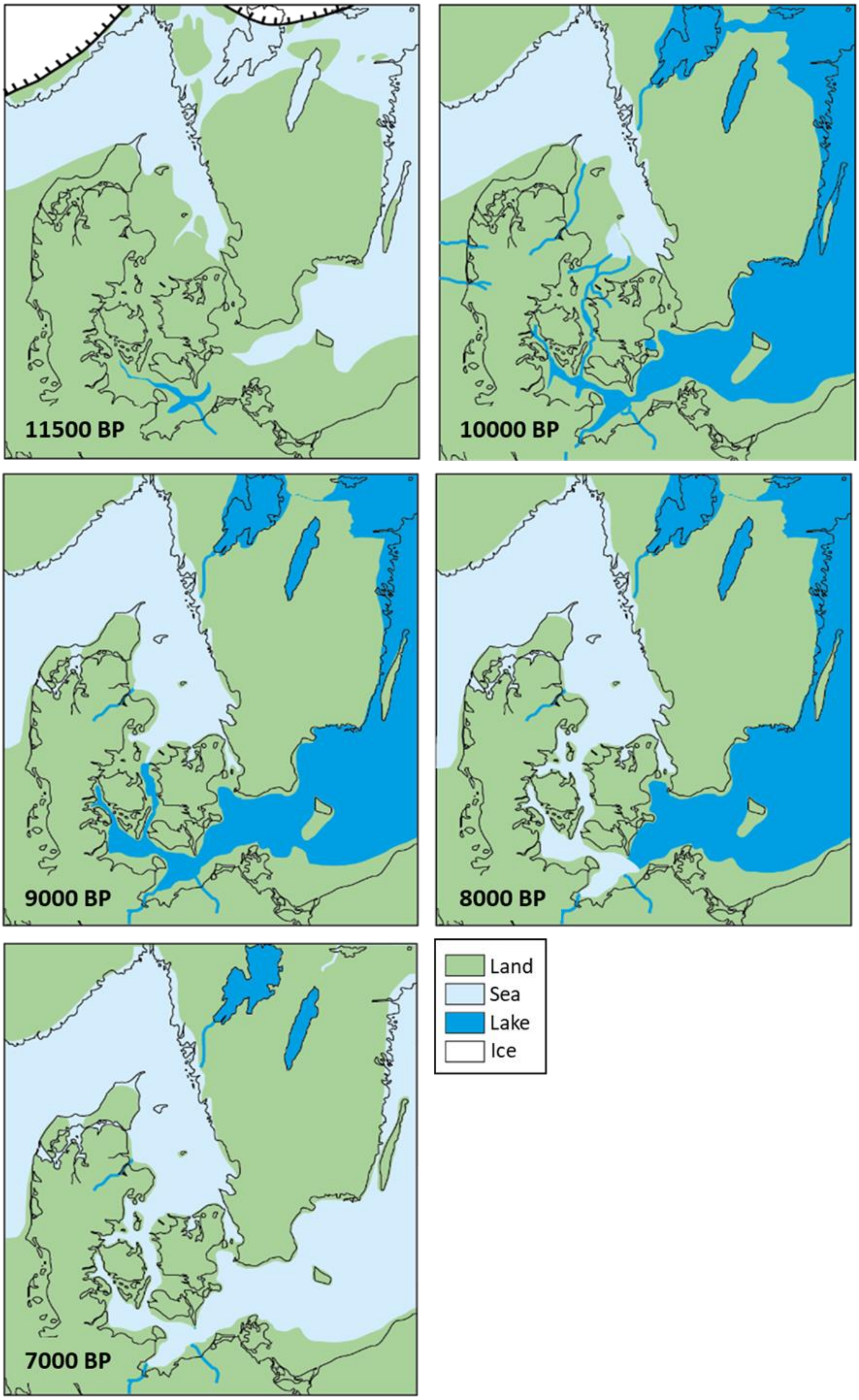


Figure 9.1. a and b. Palaeogeographical maps showing the development of the Danish area from ca. 18000 to ca. 7000 years BP. Modified from Jensen et al. (2002).


11500 BP
10000 BP
9000 BP
8000 BP
7000 BP
Land
Sea
Lake
Ice

- About 11500 years ago a strait was established through south-central Sweden and the Baltic basin was transformed into a marine basin called the Yoldia Sea. This name comes from an arctic bivalve species called *Portlandia (Yoldia) arctica*, which is found in sediments deposited during this time. The postglacial eustatic sea-level rise surpassed the rate of glacio-isostatic rebound in the southern Kattegat and the lowest postglacial relative sea-level was reached about 35 m below present sea-level.
- Continuous glacio-isostatic uplift of south-central Sweden closed the connection to the ocean and the last lake phase of the postglacial Baltic was established, called the Ancylus Lake. The stage is named after a fresh-water gastropod, *Ancylus fluviatilis*, which lives in rivers and in the coastal zone of large lakes. Due to damming, the lake reached a maximum level about 10200 years ago with only a narrow drainage pathway through the Great Belt into the southern Kattegat. Initial transgression had resulted here in the formation of a rather large lagoon - estuary basin, partly blocked by transgressive coastal barriers. Remains of this system are preserved on the sea floor as it is reported by Bennike et al. (2000) and Bendixen et al. (2017).
- About 10000 years ago the Ancylus Lake level dropped about 9 m within few hundred years. The traditional opinion was that the drainage was through the Great Belt. However, investigations in the southern Kattegat, the Great Belt as well as at the thresholds Gedser Reef – Darss Sill, south-east of Langeland and in the south-western Kattegat show that only a small lake level fall in the order of a few metres could be provided by this drainage route. Moreover, for the time of drainage calm lake and estuarine sedimentation is recorded in the Great Belt and south-western Kattegat.
- The calm lake sedimentation was followed by a gradual transgression and change into brackish conditions about 9400 years ago and a fully marine environment was reached in the Great Belt 9100 years ago marking the beginning of the Littorina transgression.
- About 8000 years BP the transgression had reached the Darss Sill – Gedser Reef area.
- And about 7000 years BP also the western part of the Baltic Proper was marine.

10. Late glacial and Holocene fluctuating water levels

During the period after the last deglaciation, the south-western Baltic Sea region was characterised by highly fluctuating water levels (Figure 10.1). Transgressions were interrupted by two abrupt forced regressions, the first at ca. 12800 years BP and the second at ca. 11700 years BP. Prior to these regressions, the Baltic Ice Lake was dammed by glacier ice in south-central Sweden. Following retreat of the Scandinavian Ice Sheet, the dam was broken twice, and the water level dropped by 20-25 metres over a few years. During the early Holocene, during the Yoldia Sea Stage, water level increased rapidly, and water level continued to increase rapidly during the early part of the Ancylus Lake Stage. The rapid increase was followed by a period with relatively stable water level. Water level soon continued to rise, and at ca. 7000 years BP marine waters inundated the region: The Littorina Sea Stage began. During the past 6000 years, the water level has increased a few metres only. The global eustatic sea level rise has surpassed the glacio-isostatic uplift of the region, and fossil shorelines are submerged.

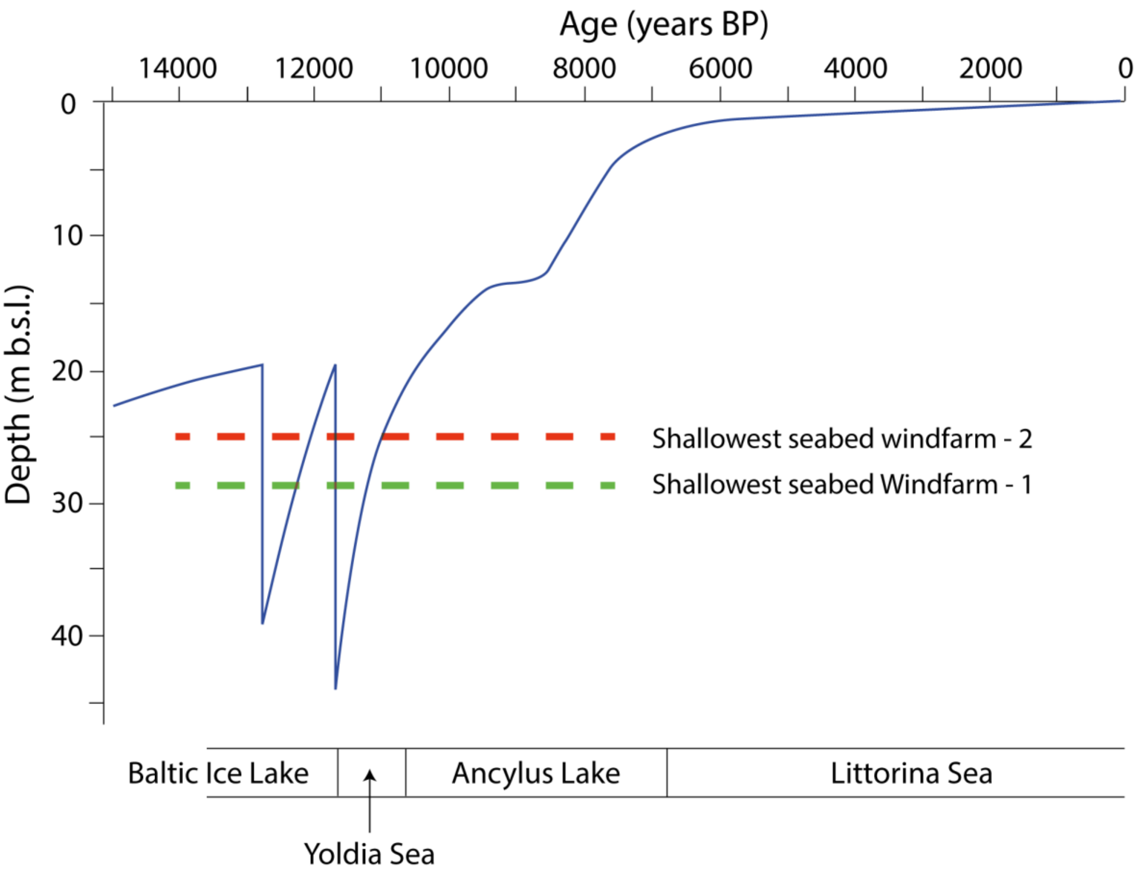


Figure 10.1. Shoreline displacement curve for the south-western Baltic Sea. The curve is based on radiocarbon dating of samples collected from vibrocores (

Table1).

Core	N. lat. °	E. long. °	Laboratory number	Material	Depth (m)	Age (^{14}C years BP) [1]	Cal. age (years BP) [2]
Marine							
7250/26	54.821	12.523	AAR-2647	*Mytilus edulis*	26.3	7090±90	7530
282080	54.845	13.925	KIA-26266	*Mytilus edulis*	46.5	6675±35	7141
526188	54.792	14.554	Ua-4861	*Mytilus edulis*	410	5185±90	5508
526189	54.806	14.50	Ua-4862	*Mytilus edulis*	340	1980±75	1539
Lake deposits							
526187	54.804	14.53	Ua-4859	Land plants	365-380	8050±100	8912
526187	54.804	14.53	Ua-4860	*Pinus sylvestris*	480	9095±140	10261
526189	54.806	14.50	Ua-4863	*Pinus sylvestris, B. Albae*	540	9230±85	10404
200540	54.725	12.766	AAR-2637	*B. nana, S. herbacea*	27.7	12700±110	15132
258000	54.750	13.765	KIA-21680	*Cladium mariscus*	45.2	10980±55	12896
526015-1	54.949	15.362	Ua-57754	*Betula Albae*	44.6	9581±59	10934
526030-4	55.135	14.641	Ua-57755	*Lycopus, Ranunculus*	35.3	9593±51	10938
BP09 ext 11	54.946	14.744	Beta-560826	*Populus tremula*	23.0	9240±30	10407
RAM-05-09	54.942	14.754	Beta-560827	*Cladium, Scirpus*	19.6	8070±30	9002
222810	54.457	15.156	KIA-9342	*Scirpus, Pinus*	35.9	9930±45	11337
222810	54.457	15.156	KIA-9341	*Menyanthes, Phragmites*	34.5	9365±50	10583
222820	54.483	15.172	KIA-9343	*Pinus, Betula Albae*	36.1	9740±55	11177
5775/01	54.913	13.05	AAR-1923	*Cladium mariscus*	44.3	9360±90	10574
258010	54.920	13.151	KIA-21682	*Phragmites*	46.3	7880±50	8522

[1] Radiocarbon ages are reported in conventional radiocarbon years BP (before present = 1950; Stuiver & Polach (1977)).
[2] Calibration to calendar years BP (median probability) is according to the INTCAL20 and MARINE20 data (Reimer *et al.* 2020).

Table 1. Selected radiocarbon ages from the Rønne Banke, Arkona Basin and Bornholm Basin region.

The Bornholm wind farm areas have been submerged most of the time after the last deglaciation, but in the lowstand periods around 12800 and 11700 years BP the shallowest parts were dry land.

11. Details from the windfarm areas

11.1 Bathymetry

To the southwest of Bornholm, a shallow water area with Adler Grund and Rønne Banke separates the Arkona and Bornholm Basins (Figure 11.1). The Water depths on Rønne Banke is about 20 m, and on Adler Grund the shallowest area is about 10 m deep. The maximum water depth in the Bornholm Basin is 92 m and the average depth in the Arkona Basin is 48 m. In the wind farm 1 area the water depth increases towards the northwest, from ca. 35 to ca. 45 m and in the wind farm 2 area the water depth increases towards the south-east, from ca. 30 m to ca. 50 m.

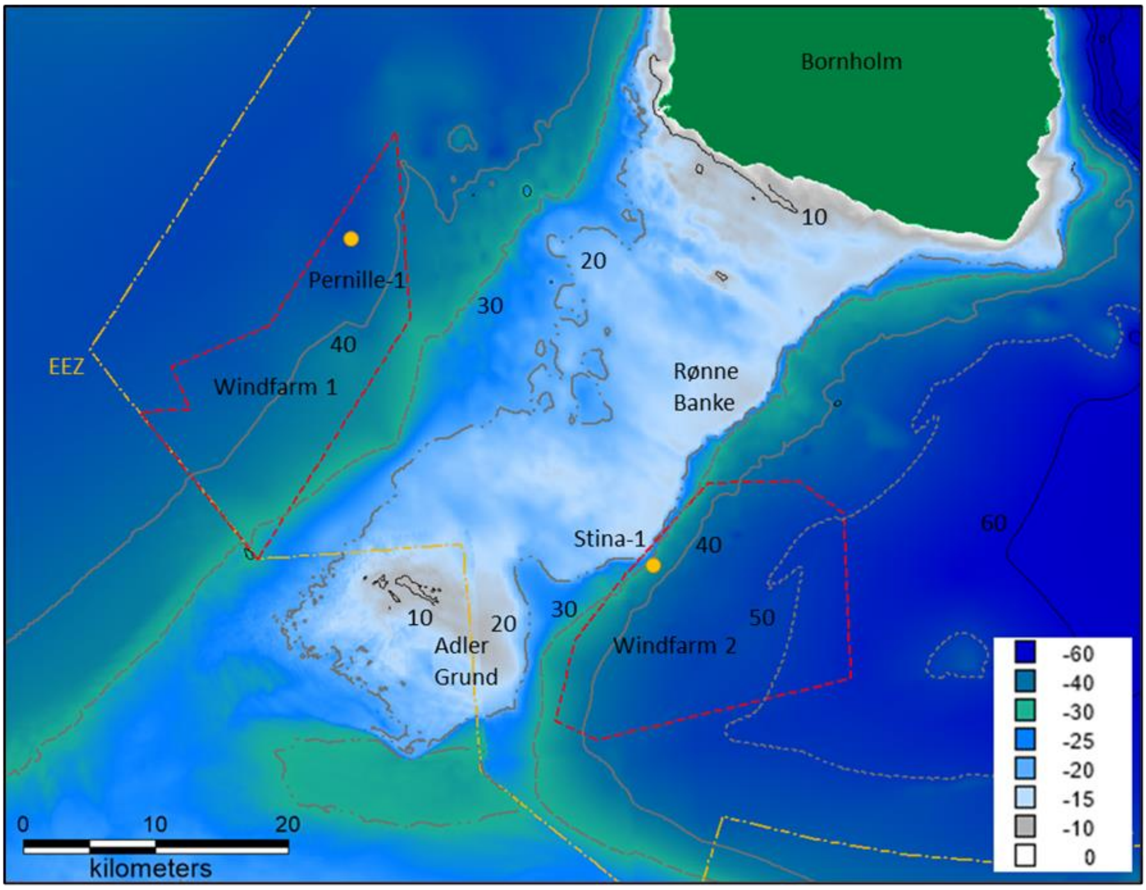


Figure 11.1 Bathymetry in the proposed windfarm areas (red polygons) southwest of Bornholm in the Baltic Sea. EEZ yellow lines, Bathymetry from Emodnet and the 2 deep drillings Pernille-1 and Stina-1 as yellow dots.

11.2 Seabed sediments

The distribution of seabed sediments reflects to some degree the bathymetry of the region. Fine-grained mud has accumulated in the central parts of the basins, whereas areas with till and bedrock in the shallow parts indicate non-deposition or erosion (Figure 11.2). In the wind farm 1 area sand is found in the shallowest areas whereas muddy sand dominates. Small areas mapped as mud and clay and silt are also found. The wind farm 2 area is dominated by clay and silt, muddy sand, and sand.

According to vibrocore data, clayey till is found at the seabed or close to the seabed in some parts of the wind farm 1 area and late glacial clay deposited in the Baltic Ice Lake is found in the north. Vibrocore data from the wind farm 2 area indicate marine sand and silt in the south and late glacial glaciolacustrine clay in the northeast (Figure 11.2).

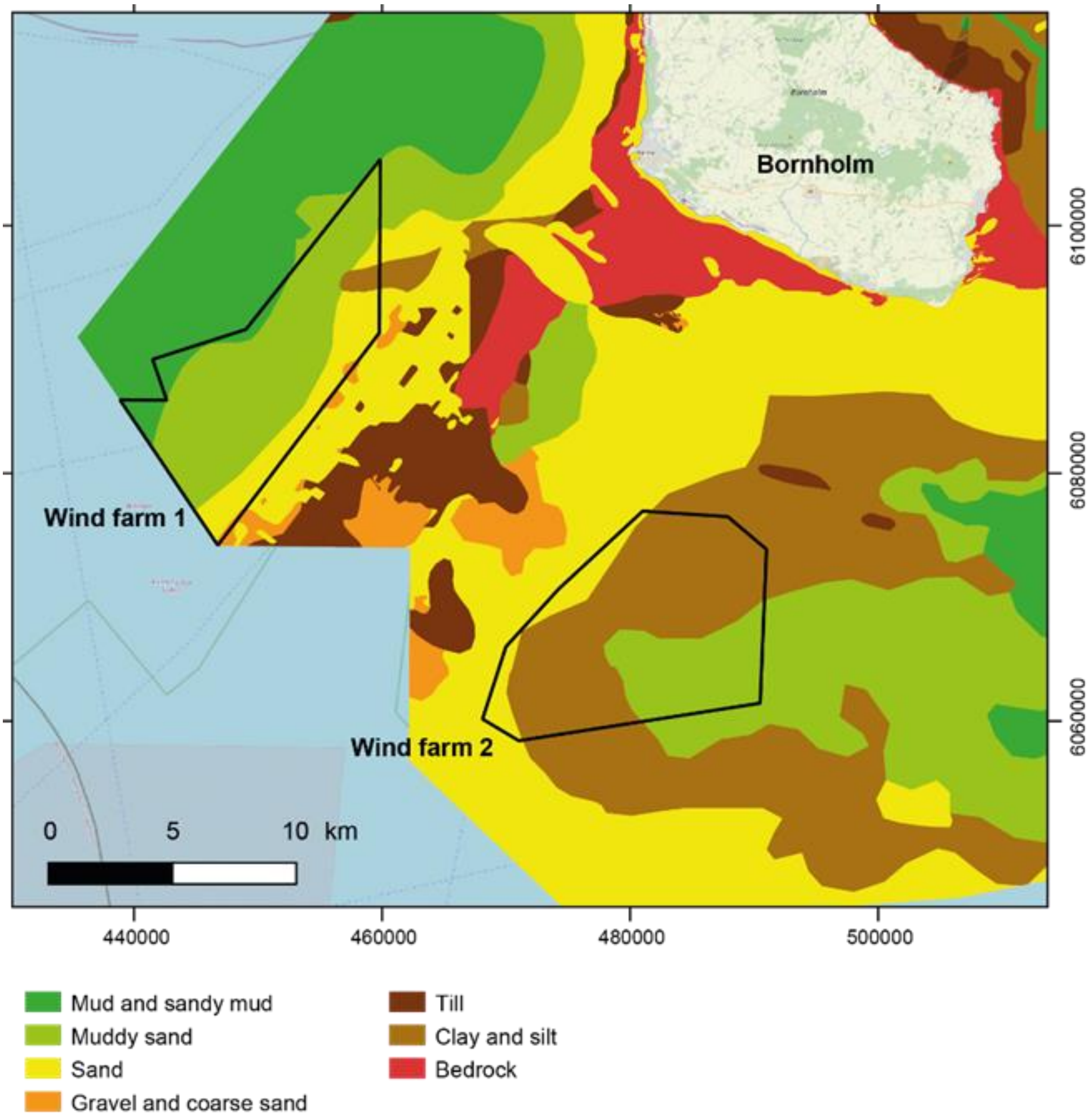


Figure 11.2. Seabed sediments in the Bornholm OWFs region, according to the Marta database. The map gives only a general impression of the seabed sediments.

11.3 Shallow sediments in Windfarms 1 and 2

A few representative boomer seismic lines and data from vibrocores from the windfarm areas have been interpreted and a short description will be presented in the following chapters.

The boomer seismic lines show a combination of near surface pre-Quaternary deposits covered by Quaternary glacial, late glacial and Holocene sediments.

The location of the seismic examples, deep wells and vibrocores, in the wind farm areas southwest of Bornholm, is illustrated on a bathymetric map in Figure 11.3 and in relation to the major faults and pre-Quaternary stratigraphic units in Figure 11.4.

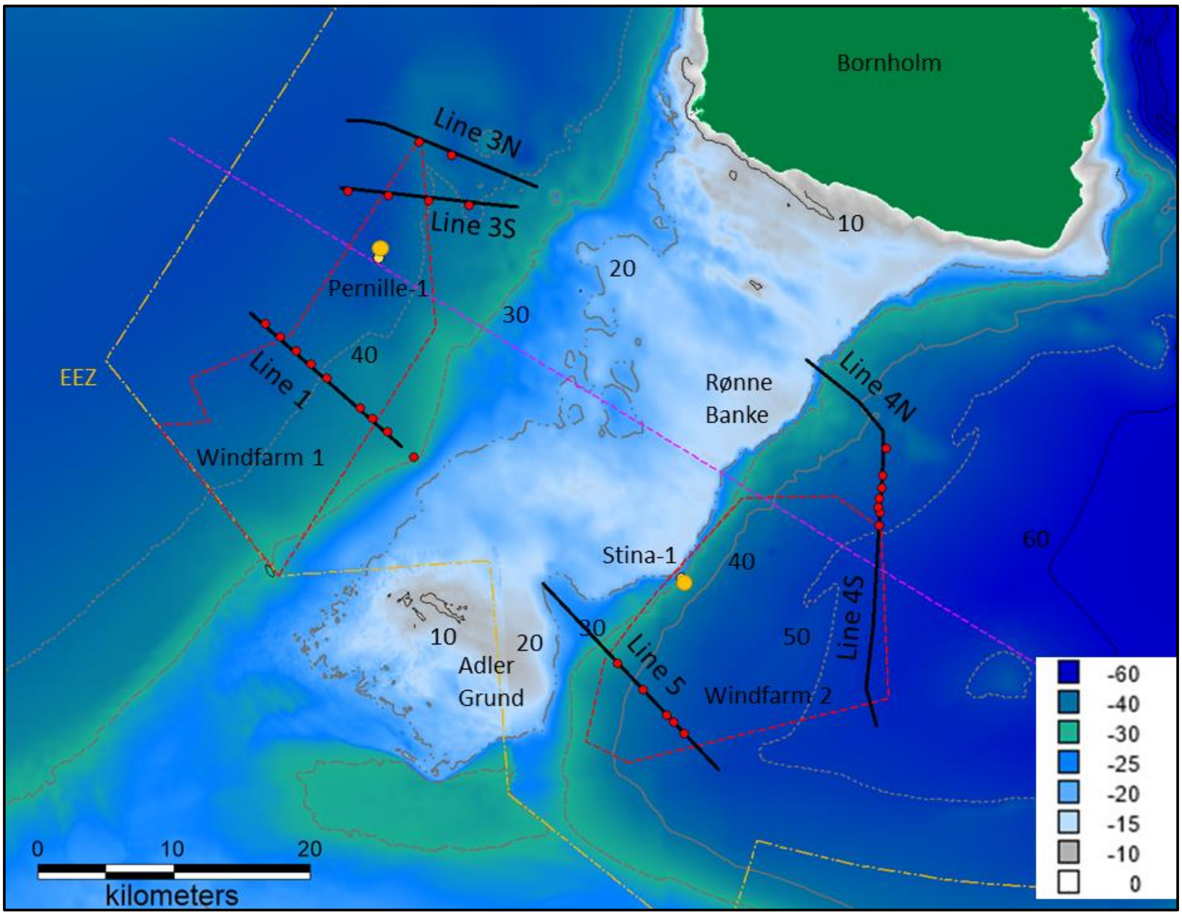


Figure 11.3. Location of deep wells (yellow dots), Boomer seismic examples (black lines) and vibrocores (red dots) southwest of Bornholm. The location of the proposed wind farms is indicated by polygons. The bathymetry is from Emodnet.

As described in chapter 4 the pre-Quaternary geology southwest of Bornholm is dominated by block faulting in a lineament characterised by complex extensional and strike-slip faulting followed by structural inversion. The overall graben and block structures are shown in Figure 4.1, Figure 4.2 and Figure 4.3 and the detailed blocks and pre-Quaternary stratigraphy is presented in Figure 11.4. together with the locations of windfarms and seismic as well as core examples described in the following chapters.

The pre-Quaternary interpretation on the boomer profiles is based on published structures and stratigraphy, the two deep wells Pernille-1 and Stina-1 (Figure 7.1 and Figure 7.2) as well as the characteristic seismic reflection patterns described by Jensen and Hamann (1989) (Figure 11.5 and Figure 11.6). The windfarm boomer profiles interpretations must be seen as a tentative proposal of possible faults and stratigraphic distribution of Mesozoic sediments.

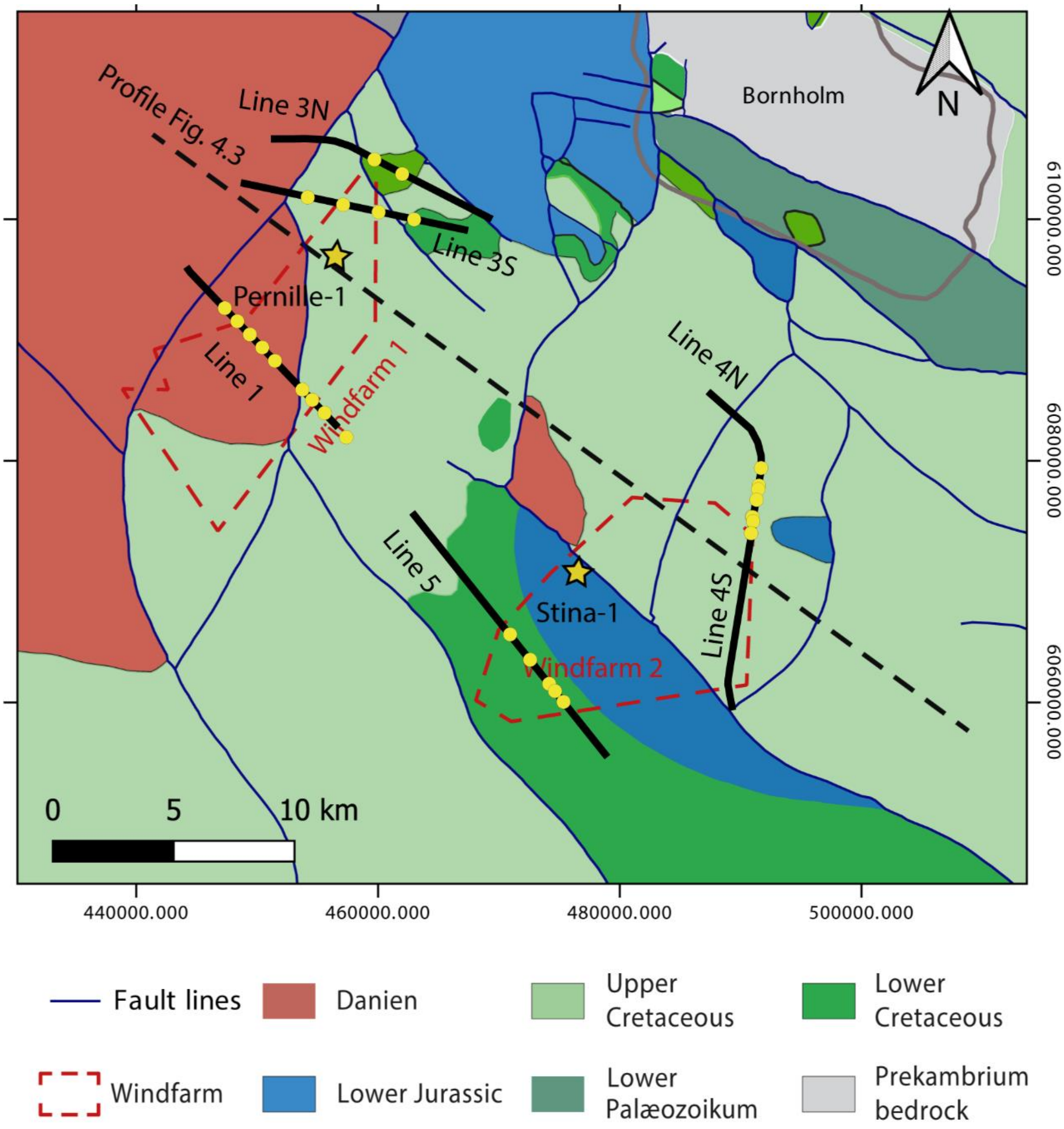


Figure 11.4. Major faults and pre-Quaternary stratigraphic units southwest of Bornholm. Stars represent deep wells. Dots represents vibrocores and thick black lines boomer seismic examples.

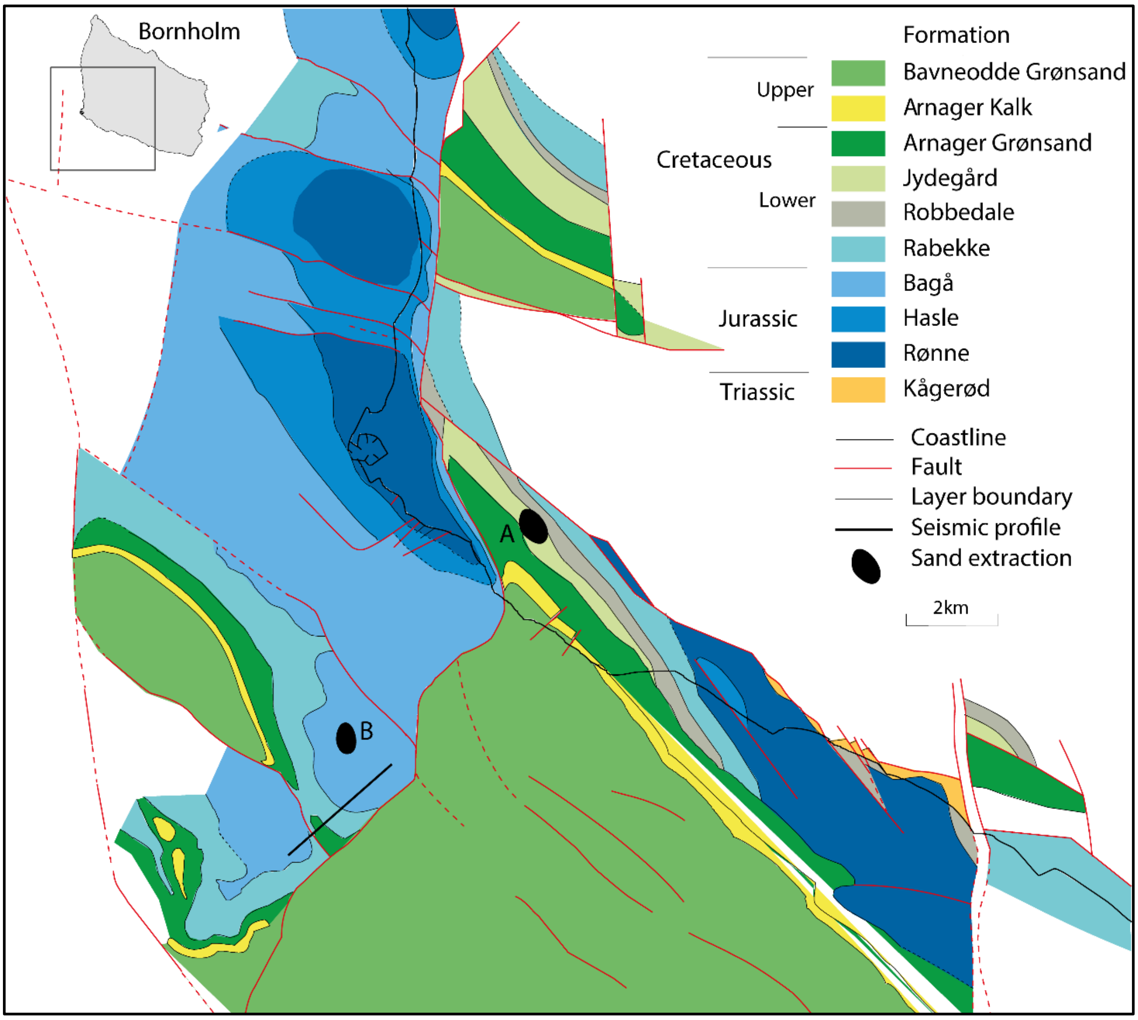


Figure 11.5. The pre-Quaternary Mesozoic surface, exposed at the seabed near coastal offshore Bornholm. (Jensen and Hamann 1989).

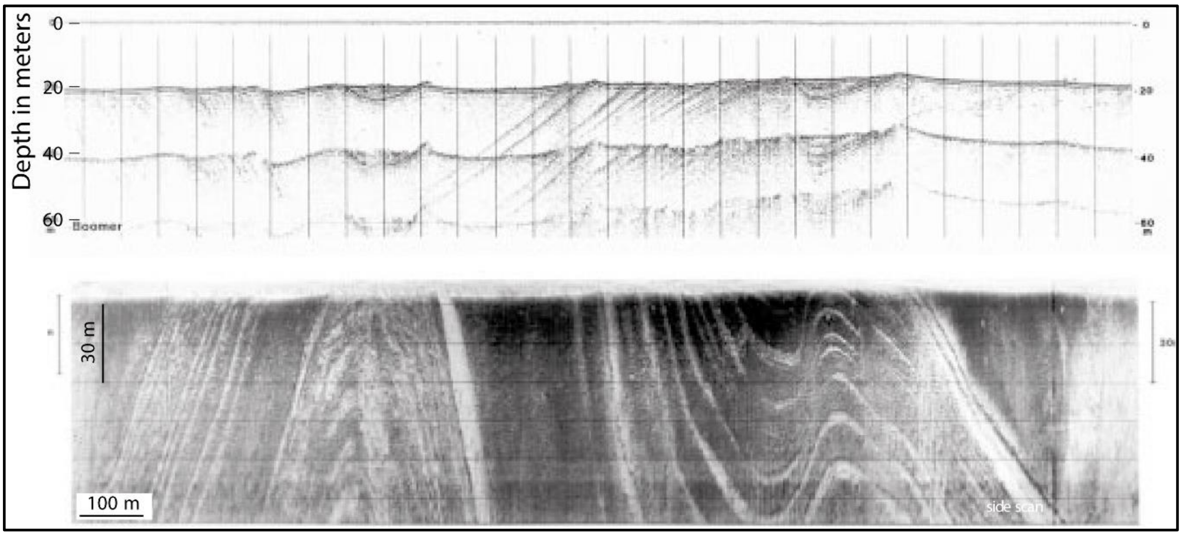


Figure 11.6. Boomer profile and side scan sonar image of the seabed south west of the seismic profile. Exposed Cretaceous sediments at the seabed. Location of profile se Figure 11.5. (Jensen & Hamann 1989).

11.3.1 Windfarm 1

Line 1, Line 3S and Line 3 N Line 1 crosses the central part of the area and transects a pre-Quaternary fault zone with normal faults (Figure 11.7). It results in a change from the south-eastern Upper Cretaceous (Maastrichtian) limestone as documented in Pernille-1 (Figure 7.1) to the north-western Danien limestone (Figure 11.4 and Figure 11.7, Figure 11.8 and Figure 11.9) describe the sediments down to 120 ms in Wind farm 1.

11.3.1.1 Pre-Quaternary setting

Line 1 crosses the central part of the area and transects a pre-Quaternary fault zone with normal faults (Figure 11.7). It results in a change from the south-eastern Upper Cretaceous (Maastrichtian) limestone as documented in Pernille-1 (Figure 7.1) to the north-western Danien limestone (Figure 11.4 and Figure 11.7).

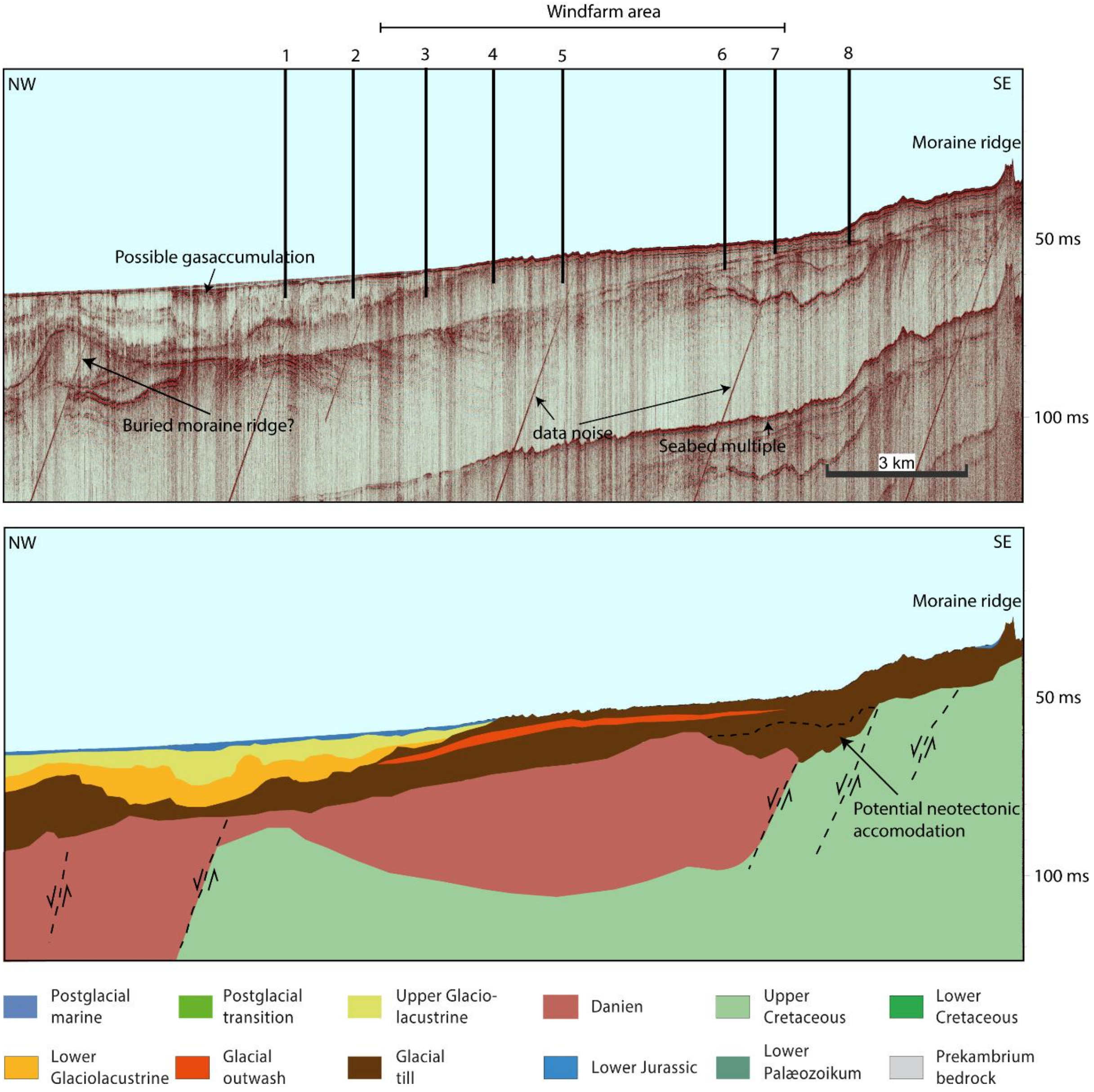


Figure 11.7. Seismic Line 1 from the central part of Wind farm 1. See Figure 11.3 and Figure 11.4 for location. The numbers refer to cores shown in Figure 11.8.

Line 3 S and 3 N represent the northern part of windfarm 1 but show different pre-Quaternary sediments.

Line 3S (Figure 11.8) shows faults combined with drag folding in-between. The result is a pre-Quaternary surface that consists of north-eastern lower Cretaceous probably Rabække Formation characterised by folded strong parallel reflectors, probably related to kaolinitic clay and coal-bearing clay horizons interbedded with fine-grained sand units overlain by Arnager Greensand with few strong reflectors consisting of phosphorite conglomerates in a glauconitic marine sand.

In the central part of the section, between the two faults, Upper Cretaceous (Maastrichtian) limestone is expected as documented in Pernille-1 (Figure 7.1) and southwest of the faults Danien limestone is likely.

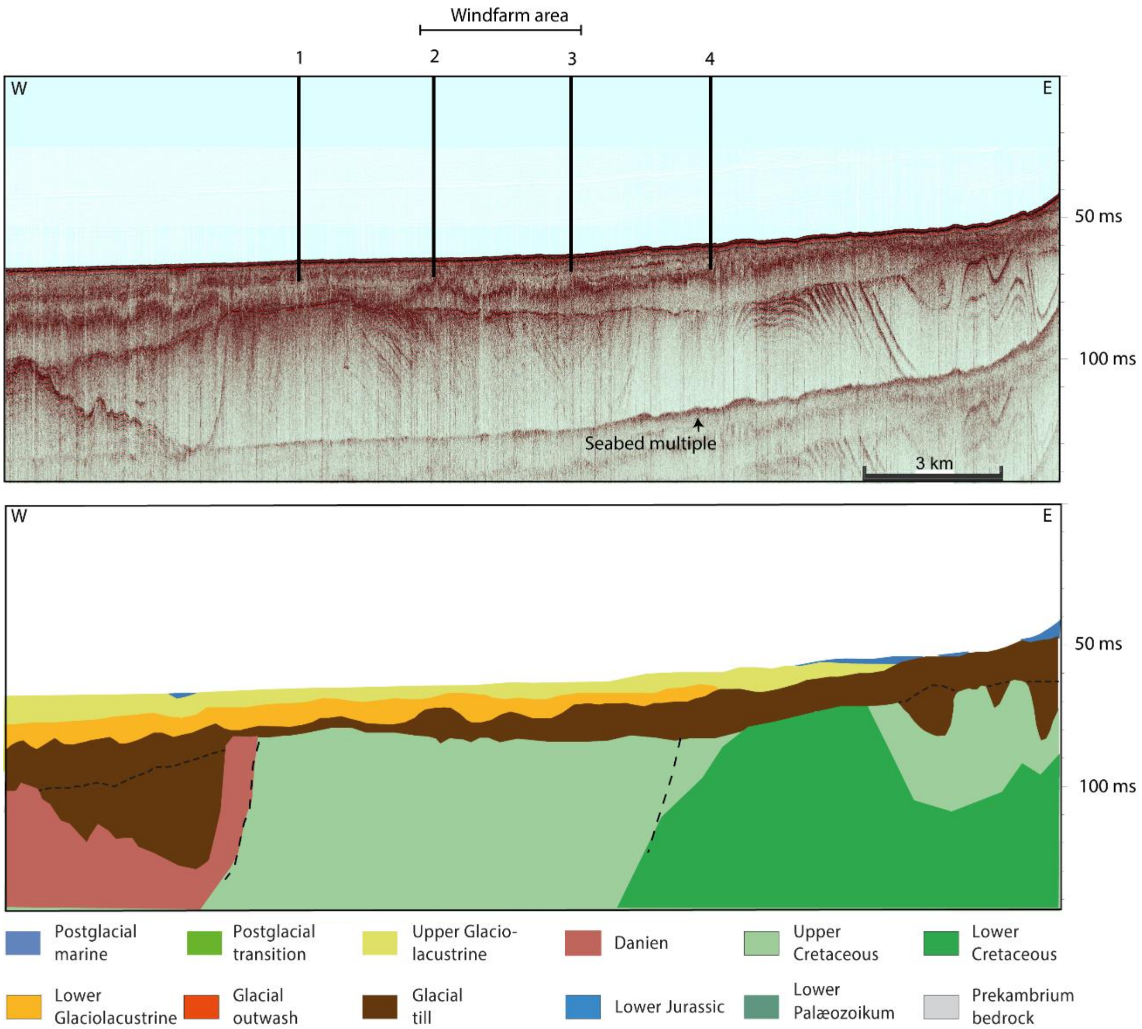


Figure 11.8. Seismic Line 3S from the northern part of Wind farm 1. See Figure 11.3 and Figure 11.4 for location. The numbers refer to cores shown in Figure 11.11.

Line 3N (Figure 11.9) crosses three faults and the pre-Quaternary surface consists of north-eastern lower Jurassic probably Bagå formation of alternating layers of sand, clay and coal.

In the middle section lower Cretaceous Rabække Formation with strong parallel reflectors reflects kaolinitic clay and coal-bearing clay horizons interbedded with fine-grained sand units overlain by Arnager Greensand and followed by Upper Cretaceous (Maastrichtian) limestone. Southwest of the faults Danien limestone is likely present.

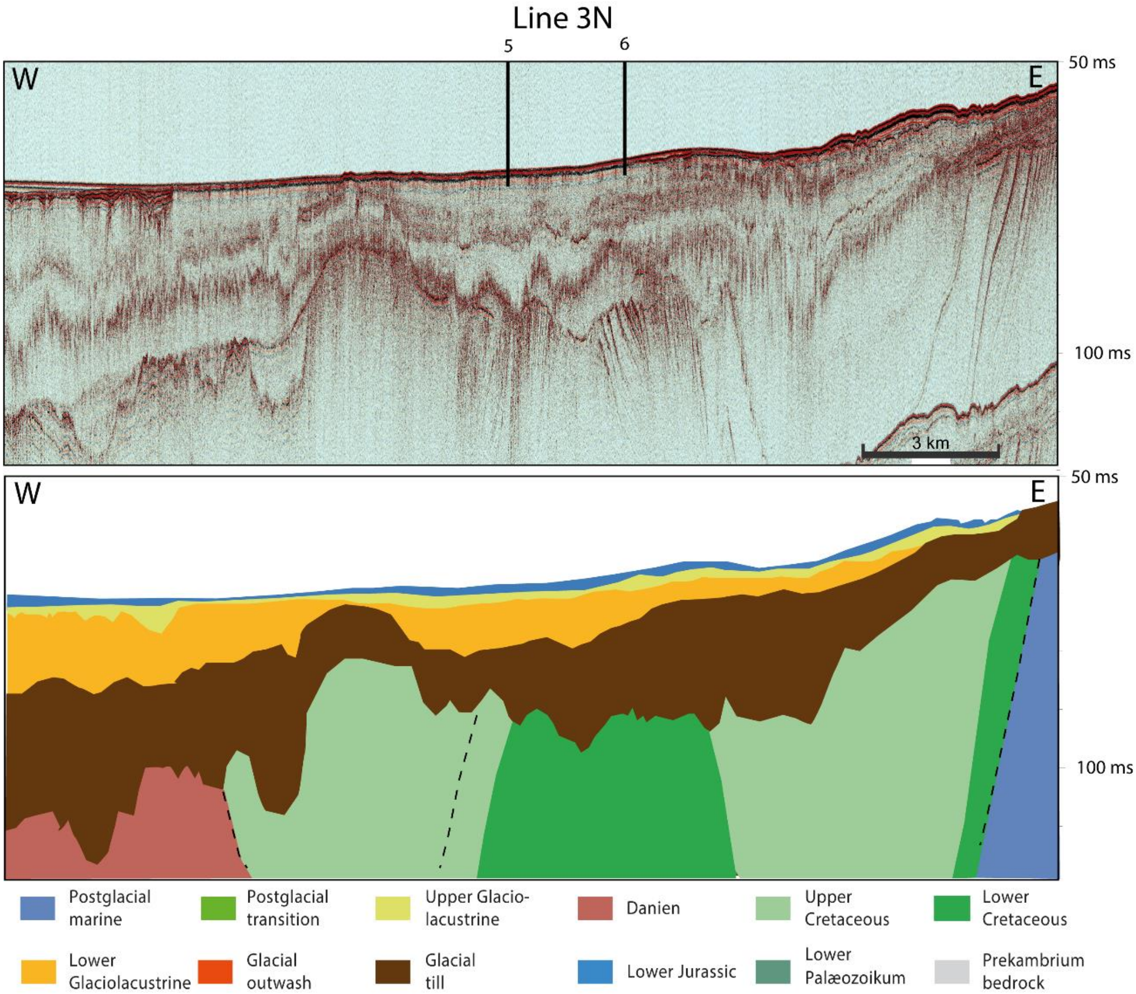


Figure 11.9. Seismic Line 3N just north of Wind farm 1. See Figure 11.3 and Figure 11.4 for location. Numbers refer to cores shown in Figure 11.11.

11.3.1.2 Quaternary sediments

The glacial unit includes a package of sandy meltwater deposits interpreted in the core logs in Line 1 (Figure 11.10). This unit is deposited in front of a moraine ridge, present in the south-eastern end of the line and there is another potential buried moraine ridge in the north-western end of the line, beneath the younger lacustrine deposits. There are multiple internal reflections within the interpreted glacial unit in all three lines (Figure 11.7, Figure 11.8 and Figure 11.9). Especially within the depressions in the pre-Quaternary surface above the fault zones (e.g., Line 1). These may represent accommodation space provided by neotectonic movements in the deeper faults, similar to observations in the Bornholm Basin (Jensen et al. 2016) Neotectonic movements have also been attributed to the formation of depressions and subsequent infill south of the island of Anholt (Jensen et al. 2008), which is also situated in the Tornquist zone. There are, however, no lithological evidence of the infill within these depressions, nor dating from the deposits. Neotectonic movement is thus speculative but a possible scenario.

The late glacial units represent the two lake stages described in chapter 8.1.2; the Baltic Ice Lake I and II (Figure 8.3). They are separated by a thin (below vertical seismic resolution) homogenous clay deposit (Figure 8.5). The two units (IIIa and IIIc) thus represent lake level highstands separated by a drainage event, and deposition of a lowstand homogenous clay unit (IIIb). The glacial lake deposits thickens towards the north. It thus follows the general trend of the pre-Quaternary surface, which deepens towards the north. The late glacial lacustrine units are expected to be present in most of the Wind farm 1 area and are documented in the vibrocores (Figure 11.10 and Figure 11.11).

There are potential gas accumulations within these deposits, as indicated on seismic Line 1 (Figure 11.7). There are no remnants of the Ancylus lake in Wind farm 1, and the ice lake deposits are overlain by a thin layer of Holocene marine muddy sand. Towards the southeast, the glacial surface crops out on the sea floor.

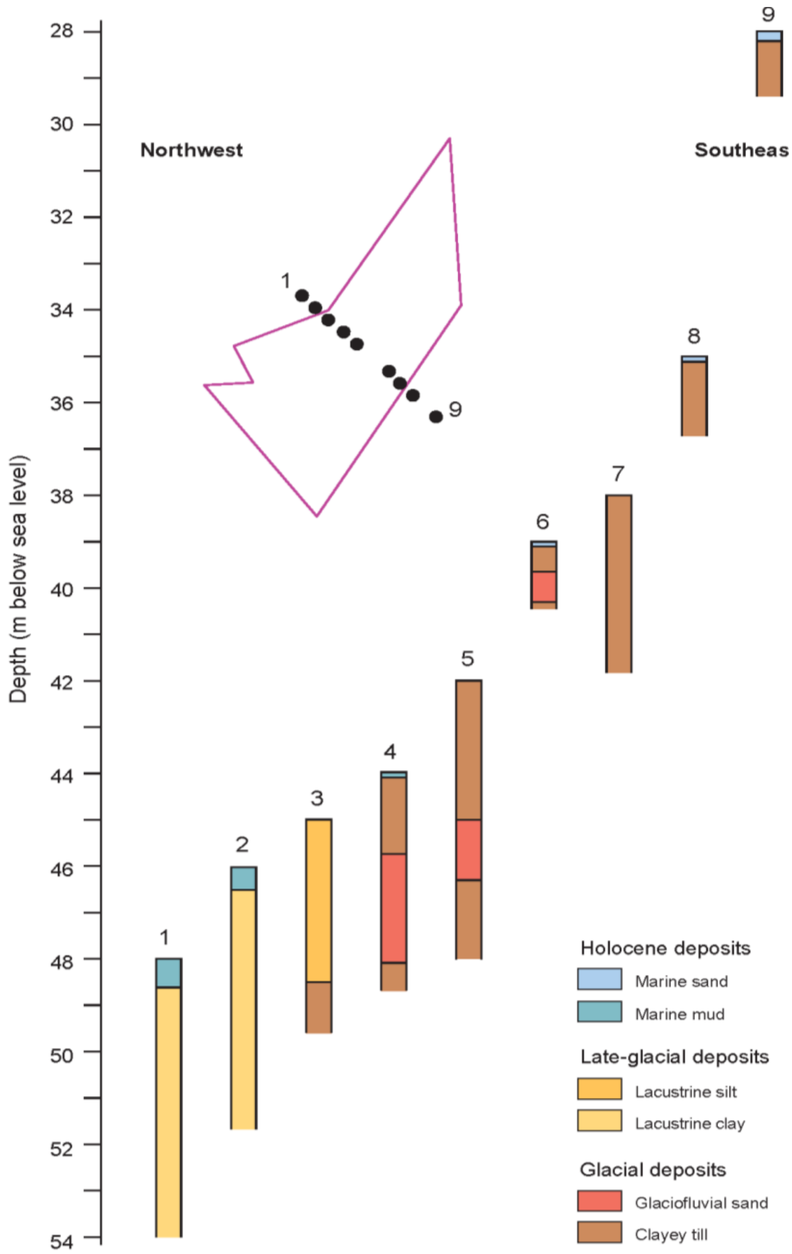


Figure 11.10. Lithological logs based on vibrocores from wind farm 1 (Line 1, Figure 11.5) southwest of Bornholm.

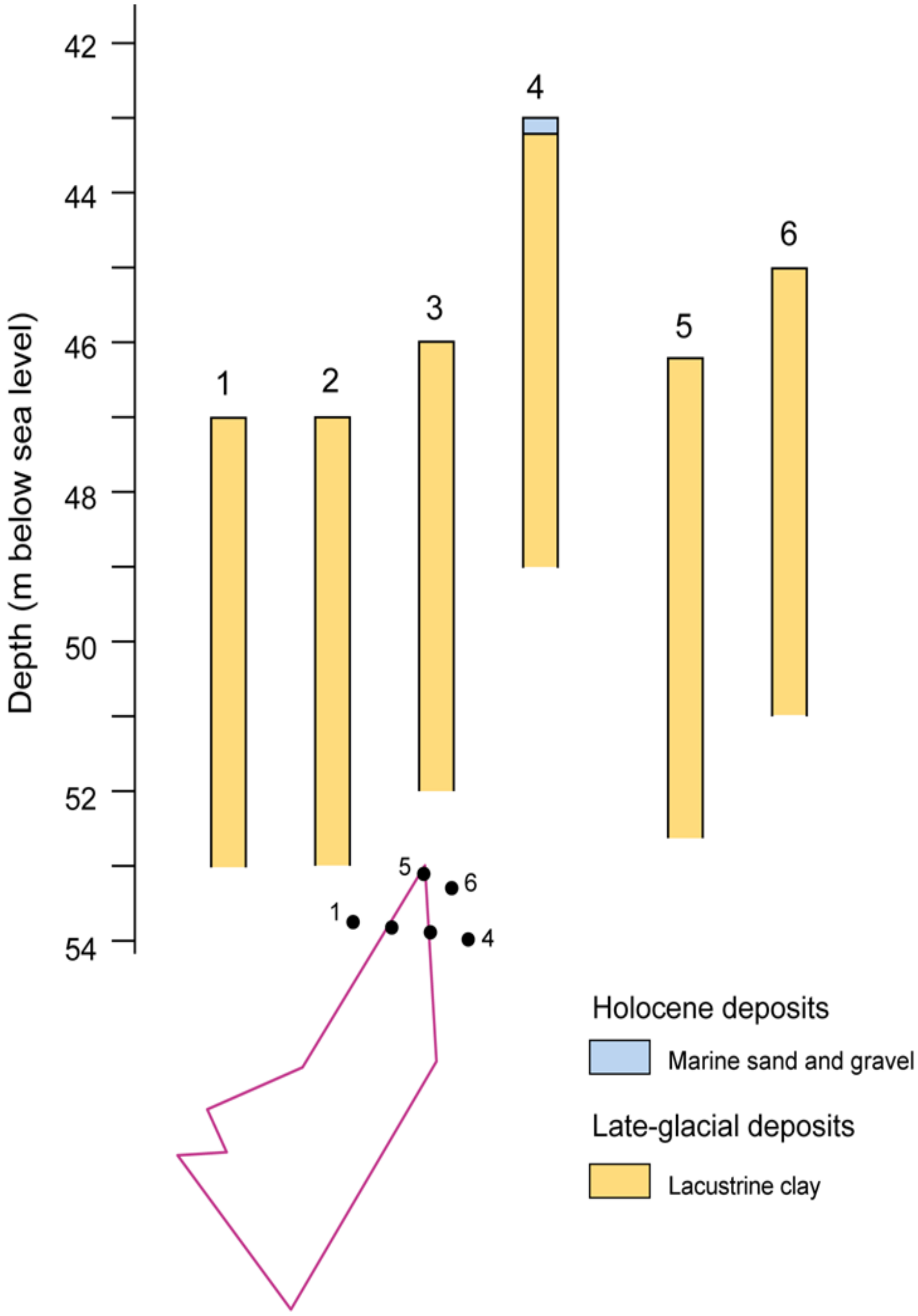


Figure 11.11 Lithological logs based on vibrocores from the northern part of wind farm 1 (Line 3N and 3S Figure 11.8 and Figure 11.9) southwest of Bornholm. The area is dominated by late glacial silty clay deposited in the Baltic Ice Lake. A thin layer of sand and gravel deposited during the Littorina Sea Stage is recorded at the shallowest site.

11.3.2 Wind farm 2

Line 4N1, Line4S and Line 5 (Figure 11.12, Figure 11.13 and Figure 11.14) describe the sediments down to 120 ms in Wind farm 2.

11.3.2.1 Pre-Quaternary setting

The Wind farm 2 area is described from Line 4 S and Line 5 primarily, which show the trends in the area, but also Line 4N, located just north of the windfarm 2 area. The pre-Quaternary surface represents both Lower Cretaceous (southern part), Jurassic (central part) and Upper Cretaceous deposits (northern part) (Figure 11.4). The Jurassic deposits are not represented in the seismic sections presented here. The Upper Cretaceous is represented in the lines 4N and 4S.

Line 4N (Figure 11.12) is dominated by strong parallel reflector bundles with a strong imprint of folding. Studies by Jensen & Hamann (1989) shows that the lithology represented by strong reflectors most likely is Bavneodde Greensand Formation cemented glauconitic quartz sandstone and occasionally conglomerates, while unconsolidated glauconitic sand gives rise to weak reflectors.

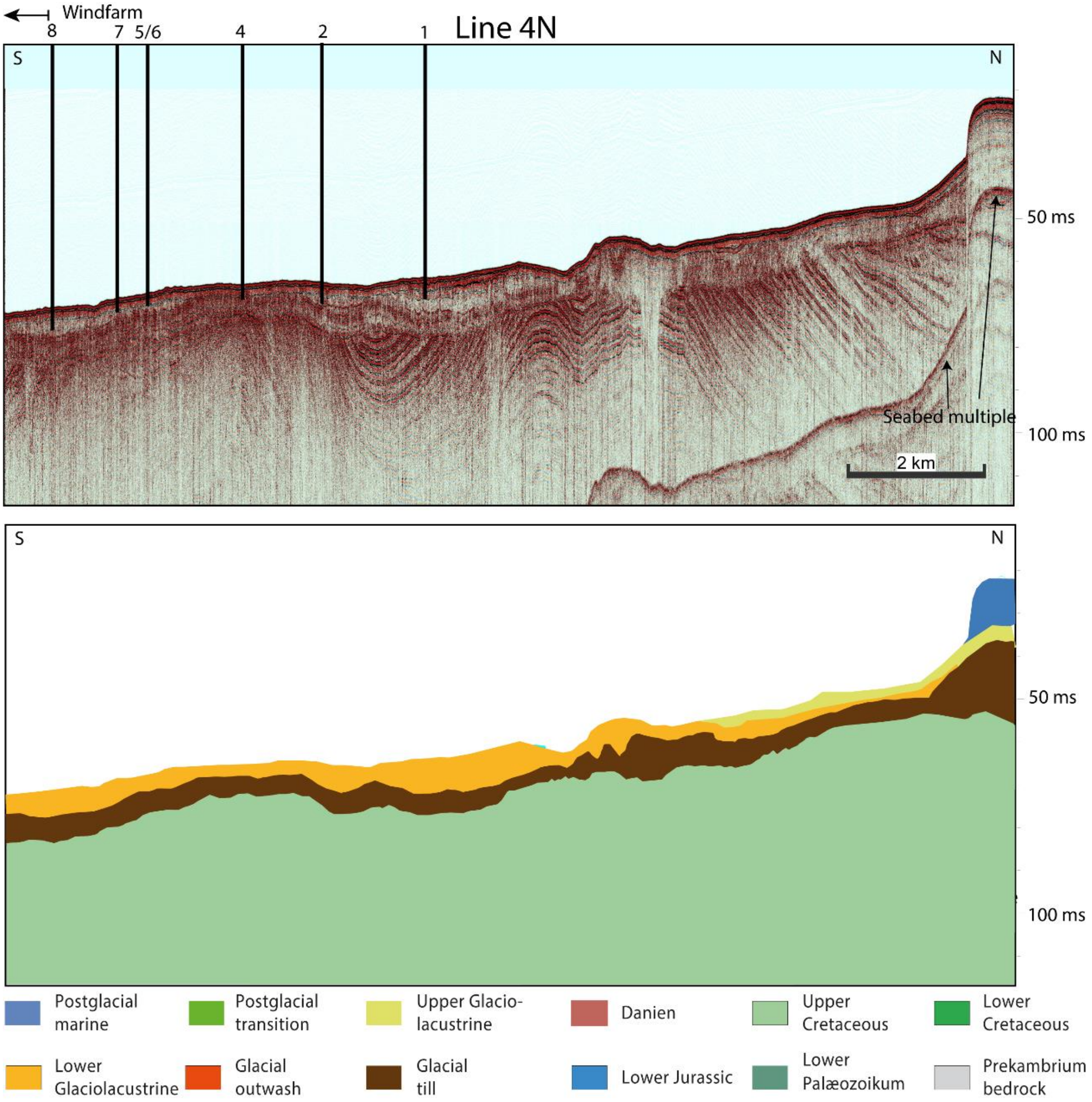


Figure 11.12. Seismic Line 4N from the northern part of Wind farm 2. see (Figure 11.3 and Figure 11.4) for location. (The numbers refer to cores shown in Figure 11.15)

Line 4S inside windfarm 2 only have bundles of strong parallel reflectors in the northern part while the southern part is dominated by weak reflectors. This indicates a change from quarts sandstone to glauconitic sand.

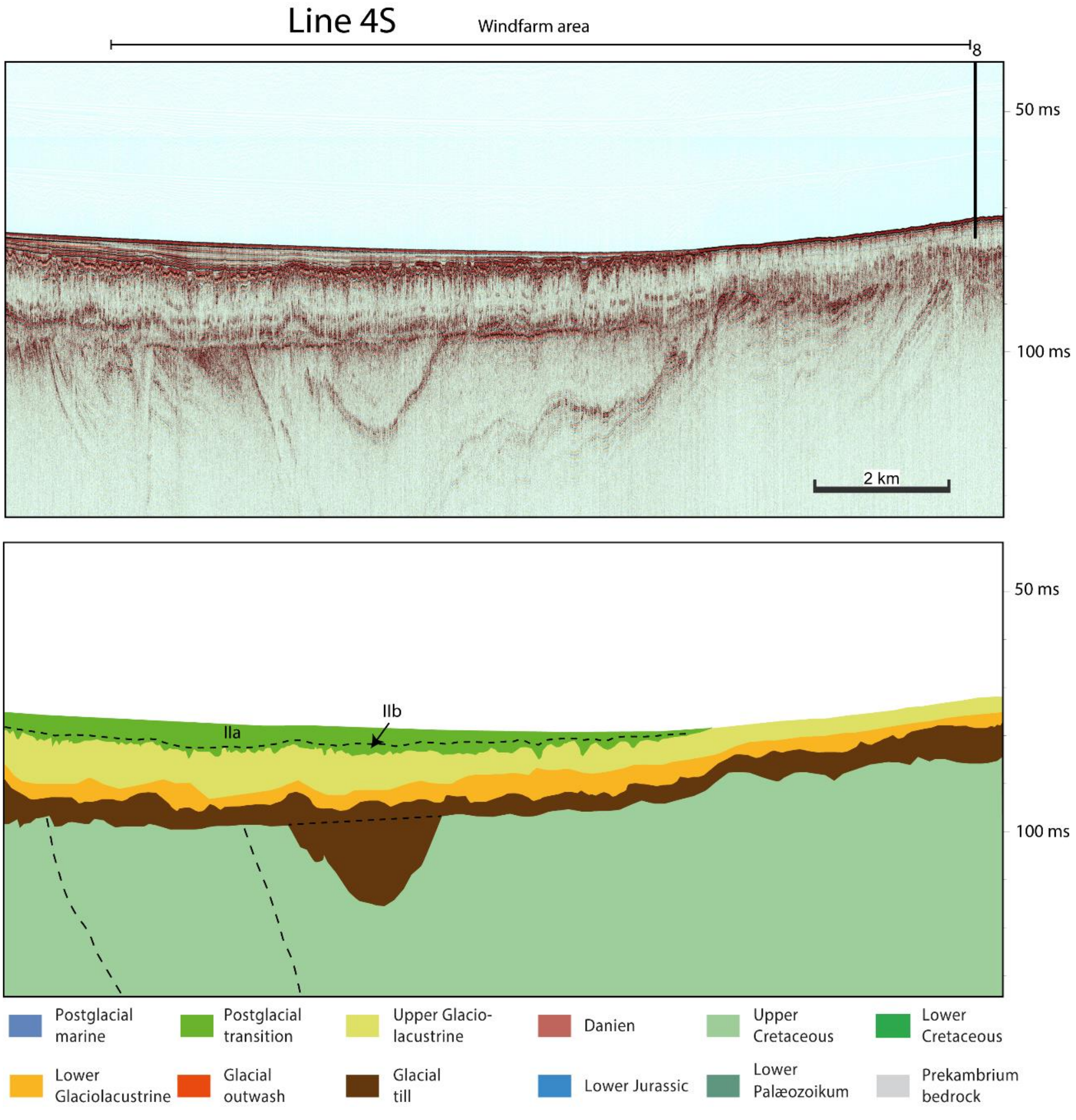


Figure 11.13. Seismic Line 3N just north of Wind farm 1. see (Figure 11.3 and Figure 11.4) for location. (The number refers to core shown in Figure 11.15).

Line 5 apparently shows Lower Cretaceous pre-Quaternary sediments in the southeast and a gradual transition to north-western Upper Cretaceous deposits. No information has been obtained about the sediment types.

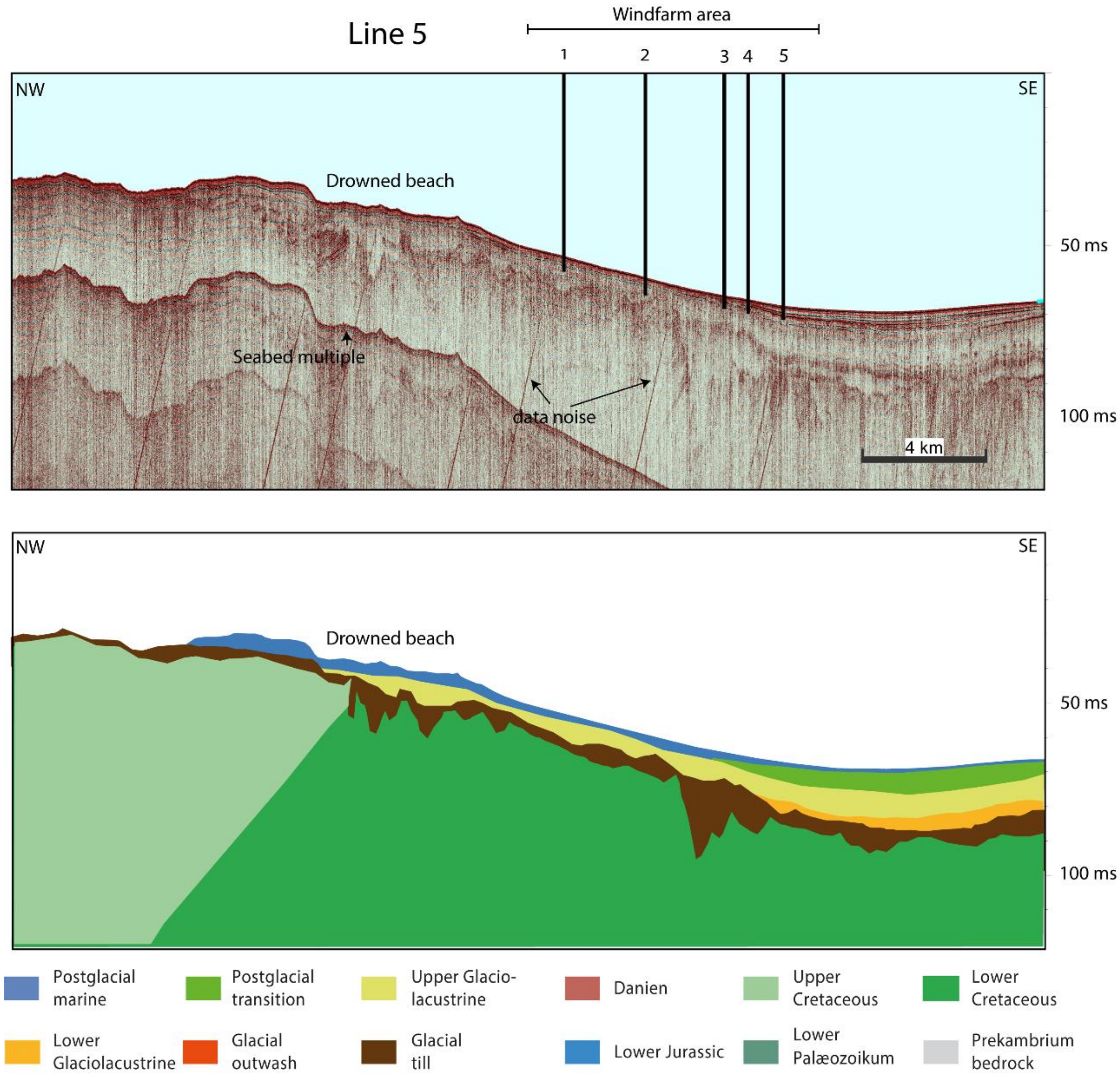


Figure 11.14. Seismic Line 5 south-western part of Wind farm 1. see (Figure 11.3 and Figure 11.4) for location. (Numbers refer to cores shown in Figure 11.16).

11.3.2.2 Quaternary sediments

The glacial unit is relatively thin compared to the deposits in the Wind farm 1 area. In general, only few metres of draping on the pre-Quaternary surface interrupted by few depressions. There are fewer internal reflections within the unit, suggesting layering of the till. Seasonal melting and resulting seasonal moraines may also have affected the wind farm 2 area in the same way as the Wind farm 1 area.

The late glacial unit shows the same pattern as in the Wind farm 1 area, with two high stand units separated by a low stand unit, below seismic resolution, but documented in the vibrocores. Towards the north-east, erosion or nondeposition has exposed late glacial unit IIIc, this is however outside the windfarm area. The top reflector of the late glacial units is characterized by a high amplitude, that may be associated with development of unconformities during low stand periods.

On top of the late glacial unit, a Holocene lacustrine unit is deposited. The seismic section shows a nicely laminated unit (unit II), with medium amplitude reflections. This unit was deposited primarily in the Ancylus Lake, with possible remnants of Yoldia clay deposits at the base.

Northwest of windfarm 2 in the northern part of Line 4N (Figure 11.12. Seismic Line 4N from the northern part of Wind farm 2. see (Figure 11.3 and Figure 11.4) for location. (The numbers refer to cores shown in Figure 11.15), there is a thick marine sandy unit that represents a drowned beach. This unit is not found in the wind farm area.

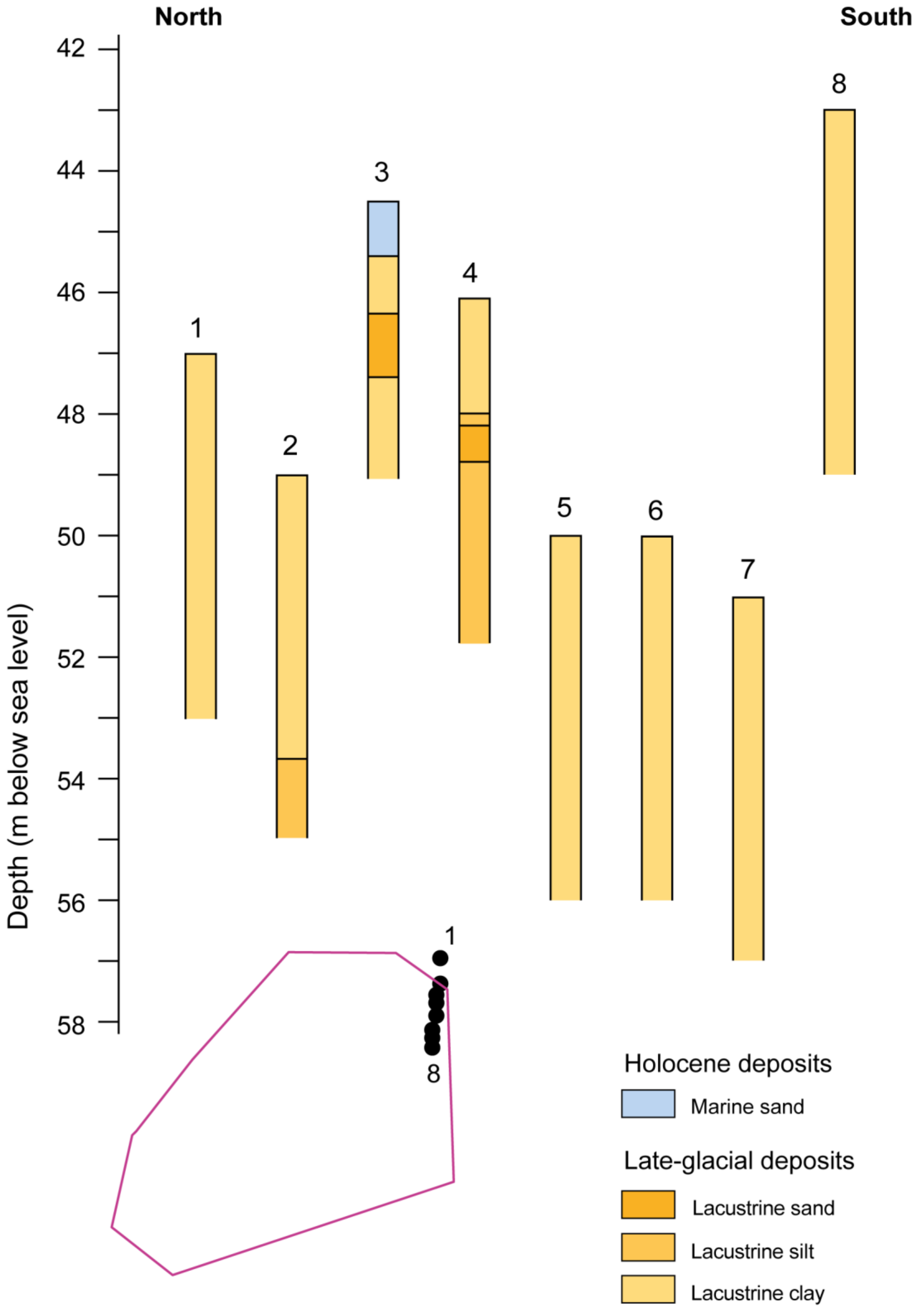


Figure 11.15. Lithological logs based on vibrocores from wind farm 2 (Line 4N and 4S) (Figure 11.12 and Figure 11.13) south-west of Bornholm.

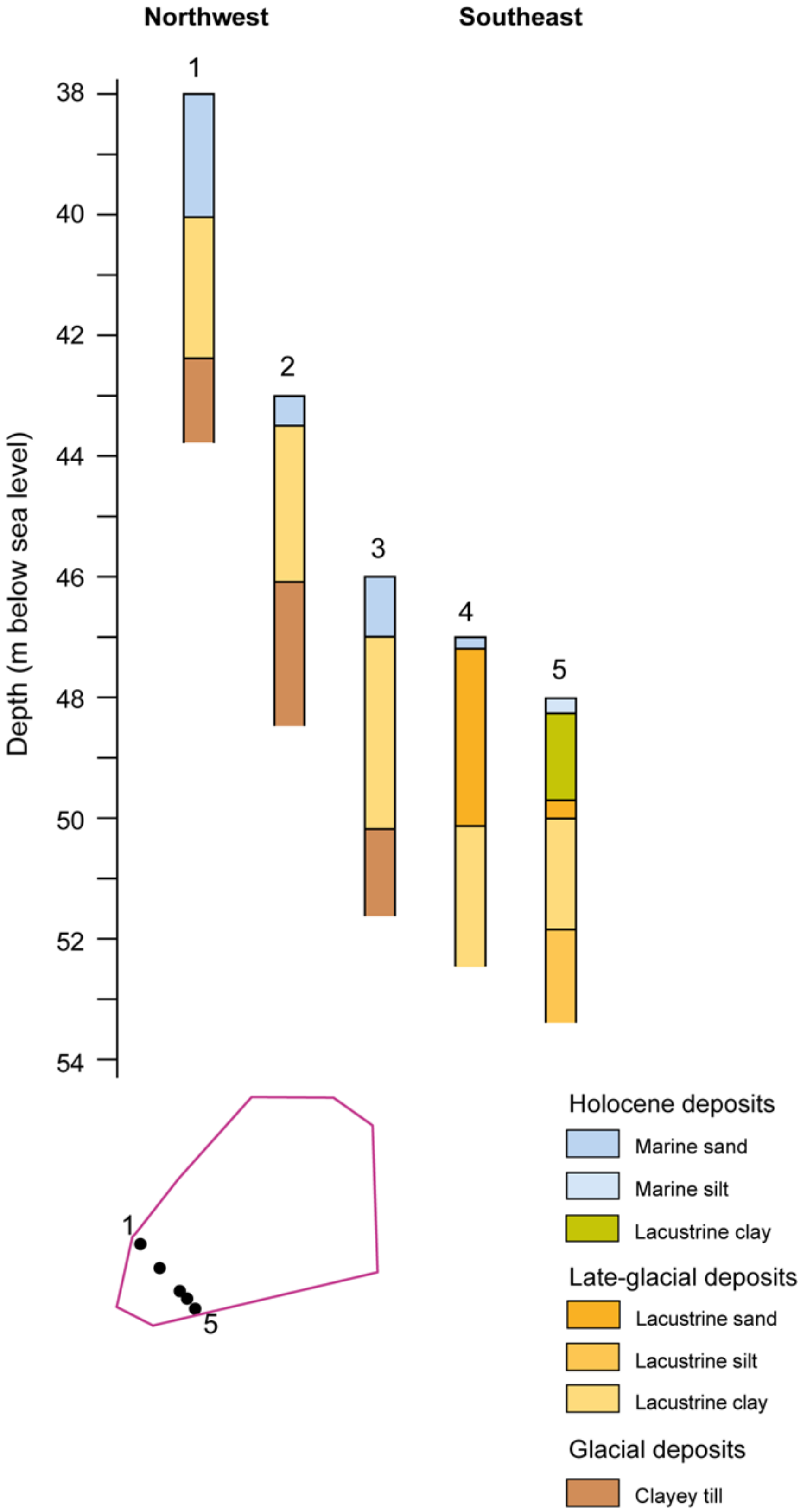


Figure 11.16 Lithological logs based on vibrocores from the southern part of wind farm 2 (Line 5, Figure 11.14) southwest of Bornholm.

12. Danish windfarm Site 6. Rønne Banke

In 2013, Energinet conducted surveys on six offshore near coastal areas planned by the Danish Energy Agency towards licensing for a total of 500MW OWF. One of these areas (Site 6 Rønne Banke) covers 45km^2 and is located about 10km south of Rønne. Site 6 is located at water depths between 9 and 24m, in general shallower than Windfarm 1 and 2 (Figure 12.1). Only the north-western most part of Windfarm 2 reaches 22m water depths in a few hundred meters narrow rim.

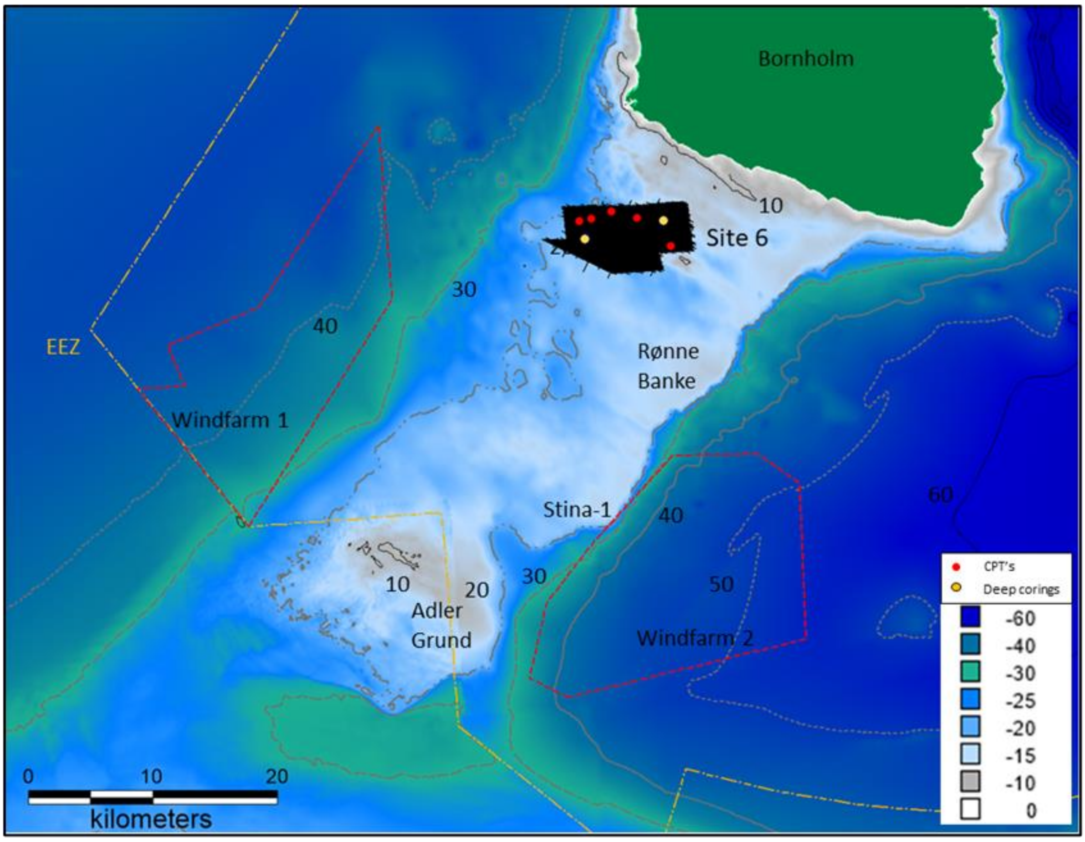


Figure 12.1 Location of Site 6 Rønne Banke in relation to Windfarm 1 and Windfarm 2. Location of 2 combined deeper coring's and CPT's (yellow dots) and 5 CPT's (read dots) in site 6.

The general distribution of seabed sediments in Rønne Banke site 6 is described in the GEUS Martha database as dominated by bedrock at the seabed (Figure 12.2) with thin sand and glacial deposits in the southernmost margin areas. It also clearly shows that the lateglacial and Holocene basin deposits in the deeper Windfarm 1 and 2 areas are not represented in the Rønne Banke Site 6 area.

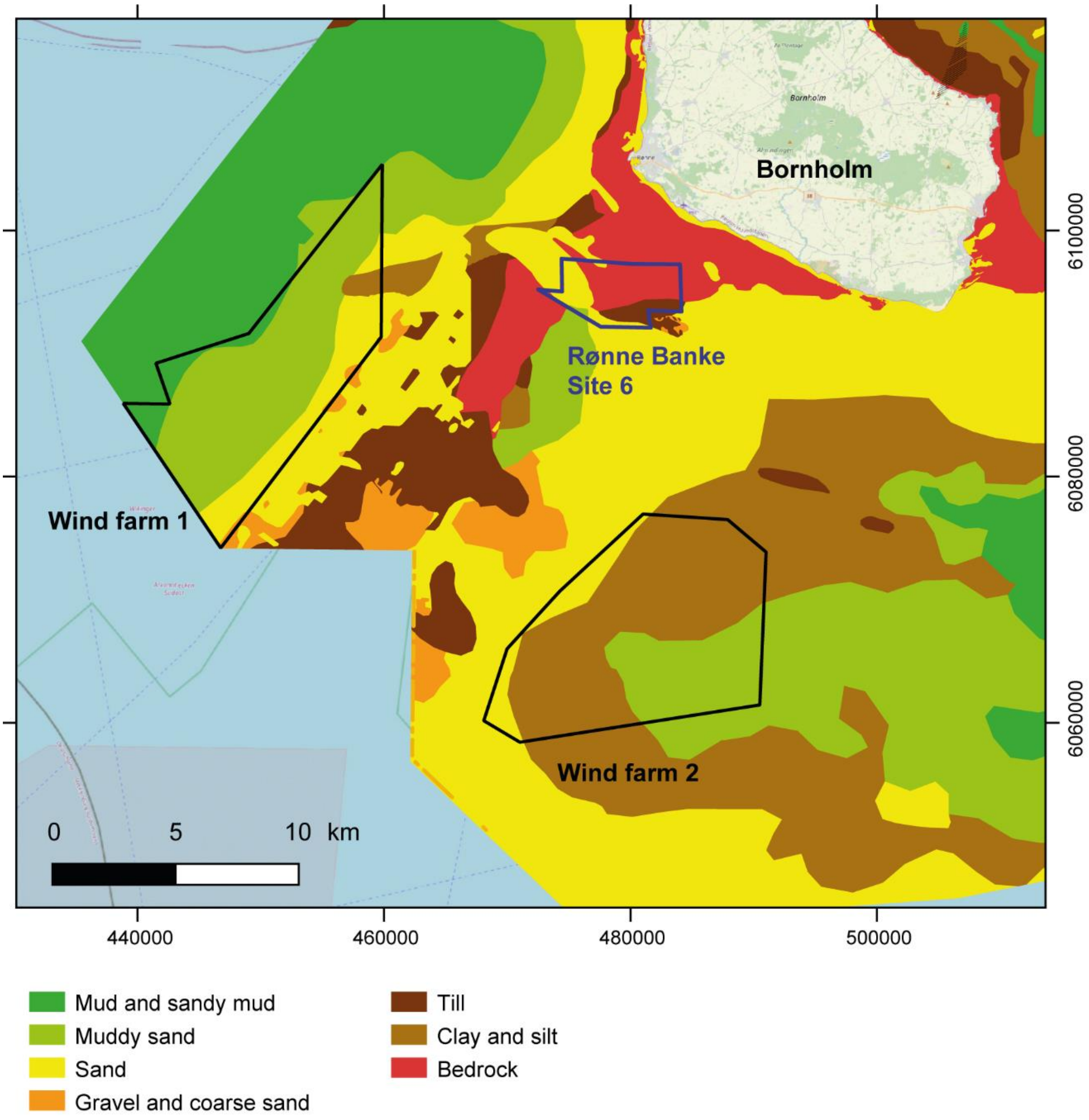


Figure 12.2 Seabed sediments in the Bornholm OWFs region, according to the Marta database. The map gives only a general impression of the seabed sediments. The location of OWF site 6 is in an area dominated by bedrock at the seabed.

Energinet carried out an assessment and an initial evaluation of the foundation of wind turbines, to lower the risk for companies with interest in acquiring the license to build and operate the wind farms providing a general assessment of the areas.

The studies were divided in a geophysical survey and a geotechnical coring survey:

12.1 Geophysical survey

A geophysical survey was carried out in 2013 by EGS (International) Limited and reported in their report “Danish Wind Farm Site Surveys, Site 6, Rønne Banke” (Energinet 2014 (a) and (b)).

The survey included the following:

- Bathymetric mapping.

- Side-scan sonar mapping
- Sub-bottom profiling with two systems,
- high resolution pinger (chirp) single channel system
- deep penetration sparker multi-channel system.
- Magnetic profiling.
- Grab sampling to support seabed interpretation.

Survey lines with 65m line spacing has been collected over an approximate area of 45km^2. This equated to a total planned line length of 755km. Data were acquired processed and interpreted resulting in the interpretation of bathymetry, seabed features and shallow geological profiles. Full data coverage was achieved during survey operations. A total of 26 grab samples were taken as a ground-truth.

Products from the survey are:

- A vessel track chart plot
- A Full coverage multibeam bathymetric chart
- SSS mosaic charts displaying elements of the seabed features, morphology and sediments.
- An overview SBF chart has also been created at a scale of 1:25,000 and
- Sub-seabed geological components were also charted as example geological interpretation of 6 mainlines and 5 cross lines

The sub-surface sediments have been mapped based on seismic evidence. The distribution of the most significant geological units has been mapped (Figure 12.8) as a background for the geotechnical evaluations of the turbines.

The interpretations are primarily made on basis of the seismic reflection pattern.

12.2 Geotechnical investigations

Geotechnical investigations were carried out by Fugro Sea core Limited (FSCL) and reported in their report "PRELIMINARY GEOTECHNICAL INVESTIGATIONS 2014_RØNNE BANKE FACTUAL REPORT ON GROUND INVESTIGATION" (Energinet 2014 (c) and (d)).

The purpose of the ground investigations was to provide preliminary geotechnical data to allow for the evaluation of the site for further investigations and development into a nearshore wind farm.

On basis of the seismic data ground investigation locations were selected (Figure 12.7 and Figure 12.3):

- Two combined borehole and CPT locations (RNB-BH001/CPT001 and RNB-BH002/CPT002). Both with core penetration 50m below seabed and CPT depth of recovery of 8,5m (CPT001) and 49m (CPT002).
    - The two borehole studies include:
        - Sediment description
        - Moisture
        - Atterberg Limits

    - Particle size distribution
    - Minimum and maximum density
    - Undrained shear strength
    - Isotropically consolidated drained triaxial tests
    - Termal resistivity
    - Unixial compressive strength
    - Carbonate content
    - Sulphate content
    - Chloride content

- Five CPT locations (RNB-CPT003 to RNB-CPT007) with depth of recovery up to 24m.
  - CPT results ae presented in three plot types
    - Plot1. Cone end resistance, sleeve friction, friction rate, porewater pressure, penetration speed.
    - Plot2. Net cone resistance, excess porewater pressure ratio, friction ratio, estimated soil type
    - Plot3. Net cone resistance, friction ratio, derived relative density, derived angle of internal friction and derived undrained shear strength.

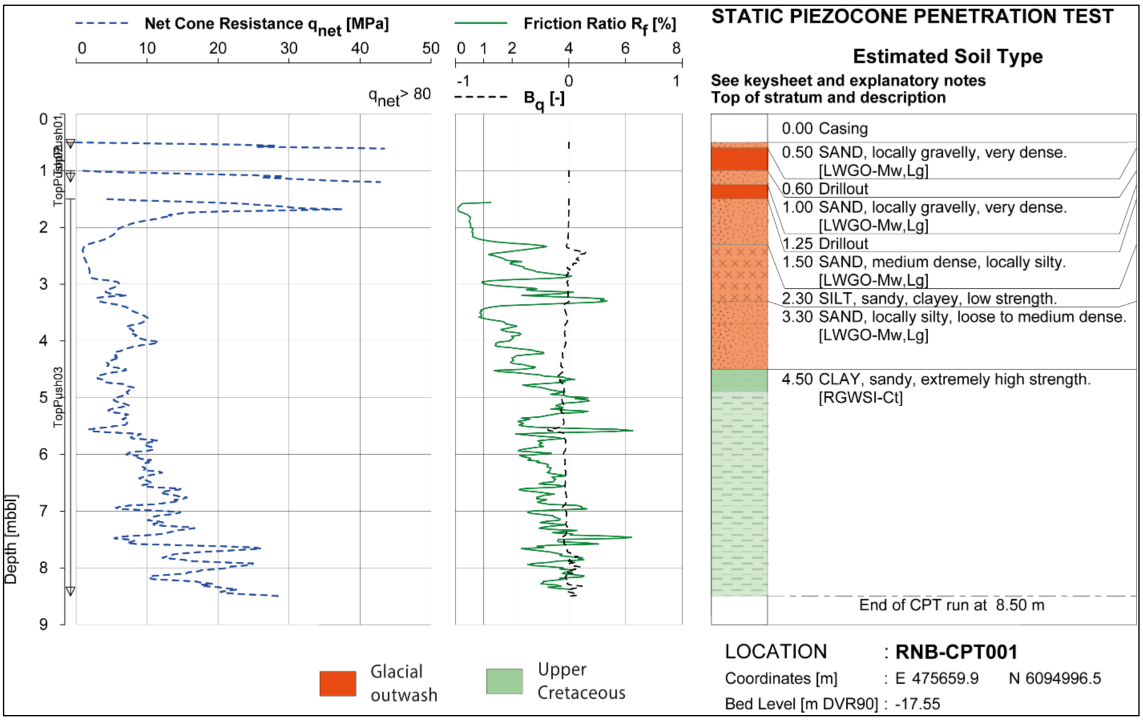


Figure 12.3 Example of CPT test with lithological interpretation on location RNB-CPT001. (ref. Energinet 2014 (d)).

12.3 Interpretation results

12.3.1 Sediment distribution

The Rønne Banke Site 6 survey area includes parts of the Rønne Fault, which appears at the seabed and is orientated north northeast to south-southwest across the survey area separating the Rønne Graben to the west, and the Arnager Block to the east (Figure 12.4).

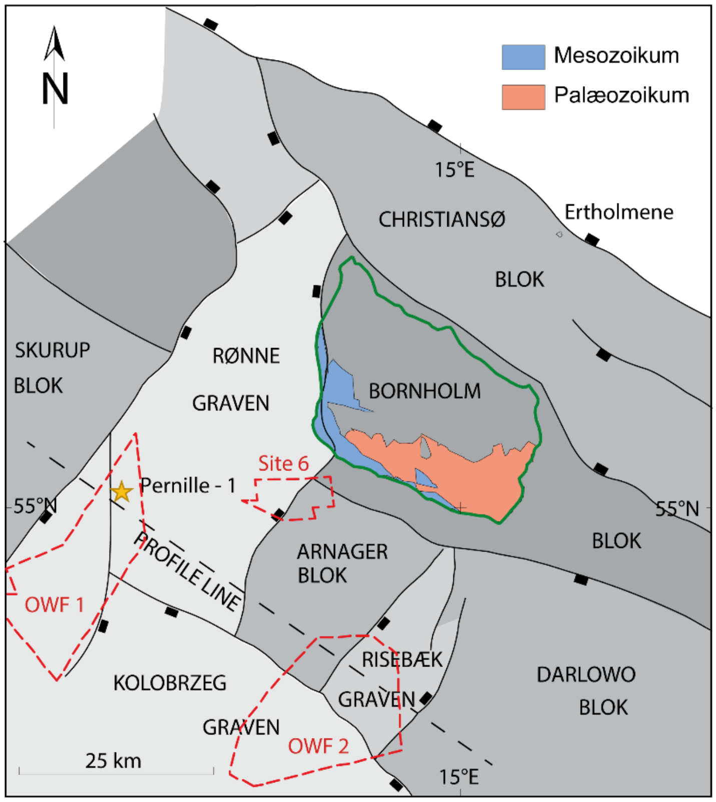


Figure 12.4 Major fault blocks of the Bornholm region. The fault pattern is based on Vejbæk & Britze (1994) and Vejbæk (1997). Location of Windfarm 1 and 2 as well as Site 6 is indicated. Profile line of Figure 4.3 is shown.

The block faulting complex described in Chapter 4 explains the reason for older sediments occurring west of the Rønne Fault than to the east (Figure 12.5).

The structural history has resulted in severe folding of the sediments on both sides of the fault. The sediments occurring at and within 50m of the seabed on the West side (Rønne Graben) consist predominantly of Early Jurassic to Late Cretaceous SANDS and SANDSTONES (variably consolidated) with occasional LIMESTONE and SHALE also with a possiblility of CLAY and COAL within 50m of the seabed (Figure 12.6). On the Eastern side of the Rønne Fault the sediments consist of interbedded, cemented SANDSTONES and unconsolidated SANDS. Outcrops of these sedimentary units occur at the seabed over much of the survey area predominantly to the east of the fault where thick beds of SANDSTONE are ridges at the seabed with troughs of sediment infill between where unconsolidated SANDS have been eroded (Figure 12.7). The ROCK outcrop to the west of the fault has a different character with smaller patches of more continuous exposure at the seabed displaying more uniform bedding planes. These patches are expected to consist predominantly of cemented SANDSTONE with minor hard LIMESTONE.

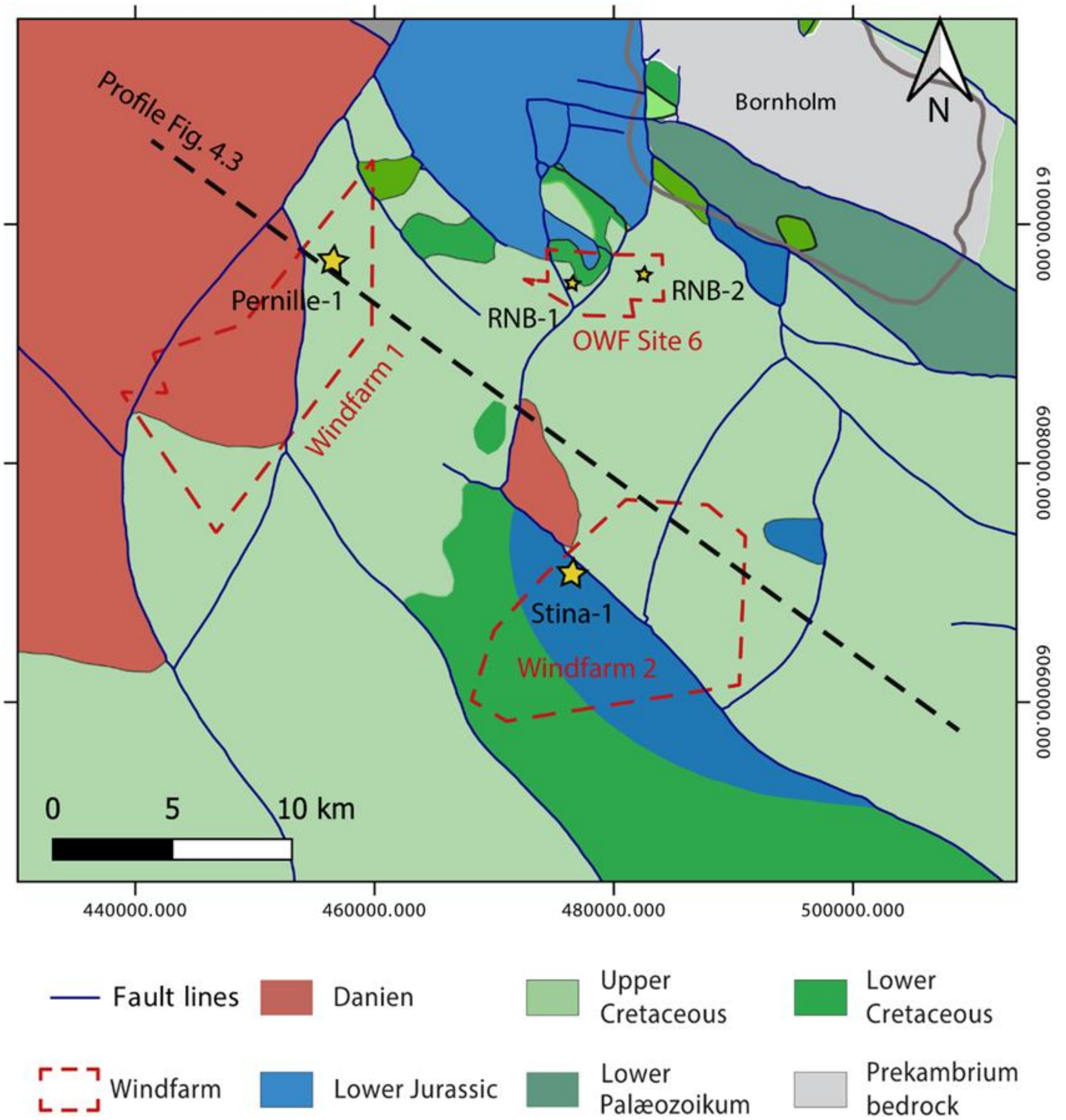


Figure 12.5 Major faults and pre-Quaternary stratigraphic units southwest of Bornholm. Location of Rønne Banke Site 6 survey area is located as well as stars representing deep wells.

Variable thickness of a glacial unit occurs at the seabed over most of the survey area where ROCK is not present at the seabed. This glacial unit infills an erosion surface in the bedrock and elsewhere forms a shallow veneer between outcrops (Figure 12.10). The glacial unit is expected to consist of SAND, GRAVEL and TILL in variable concentrations and reaches a maximum thickness of 43m in an extended channel orientated east-west across the northern half of the survey area (Figure 12.10). More localised eroded depressions infilled with glacial sediments occur on the southern and eastern margins of the survey area (Figure 12.6). A thin layer of post-glacial SAND occurs at the seabed in the west of the survey area overlying the glacial sediments. The unit reaches a maximum thickness of 4m near the western margin of the area and pinches out towards the north and east (Figure 12.9).

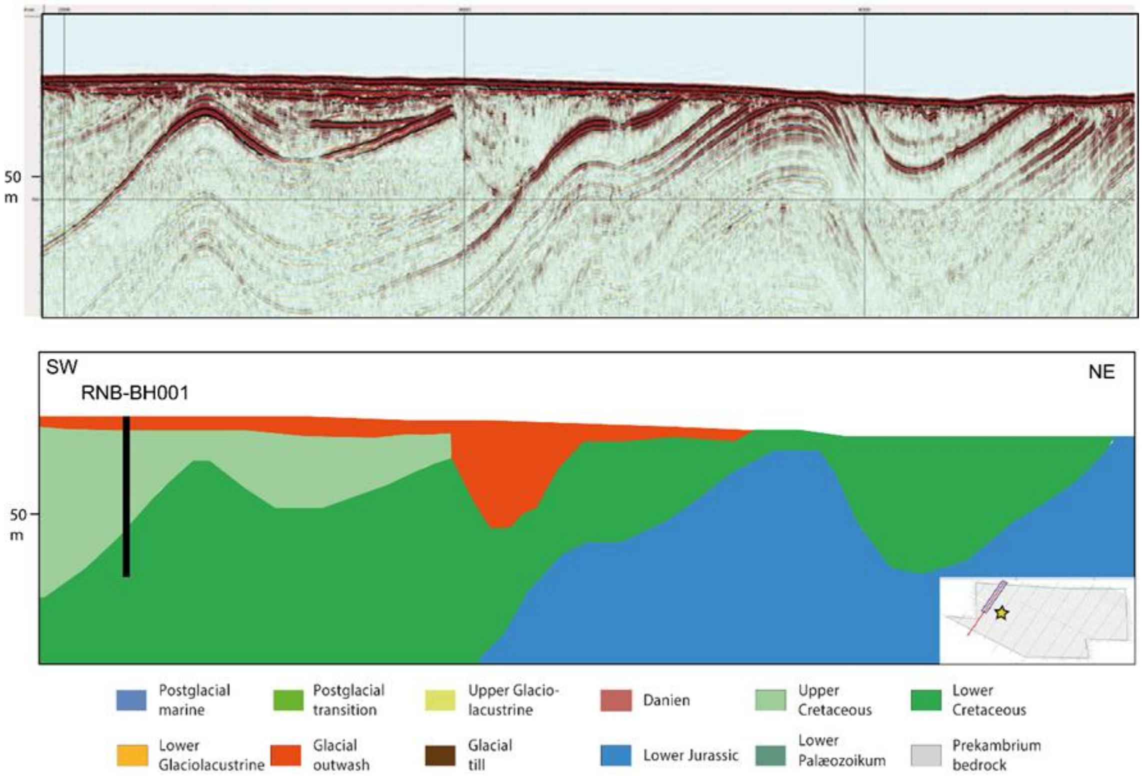


Figure 12.6 High Resolution Sparker multi-channel line XL_010 and below geological interpretation. Location is indicated at inset chart in lower right corner.

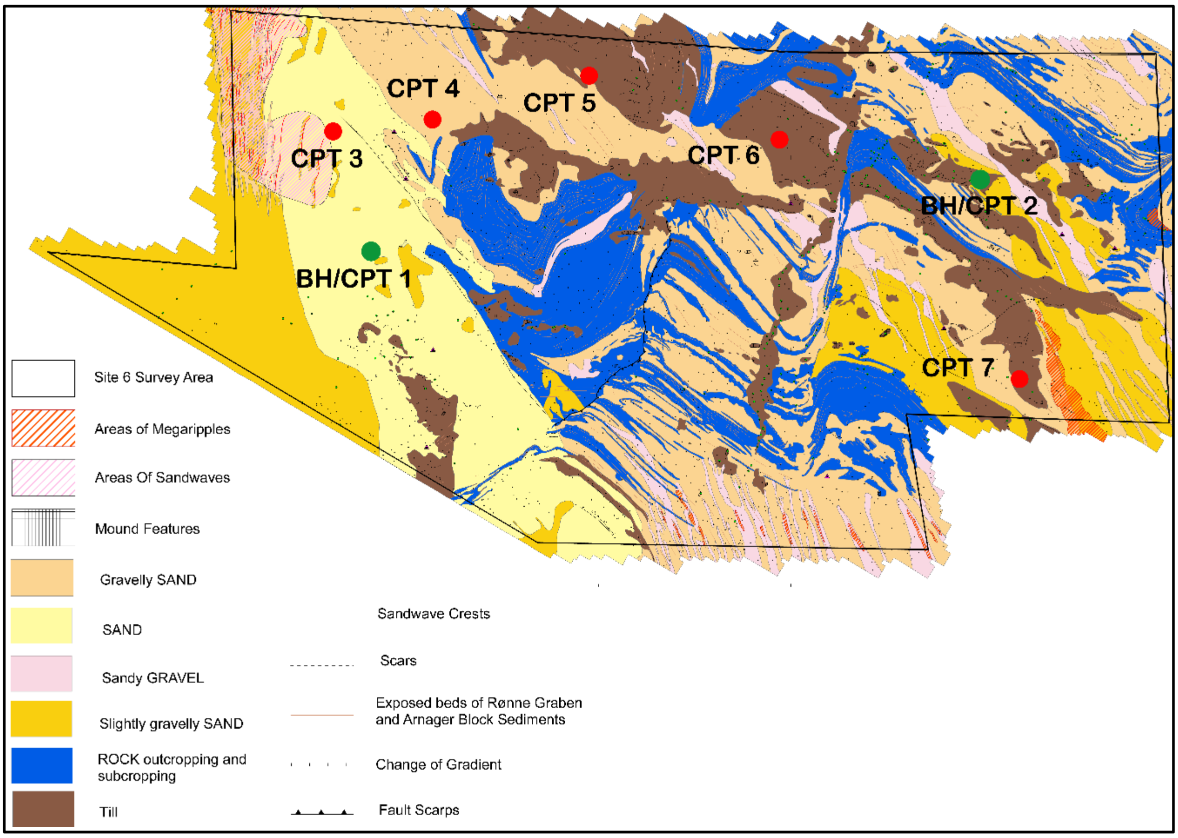


Figure 12.7 Seabed sediment map Rønne Banke Site 6. Surface sediment types and features are indicated as well as location of boreholes (BH 1 and BH 2) and CPT's (CPT 1 to CPT 7)

12.3.2 Sediment types and composition

The coring and CPT results revealed several sediment types that improves the understanding of the layers (detailed results in Energinet 2014 (c) and (d)). The combination of lithology geotechnical parameters and stratigraphy (Figure 12.8) provides the possibility of correlation to Windfarm 1 and 2.

		Interpreted Unit	Lithology	Stratigraphy	
	Glacial Sediments (GS)	Quaternary	marine sands outwash sand and gravel Till	Holocene Late glacial (Weichselian)	
Rønne	Arnager Block (AB)	Bavnodde Greensand Formation	Interbedded cemented and unconsolidated Glauconitic SANDS	Upper Cretaceous	Rønne
Fault	Rønne Graben (RG)	Bavnodde Greensand Formation	Interbedded cemented and unconsolidated Glauconitic SANDS	Upper Cretaceous	Fault
		Arnager Limestone Formation	Hard siliceous LIMESTONE (55-65% carbonate)	Upper Cretaceous	
		Arnager Greensand Formation	Basal CONGLOMERATE overlain by interbedded cemented and unconsolidated Glauconitic SANDS	Lower Cretaceous	
		Rabaeke Formation	Upper: SHALE interbedded with SAND Lower: Iron cemented SANDSTONE	Lower Cretaceous	
		Bagå Formation	Upper: Variably cemented SANDS Lower: Interbedded SAND, CLAY and COAL	Early to Middle Jurassic	

Figure 12.8 Stratigraphic diagram of Rønne Banke Site 6 on both sites of the Rønne Fault.

12.3.2.1 Holocene marine deposits

Thickness of Holocene marine deposits has been mapped in the southwestern part of Site 6 on basis of the seismic survey (Figure 12.9) and the geotechnical studies encountered, sand, clays, and possible organic clays in RNB-CPT003, RNB-CPT004, RNB-CPT005, RNB-CPT006 to a maximum depth of 4m below seabed (RNB-CPT003). From very loose to very dense occasionally silt, gravelly sand, to medium to extremely high strength sandy clays.

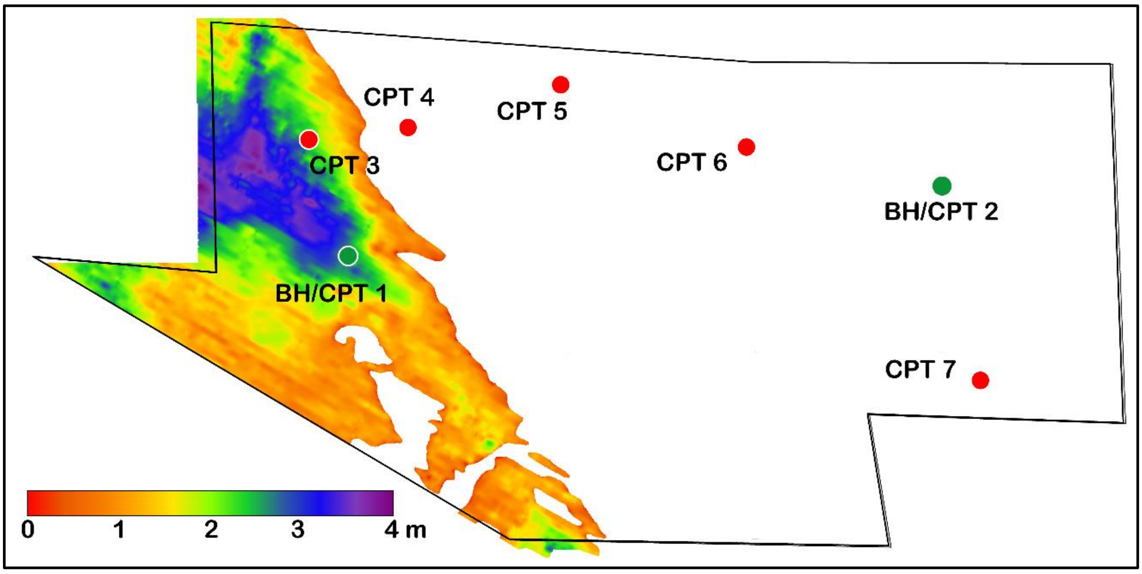


Figure 12.9 Thickness of Holocene marine deposits mapped form chirp seismic data. Locations of Boreholes and CPT's are located

12.3.2.2 Late glacial outwash deposits

Thickness of glacial to late glacial meltwater sand and till has been mapped (Figure 12.10) on basis of the seismic data and the geotechnical studies shows meltwater sand deposits in RNB-BH001, RNB-BH002 and RNB-CPT001 to a maximum depth of 6m below seabed. The fine and medium sand and gravel contains a variable content of clay and the gravel consist of granite, flint sandstone and siltstone.

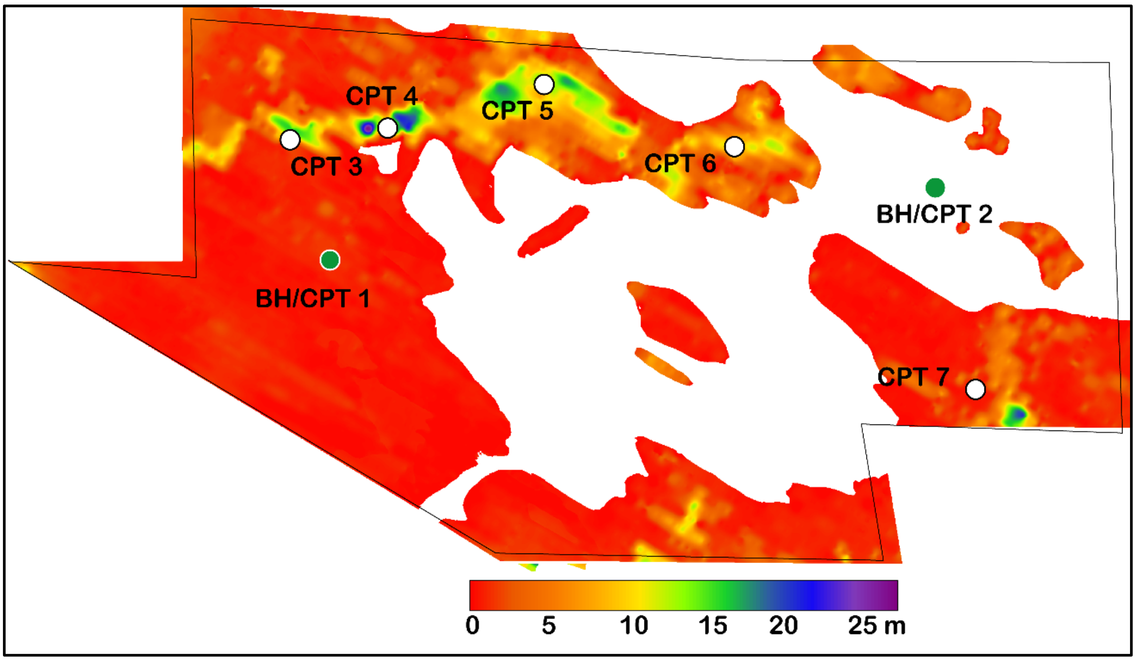


Figure 12.10 Combined thickness of glacial meltwater sand and till. Locations of Boreholes and CPT's are located.

12.3.2.3 Arnager Block weathered mudstone (possibly Till)

Arnager Block Weathered Mudstones is observed in positions RNB-CPT006 and RNB-CPT007 with a maximum thickness of 10m (RNB-CPT006). Based on interpretation of cone penetration tests it is anticipated that the mudstone generally comprises high to extremely high strength clays with mudstone clasts occasionally with interbeds of sand or weathered sandstone.

Combining the information from the seismic- and geotechnical studies leads to the conclusion that the interpreted mudstone must be clay till (Figure 12.7 and Figure 12.11).

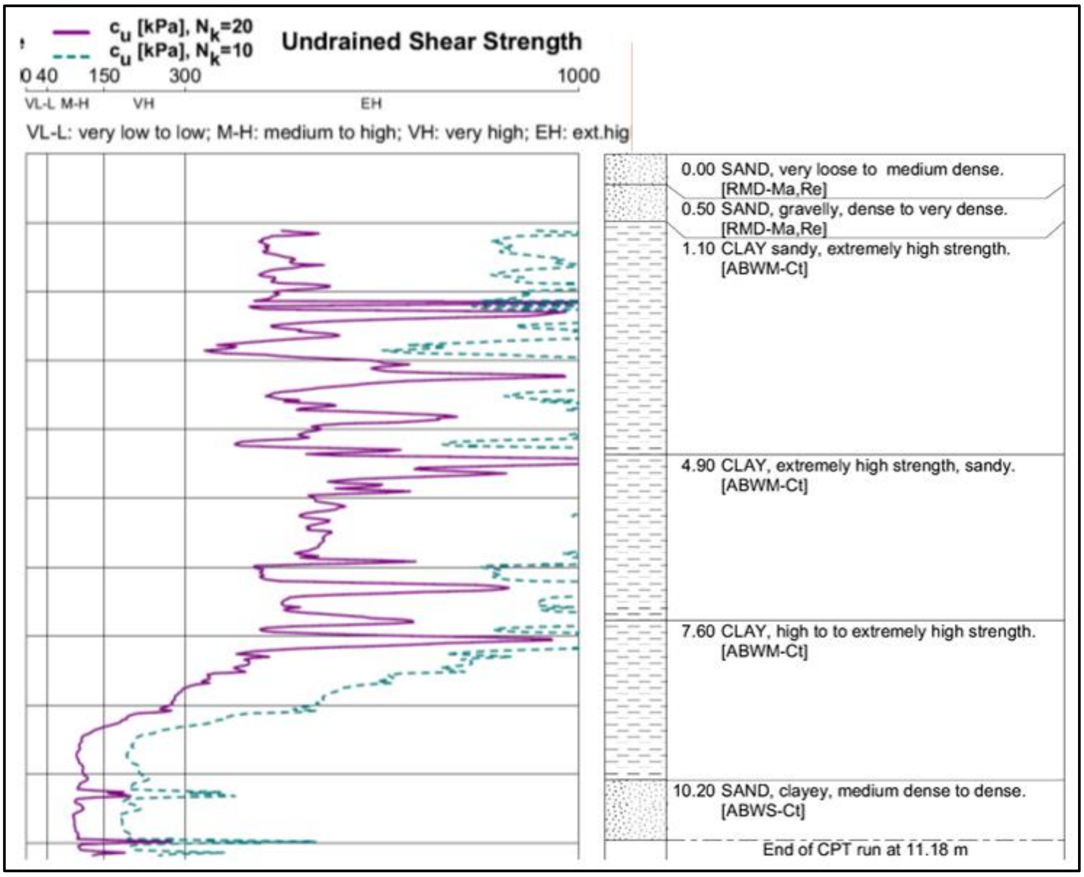


Figure 12.11 Undrained shear strength of RNB-CPT006 showing extremely high strength clay (till) to 10 m and medium high to high in the Bavneodde Greensand below (ref. Energinet 2014 (d)).

12.3.2.4 Arnager Block Sand/Weathered Sandstone (Bavneodde Greensand Formation)

The lithology represented by the strong reflectors consists of cemented glauconitic quartz sandstone (and occasional conglomerates) which form ridges on the sea floor; unconsolidated glauconitic sand gives rise to the weak reflectors. The sandstone was encountered in positions RNB-BH/CPT002, RNB-CPT6a and RNB-CPT7a, b.. Recorded to the bottom of RNB-BH002a 50m below seabed. Interpreted to be Upper Cretaceous Bavneodde Greensand Formation.

Medium high to high undrained shear strength is observed (Figure 12.11).

12.3.2.5 Rønne Graben Weathered Siltstone (Bavneodde Greensand Formation)

The Siltstone was encountered at positions RNB-BH/CPT001, RNB-CPT003a, RNB-CPT004a and RNB-CPT005 with a maximum depth of 39m below seabed at RNB-BH001.The siltstones are extremely weak to weak and the cone penetration test data indicates extremely high to high strength clays. The siltstone is interpreted as Upper Cretaceous Bavneodde Greensand Formation deposits.

12.3.2.6 Rønne Graben Limestone (Arnager Limestone Formation).

The limestone was encountered in RNB-BH001 35m below seabed, with a thickness of about 2m and described as a weak brecciated limestone, considered to be the Arnager Limestone Formation (Figure 12.8).

12.3.2.7 Rønne Graben Weathered Mudstone (Arnager Greensand Formation)

The mudstone is observed into locations RNB-CPT003a and RNB-CPT004a with a maximum penetrated depth 24m below seabed (RNB-CPT003a). The cone test data indicates medium to very high strength sandy and silty clays. Stratigraphically the unit is referred to be Lower Cretaceous Arnager Greensand Formation (Figure 12.8).

12.3.2.8 Rønne Graben Weathered Sandstone (Arnager Greensand Formation)

The sandstone was encountered at position RNB-BH001. The deposits comprised fine, well sorted, silty, dark greenish grey cemented sand. The unit is interpreted as Arnager Greensand Formation interbedded cemented and unconsolidated glauconitic sands (Figure 12.8).

12.4 Correlation of Rønne Banke Site 6 results to windfarm 1 and 2

Rønne Banke Site 6 is located close to Windfarm 1 and 2 with the obvious possibility of collecting useful information from the Site 6 previous work.

- Site 6 is located at water depths between 9 and 24m, in general shallower than Windfarm 1 and 2 (Figure 12.1). Only the north-western most part of Windfarm 2 reaches 22m water depths in a few hundred meters narrow rim.
- Due to the shallow water depths, unit II Early postglacial transition Yoldia clay and Ancylus clay, as well as unit III Late glacial glaciolacustrine Baltic Icelake deposits, from Windfarm 1 and 2 are not represented in the Rønne Banke Site 6 area.
- Until 4m thick Holocene marine sands from site 6 may be correlated to similar deposits in Windfarm 1 and 2.
- Seismic data from Site 6 reveals until 10m of till with geotechnical parameters described in RNB-CPT006, probably well suited for comparison with Windfarm 1 and 2 till deposits.
- Pre-quaternary deposits represented by coring and CPT's includes Upper Cretaceous Bavneodde Greensand and Arnager Limestone as well as Lower Cretaceous Arnager

Greensand. Detailed information of geotechnical parameters may be found in reference Energinet 2014 (c) and (d), possibly well representing similar deposits in Windfarm 1 and 2.

13. Archaeological interests

In addition to geotechnical interests in a detailed geological model for the Bornholm OWF areas, it is also of great interest for an archaeological screening, to understand the development and distribution of land and lake/sea after the last deglaciation.

As described in Chapters 9 and 10, highstand water-level characterised the initial period after the deglaciation of the Bornholm area. The Bornholm area was deglaciated shortly after 15000 years BP and the planned Bornholm OWF areas were covered by the glaciolacustrine Baltic Ice Lake (Figure 13.1). This corresponds to the archaeological Hamburg culture or Hamburgian (15500–13100 years BP) – a Late Upper Palaeolithic culture of reindeer hunters.

The highstand period was followed by an abrupt regression and development of an erosional unconformity at around 12800 years BP. During the lowstand period the water level was about 40 m below present sea level. This means that the shallowest parts of the wind farm areas would have been dry land. However, the lowstand period was short-lived and followed by a rapid transgression. A new lowstand period is dated to ca. 11700 years BP, this time the water level was ca. 45 m below sea level and Bornholm was a peninsula connected to mainland Europe ((Figure 13.1). Larger parts of the wind farm areas would have been exposed. However, this second lowstand period was also short-lived and soon followed by a new rapid transgression. The new lowstand period corresponds to the early part of the Maglemose Culture (Figure 13.1).

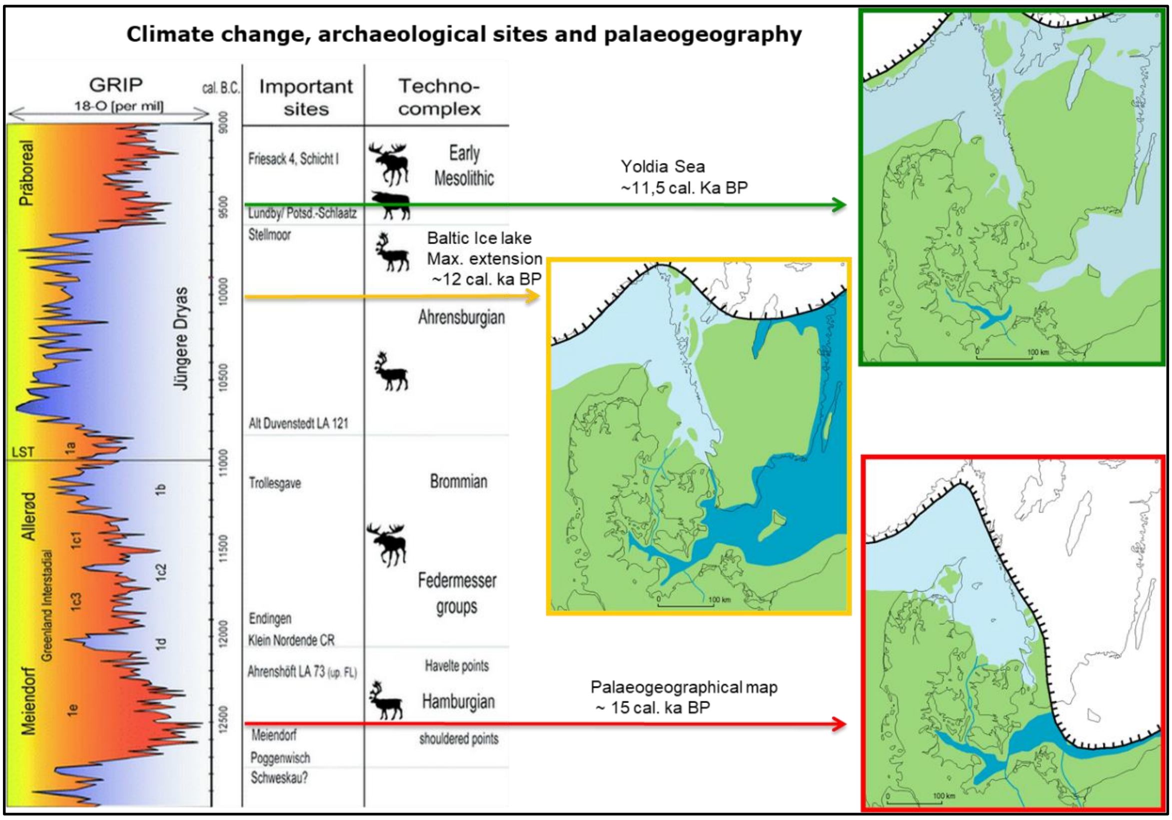


Figure 13.1. Late glacial and Holocene general palaeogeography in the Danish area and related archaeological cultures. The maps are from Jensen et al. (2003).

In contrast to the wind farm areas, the shallow-water parts of the cable corridors and the Rønne Banke Site 6 survey area would have been dry land for long periods. Submerged archaeological settlements from the Maglemose, Kongemose and Ertebølle Cultures are for example known from Mecklenburg Bay off northern Germany (Schmölcke *et al.* 2006; Hartz *et al.* 2011; Lübke *et al.* 2011). The chances to find submerged archaeological settlements are probably small in the Bornholm area due to the fetch and high energy environment. The chances are much higher along the east coast of Zealand, which is protected from the dominating westerly winds - and submerged finds have for example been made in Køge Bugt and near Amager.

14. Conclusions

In this study we have used a combination of published work, archive seismic and sediment core as well as CPT data, to assess the general geological development of the south-western Baltic Sea region, including the planned Bornholm OWFs.

A geological description has been provided and a geological model presented.

As a result of the geological desk study, it has been possible to present a relative late glacial and Holocene sea-level curve for the area and to describe the development relevant for an archaeological screening.

A number of focal points are relevant for the future geotechnical and archaeological evaluation of the area:

- The study area is in the Fennoscandian border zone characterised by pre-Quaternary dextral wrench faulting. A combination of archive data allows a tentative interpretation of the distribution of pre-Quaternary formations.
- Rønne Banke Site 6 coring and CPT data gives information about Upper and Lower Cretaceous sediment geotechnical parameters.
- Studies of the Bornholm Basin indicate that late glacial clay shows that neotectonic activities has created elongated restricted basins with syn-sedimentary infill that has continued into the Holocene. Recent earthquakes are rare in the area and points to limited recent seismological activity.
- Traces of acoustic disturbance on seismic profiles has been observed in the Quaternary sediments above fault zones and may be related to thermogenic degassing from deeper structures. Acoustic gas indications in Holocene sediments may be related to Neogene degassing.
- Glacial till ridges has been recorded at Adler Ground south east of the Bornholm OWF 1 area and similar features may be found in other areas.
- Till deposits has been mapped in Rønne Banke Site 6 and CPT data gives information on possible geotechnical parameters in Windfarm 1 and 2.
- Weakly consolidated late glacial clay (Baltic Ice lake I and II) with a thickness of up to 20 m covers most of the Bornholm OWFs area and must be taken into consideration.
- In OWF 2 early Holocene freshwater unconsolidated lake clay is deposited, it attains a thickness of up to 10 m.
- In connection with the Holocene transgression of the area, the deeper parts of the OWF’s have been draped by a relatively thin layer of mud and sandy mud, with high contents of organic material and geotechnical challenges must be expected.

- The late glacial and early Holocene coastal zone development of the Bornholm OWFs area and eastern cable corridor opens for an archaeological interest window in the time period for the Ahrensburg and Maglemosian cultures, whereas the area was transgressed by the sea under the time windows of younger cultures.

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Appendix A Site M0065

Site M0065[1]

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Chapter contents

Introduction

During Integrated Ocean Drilling Program (IODP) Expedition 347, cores were recovered from three holes at Site M0065 (Bornholm Basin), with an average site recovery of 99%. The water depth was 84.3 m, with a tidal range of <10 cm. Existing data sets, including seismic reflection profiles, were evaluated prior to coring to attempt to guide the initial drilling with an anticipated lithologic breakdown. The total time spent at this station was 2.59 days.

Operations

Transit to Hole M0065A

The vessel left Hole M0064D for Site M0065 (proposed Site BSB-7) in the Bornholm Basin at 1200 h on 23 October 2013. Position was established over Hole M0065A at 1400 h on 23 October, and operations commenced with a camera survey (Table **T1**).

Hole M0065A

A remotely operated vehicle survey was carried out on a transect over the locations for Holes M0065A, M0065B, and M0065C. This was required by the risk assessment for this site because of the possibility of chemical contaminants being present at the seabed. Following the survey, coring operations commenced. The uppermost 2 m was washed down, to avoid contamination, and additional personal protective equipment (PPE) was worn for the first run. The first run was recovered at 1850 h, and coring continued smoothly, with eight cores recovered before midnight.

Coring in Hole M0065A continued on 24 October 2013. Initially, piston coring was used to recover the clay lithologies before switching to a combination of open holing and hammer sampling in order to maximize recovery in the sandier lithologies. This continued to 73.90 mbsf, when bedrock was encountered. The hole was then flushed with mud and prepared for downhole logging, with the pipe tripped back to 14 meters below seafloor (mbsf).

Logging operations started in Hole M0065A on 24 October with rigging up the Weatherford logging setup. The first tool string comprised the total gamma ray and induction tools and reached 42 mbsf, where the uplog commenced. The second tool string

[1]Andrén, T., Jørgensen, B.B., Cotterill, C., Green, S., Andrén, E., Ash, J., Bauersachs, T., Cragg, B., Fanget, A.-S., Fehr, A., Granoszewski, W., Groeneveld, J., Hardisty, D., Herrero-Bervera, E., Hyttinen, O., Jensen, J.B., Johnson, S., Kenzler, M., Kotilainen, A., Kotthoff, U., Marshall, I.P.G., Martin, E., Obrochta, S., Passchier, S., Quintana Krupinski, N., Riedinger, N., Slomp, C., Snowball, I., Stepanova, A., Strano, S., Torti, A., Warnock, J., Xiao, N., and Zhang, R., 2015. Site M0065. *In* Andrén, T., Jørgensen, B.B., Cotterill, C., Green, S., and the Expedition 347 Scientists, *Proc. IODP,* 347: College Station, TX (Integrated Ocean Drilling Program).
doi:10.2204/iodp.proc.347.109.2015
[2]**Expedition 347 Scientists' addresses.**

comprising total gamma ray and spectral gamma ray tools reached only 16 mbsf. The decision was taken to run in hole with the drill pipe to 45 mbsf and do a wiper trip of the hole. After this, rig up for logging started again. The tool string with total gamma ray and spectral gamma ray was deployed again but only reached 20 mbsf. Following this attempt, downhole logging operations terminated.

A total of 28 cores and 15 open-hole sections were recovered from Hole M0065A to a maximum depth of 73.90 mbsf. Hole recovery was 99.19% when the open-hole sections were discounted.

Hole M0065B

The vessel moved under dynamic positioning to Hole M0065B, arriving on site at 2230 h on 24 October 2013, when operations commenced. To avoid potential chemical contamination at the surface, the hole was washed down to 3 m before coring commenced.

On the morning of 25 October (to 1010 h) coring operations ran smoothly, with 13 piston cores recovered and 2 hammer samples conducted in sandier material at the base of the hole. The final hammer sample recovered a smear of sand, and it was decided that no further penetration was required at this hole.

A total of 16 cores were recovered from Hole M0065B to 49.30 mbsf, with two open-hole sections. Hole recovery was 99.28% when the two open-hole sections (5 m) were removed from the calculation.

Hole M0065C

The vessel bumped over to begin coring Hole M0065C at 1110 h on 25 October 2013. Again, the hole was washed down to 2 mbsf and appropriate PPE was worn for the initial core run. Piston coring continued until 0010 h on 26 October, when the hole ended at 47.9 mbsf. The drill floor was then prepared for downhole logging operations.

Logging operations started in Hole M0065C on 26 October at 0105 h with rigging up the Weatherford logging setup after the drill pipe was tripped to 14 mbsf. The first tool string comprising total gamma ray, spectral gamma ray, and sonic tools reached ~40 mbsf, where an uplog was started. The second tool string with total gamma ray and microimager tools reached 40 mbsf, and a high-resolution uplog was performed. Logging operations were finished at 0330 h.

A total of 14 cores were recovered from Hole M0065C to 47.9 mbsf, with one open-hole section at the top of the hole. Hole recovery was 99.61% when the open hole-section was discounted.

Lithostratigraphy

At Site M0065, cores were recovered from three holes (M0065A–M0065C) at a water depth of 84 m. Hole M0065A reached a total depth of 73.9 mbsf, Hole M0065B reached 49.3 mbsf, and M0065C reached 47.9 mbsf. In Hole M0065A, core recovery was very low in the lowermost part, so core material available for onshore description only includes sediment to 46.6 mbsf.

Site M0065 is located in the vicinity of a World War II ammunition dump, and special precautions were required. In Hole M0065A, the uppermost 2 mbsf was washed down to avoid contamination and additional PPE was worn for the first run (see **"Operations"**). Gas expansion characterized the upper few meters, whereas the lower part was in general only slightly disturbed by coring.

Piston coring was carried out down to a hard sand layer at 46 mbsf before switching to a combination of open holing and hammer sampling to maximize recovery in the sandier lithologies (see **"Operations"**). This continued to 73.90 mbsf, where bedrock was encountered. Holes M0065B and M0065C followed the same procedure but were stopped as they entered the hard sand layer. Hole M0065C was dedicated to microbiological sampling.

Lithostratigraphic divisions are based on descriptions on the cut face of the split core from Holes M0065A and M0065B, which gives the most complete composite record of Holocene and late glacial sediments, with a core recovery of ~95% for the uppermost 40 m. Supplementary information is collected from Hole M0065C in addition to smear slide studies.

Site M0065 is divided into three lithostratigraphic units (Units I–III; Figs. **F1, F2**). Unit I (0–9 mbsf) is composed of organic-rich clays containing fragments of bivalve shells and organic remnants. Unit II (9–13 mbsf) is gray clay dominated by iron sulfide lamination in the upper part; freshwater diatoms were found in a smear slide. The lowermost Unit III is divided in three clay subunits: Subunit IIIa (13–36 mbsf) is grayish brown contorted clay, Subunit IIIb (36–36.6 mbsf) is dark gray homogeneous clay, and Subunit IIIc (36.6–49 mbsf) is interlaminated clay and silt gradually grading downward to silt and sand with a few dispersed pebbles.

At the Onshore Science Party (OSP), no samples deeper than 49 mbsf were available, as samples had been utilized offshore for either optically stimulated luminescence dating or palynological and sedimentological inspection. However, offshore data reported that very well sorted sand was collected to 68 mbsf, where it changed into sandy silt and became gradually more like a diamicton. At ~74 mbsf, the Mesozoic (Cretaceous) bedrock was reached.

Unit I

Intervals: 347-M0065A-2H-1, 0 cm, to 4H-1, 58 cm; 347-M0065B-2H-1, 0 cm, to 3H-3, 33 cm; 347-M0065C-2H-1, 0 cm, to 4H-1, 62 cm

Depths: Hole M0065A = 2–9.18 mbsf; M0065B = 3–9.63 mbsf; M0065C = 2–9.22 mbsf

Unit I consists of very well sorted dark greenish gray organic-rich clay with weak lamination by color due to uncommon bioturbation (Fig. F2). The general stratification is overprinted by intervals of black bands with sharp bases. Dispersed shell fragments are found down to the lowermost transition zone with Unit II, where ~10 cm of prominent laminations at the millimeter scale and no bioturbation are found. The boundary with Unit II is gradual.

Smear slide data (see "Core descriptions") show, in general, very low silt and sand contents, remarkable contents of opaque authigenic minerals, and the existence of large centric diatoms. Organic debris is common, possibly algal or plant debris.

The organic-rich clay with bioturbated weak lamination and intervals of black bands is interpreted to indicate general oxic conditions in the marine Holocene sediments of the Bornholm Basin, whereas the lowermost laminated transition zone may represent an initial anoxic phase, similar to the anoxic phases reported in the Eastern Gotland Basin (Zillén and Conley, 2010).

Unit II

Intervals: 347-M0065A-4H-1, 58 cm, to 5H-1, 130 cm; 347-M0065B-3H-3, 33 cm, to 5H-1, 95 cm; 347-M0065C-4H-1, 62 cm, to 5H-2, microbiology sample

Depths: Hole M0065A = 9.18–13.20 mbsf; Hole M0065B = 9.63–13.85 mbsf; Hole M0065C = 9.22 mbsf through microbiology sample

In Unit II, organic content diminishes and the clay is gray to dark gray (Fig. F2). The clay is laminated by color with very fine dark gray iron sulfide–rich laminae at 2–3 mm scale. Downhole, the number of laminae decreases and is substituted by black spots and specks, as well as homogeneous gray intervals. In the lowermost part, a gradual transition to brown clay is observed.

Smear slide studies (see "Core descriptions") show, as with Unit I, typical very low sand and silt contents and fragments of freshwater colonial "lake-dump" diatoms with complete valves of centric diatoms.

Sulfide migration downhole from the upper organic-rich Unit I sediment is a likely example of diagenetic iron sulfidization enhancing Unit II laminations. Alternatively, this migration may be the result of breakdown of primary organic material in the laminations. The smear slide observations of lake-dump diatoms indicate freshwater lake deposition and iron sulfide–laminated clay deeper than the lacustrine Holocene clay that was previously documented as Ancylus Lake sediment (Andrén et al. 2000b).

Unit III

Subunit IIIa

Intervals: 347-M0065A-5H-1, 130 cm, to 12H-1, 105 cm; 347-M0065B-5H-1, 95 cm, to 12H-1, 10 cm; 347-M0065C-5H-2 through microbiology sample

Depths: Hole M0065A = 13.20–36.05 mbsf; Hole M0065B = 13.85–36.10 mbsf; Hole M0065C microbiology sample

Subunit IIIb

Intervals: 347-M0065A-12H-1, 105 cm, to 12H-2, 15 cm; 347-M0065B-12H-1, 10 cm, to 12H-1, 80 cm; Hole M0065C microbiology sample

Depths: Hole M0065A = 36.05–36.65 mbsf; Hole M0065B = 36.10–36.80 mbsf; Hole M0065C microbiology sample

Subunit IIIc

Intervals: 347-M0065A-12H-2, 15 cm, to end of 15H; 347-M0065B-12H-1, 80 cm, through 17S-1; Hole M0065C microbiology sample

Depths: Hole M0065A = 36.65–46.60 mbsf; Hole M0065B = 36.80–49.20 mbsf; Hole M0065C microbiology sample

In Subunit IIIa, the clay color shifts to grayish brown (Fig. F2). The very well sorted clay shows weak lamination by color with a few silt laminae at the millimeter scale. However, the larger intervals are characterized by a massive to contorted (marble structure) appearance. In addition, the unit is characterized by numerous dispersed gray clay/silt intraclasts of millimeter to centimeter scale. Subunit IIIa has a sharp lower boundary. Smear slide studies (see "Core descriptions") show very homogeneous clay with barely any silt and sand content, as well as traces of authigenic minerals characterized by numerous brown flakes, possibly biotite.

Another color change characterizes Subunit IIIb, which consists of dark gray homogeneous clay with weak light–dark color banding and a sharp lower boundary (Fig. F2).

Subunit IIIc, the lowermost subunit, consists of very well sorted grayish brown silty clay with parallel lamination (Fig. F2). Color change on a millimeter to centimeter scale defines the clay lamination, and millimeter-scale silt laminations are common. Downhole, the unit coarsens to a fine to medium sand with laminated silt interbeds and in the lowermost few meters to massive medium-grained sand with few dispersed pebbles.

Smear slide studies (see "Core descriptions") reflect the observed coarsening of grain size. Detrital carbonate is found in all grain sizes up to fine gravel, as well as angular to subrounded quartz sand grains. Reworked foraminifers, rounded oxidized ferromagnesian minerals, and glauconite grains are likewise common.

Unit III is interpreted as a glacial lake deposit. The weak lamination combined with massive and contorted sedimentary structures, as well as clay intraclasts in Subunit IIIa, may be indicative of slumping in an unstable sloping environment with high sedimentation rates. Subunits IIIb and IIIc represent earlier more stable phases of the glaciolacustrine environment. The rhythmically banded clays, increased grain size, and frequency of sand laminations indicate that the lower part is deposited in a more ice-proximal setting.

Biostratigraphy

Diatoms

Hole M0065A was qualitatively analyzed for siliceous microfossils. Unevenly distributed samples were analyzed in Core 347-M0065A-15H (~43 mbsf) (Fig. F3). All 69 diatom taxa found at Site M0065 were identified to species level, with the exception of *Chaetoceros* resting spores, which were recorded if present (Tables T2, T3). Chrysophyte cysts were divided into different morphotypes based on the morphology of their silica cell walls.

The results of the qualitative diatom analyses of Hole M0065A are summarized in a graph showing the number of taxa found divided into different salinity affinities and life forms (planktonic, periphytic, and sea ice) (Fig. F3). Diatoms were classified with respect to salinity tolerance according to the Baltic Sea intercalibration guides of Snoeijs et al. (1993–1998), which divide taxa into five groups: marine, brackish-marine, brackish, brackish-freshwater, and freshwater. Furthermore, if present, other siliceous microfossils found (silicoflagellates, ebridians, and chrysophyte cysts) are recorded (Fig. F3).

2 to ~9 mbsf

The preservation of diatoms is considered poor in this sequence based on the finding of corroded valves and the absence of finely silicified taxa. There is also a high abundance of fractured diatoms and a low overall abundance of diatoms in general throughout this sequence, in accordance with previous studies from the area (Abelmann, 1985; Thulin et al., 1992; Andrén et al., 2000b). Poor preservation may result in overrepresented valves with thick cell walls (e.g., *Paralia sulcata* or the spines of *Pseudosolenia calcar-avis*). This sequence records a brackish-marine assemblage of medium diversity with a high proportion of periphytics. The ice-associated taxon *Fragilariopsis cylindrus* is recorded at one level (Fig. F3).

The silicoflagellate *Dictyocha speculum* and ebridian *Ebria tripartita* are both recorded at two levels, and chrysophyte cysts are recorded with various morphotypes throughout the sequence (Fig. F3).

9–11.4 mbsf

This sequence is dominated by taxa that indicate large lake conditions (i.e., *Aulacoseira islandica*, *Stephanodiscus neoastraea*, *Cocconeis disculus*, *Navicula jentzschii*, *Aneumastus tusculus*, and *Cymatopleura elliptica*) (cf. Hedenström and Risberg 1999). This probably indicates the conditions of the final freshwater phase of the Yoldia Sea stage of Baltic Sea history and/or the Ancylus Lake. These two stages are not easily distinguished in the diatom stratigraphy in the open Baltic Basin because there is no change in salinity (Sohlenius et al., 1996). However, more detailed study with careful diatom counts may show a response to the transgression that defines the transition from the Yoldia Sea stage to Ancylus Lake (Andrén et al., 2011). Abelmann (1985) records high primary production at the beginning of the Ancylus Lake and suggests that the silica supply was high and that valves were less affected by dissolution. A similar observation is made by Andrén et al. (2000b), who found that the preservation of diatoms is good and redeposition of valves less likely. There is no obvious transition (i.e., initial Littorina Sea stage) recorded between this sequence and the succeeding brackish-marine sequence.

Chrysophytes are recorded occasionally in this sequence, exclusively as a morphotype with smooth cell walls.

Core depth interval 11.9 mbsf

A single sample records a diatom assemblage with >50% brackish-freshwater and brackish water taxa. It contains a fairly diverse assemblage with both planktonic and periphytic components (e.g., brackish-freshwater *Gyrosigma acuminatum* and *Thalassiosira baltica* and brackish *Brachysira aponina* and *Chamaepinnularia witkowskii*) (Fig. **F3**). This single sample might reflect the brackish phase of the Yoldia Sea stage of Baltic Sea history, but it does not contain the dominance of *T. baltica* that characterizes the assemblage in other parts of the Baltic Basin (cf. Lepland et al., 1999; Paabo, 1985; Andrén et al., 2000a, 2002). According to Abelmann (1985), the Arkona Basin and the southern Bornholm Basin contain no brackish Yoldia Sea stage flora. This is further discussed in Andrén et al. (2000b) in a study from the Bornholm Basin. Because we analyzed a single sample, a more thorough study should be conducted to enable conclusions about the southern extension of the brackish water influence during the Yoldia Sea stage to be drawn.

Core depth interval 12.6 to ~43 mbsf

The lowermost analyzed sequence of Hole M0065A was devoid of siliceous microfossils (Fig. **F3**).

Foraminifers

Results are summarized for the samples taken offshore and onshore (i.e., samples taken from core catchers and regular sections). A total of 55 samples were processed from Holes M0065A, M0065B, and M0065C for the presence of foraminifers (Table **T4**).

Although Sites M0064–M0066 (located in Hanö Bay and Bornholm Basin) are located close to each other, Site M0065 is the only one at which foraminifers occur. Benthic foraminifers occur from the first core (which begins at 2 mbsf) to 8.90 mbsf with the maximum abundance between 3.17 and 6.62 mbsf (common to abundant) (Fig. **F4**). A single foraminifer occurs in Sample 347-M0065A-4H-CC at 12.12 mbsf.

Hanö Bay and Bornholm Basin today have bottom water salinities between 12 and 17 (Samuelsson, 1996), which is intermediate between the salinities of Landsort Deep and Little Belt. The foraminiferal assemblage indeed reflects this, as *Elphidium* spp. still dominate but show more species diversity within the genus. The faunal assemblage is composed of *Elphidium excavatum* f. *clavata*, *Elphidium excavatum* f. *selseyensis*, *Elphidium williamsoni/Elphidium gunteri*, *Elphidium incertum*, and *Haynesina* spp. A similar assemblage was previously described for the Pomeranian Bight, located just southwest of the island of Bornholm (Frenzel et al., 2005).

The highest diversity of species occurs in the same range where the abundance is also highest. This would suggest that bottom water salinity was slightly higher during this time period, which is also in accordance with the ostracod results (see **"Ostracods"**). The occurrence of *Haynesina* sp. around 3.8–4.7 mbsf (Hole M0065B) suggests elevated salinity (~20) compared to the previous and subsequent periods (i.e., more similar to typical assemblages from farther west) (Frenzel et al., 2005; Anjar et al., 2012). When diversity decreases, the remaining species are the *Elphidium* varieties, which are most adapted to harsher conditions.

Ostracods

A total of 52 samples (including 36 core catchers) from Holes M0065A, M0065B, and M0065C were examined for ostracods during the onshore phase of Expedition 347 at the Bremen Core Repository (Germany). Samples were studied in the >125 µm fraction. Ostracods were present in eight samples (Table **T5**).

Ostracod abundance per sediment volume from the three holes varies between 1 and 5 valves per 20 cm^3 sample and up to a maximum abundance of 42 valves per 20 cm^3 at ~8 mbsf (Hole M0065B) (Fig. **F5**). Maximum abundance of foraminifers occurs at ~3–7 mbsf, where common to abundant *Elphidium* tests were recorded (see **"Foraminifers"**). It is possible that salinity changes caused the difference in depths of abundance peaks for foraminifers and ostracods. A total of five taxa were identified for this site: *Palmoconcha* spp., *Robertsonites tuberculatus*, *Cytheropteron latissimum*, *Sarsicytheridea bradii*, and *Paracyprideis* sp.

Palmoconcha spp. is a predominant taxon found in six out of eight samples with ostracods in the interval of 5.73 to 8.88 mbsf (Holes M0065A–M0065C). *Palmoconcha* is a brackish to euhaline genus found at salinities of 10–14 and higher (Frenzel et al., 2010). The uppermost samples at 2.16 mbsf (Hole M0065A) and 3.16 mbsf (Hole M0065B) do not contain this taxon. *C. latissimum*, *R. tuberculatus*, *S. bradii*, and *Paracyprideis* sp. occur in these samples, indicating higher salinities and an open-sea marine environment.

It is possible that in the interval ~8–9 mbsf salinity is lower and less favorable for foraminifers, such that brackish water ostracods dominate. In the upper part of the record, salinity increases and foraminifers become more abundant, whereas brackish water ostracods decrease in abundance and are replaced with marine species.

Palynological results

Site M0065 is situated in the central part of the southern Baltic Sea. The vegetation of the borderlands in that region belongs to cool temperate forest zone with mixed coniferous and deciduous trees, but the boreal-forest vegetation zone is very close to the site. Palynological analyses for this site focused on Hole M0065A.

Four samples from Hole M0065A were analyzed in total. The two uppermost samples at 2.17 and 8.82 mbsf are characterized by high pollen concentrations (~64,000 and 89,000 pollen grains, respectively), whereas the two other samples (15.78 and 22.63 mbsf) are virtually barren of palynomorphs.

Taxa in samples at 2.17 and 8.82 mbsf are very similar. In both samples, *Pinus sylvestris* type pollen prevails (52% and 53.5%). Among broad-leaved trees, the highest percentages are for *Quercus* pollen (Fig. F6, No. 2): 13% for the sample at 8.82 mbsf and 21% for the one at 2.17 mbsf. *Betula alba* pollen occurs in low abundances: 10% and 6.5%, respectively. In the lower sample (8.82 mbsf), 4% of the total pollen encountered was *Tilia cordata* (Fig. F7).

Age estimates based only on these two pollen spectra are fairly difficult. Because of the location in the center of the southern Baltic Sea and the relatively large distance of Site M0065 to the coast, overrepresentation of *Pinus sylvestris* type and *Picea* pollen (both bisaccate) and far-distance transport from the eastern Baltic region into the site area cannot be ruled out. Fairly high *Quercus* and *Picea* percentages may, however, imply a late Atlantic/Subboreal age for these spectra (Kabailene, 2006). In addition to pollen grains, freshwater algae (e.g., *Botryococcus*) and a mandible of an aquatic insect larva (probably from *Endochironomus*) have been found in the uppermost sample (Fig. F6, No. 1). The only organic-walled dinoflagellate cysts encountered in the uppermost samples belong to the genus *Operculodinium*/*Protoceratium*. The specimens found show particularly short processes. The samples are likely to reflect very minor marine influence.

Geochemistry

Interstitial water

At Site M0065, freshwater and glaciolacustrine deposits are overlain by ~9 m of brackish-marine sediment (see **"Lithostratigraphy"** and **"Biostratigraphy"**). Because of safety reasons, the upper ~2 m of the sediment sequence was not sampled (see **"Operations"**). The brackish-marine deposit in this area is relatively thin compared to those at Sites M0059 and M0063, where they extend to ~47 and 30 mbsf, respectively. The pore water composition reflects a rise in salinity due to the transition from freshwater to brackish-marine conditions (Table T6).

Salinity variations: chloride, salinity, and alkalinity

Concentrations of chloride (Cl^-) are highest near the surface at ~250 mM and then decline to ~20 mM at depth (Fig. F8A). Pore water salinities from shipboard measurements determined with a refractometer and calculated from Cl^- concentrations show good agreement, with salinities derived from both measurements declining from ~15 to 1 across the sampled interval (Table T7; Fig. F8B–F8C). Alkalinity shows a broad maximum of ~40 meq/L from 3 to 10 mbsf, followed by a decline with depth to values of <5 meq/L (Fig. F8D). These results are in line with a transition from freshwater to brackish-marine conditions.

Organic matter degradation: methane, sulfate, sulfide, ammonium, phosphate, iron, manganese, pH, bromide, chloride, and boron

Methane (CH_4) is present to ~36 mbsf in the sediment (Fig. F9A; Table T8). Similar to Sites M0059 and M0063, observed scatter in CH_4 concentrations with depth is probably due to degassing upon core recovery, in particular shallower than ~25 mbsf. Deeper CH_4 concentrations gradually decrease following a smooth profile, suggesting that in this part of the sediment the measurements may reflect actual methane concentrations. Sulfate (SO_4^{2-}) concentrations in the pore water are generally <0.5 mM (Fig. F9B). The presence of sulfide (H_2S; ~0.7 mM) at depths shallower than ~5 mbsf suggests active SO_4^{2-} reduction in the upper part of the sediment (Fig. F9C). Pore water profiles of ammonium (NH_4^+) and phosphate (PO_4^{3-}) (Fig. F9D–F9E) follow the general trend of alkalinity (Fig. F8D), which is consistent with organic matter degradation as a dominant control. Dissolved iron (Fe^{2+}) and manganese (Mn^{2+}) show distinct maxima in the pore water (Fig. F9F–

F9G). Dissolved Fe^{2+} is mostly present in the former lake sediments (with concentrations as high as ~1000 µM), whereas dissolved Mn^{2+} is largely restricted to the brackish-marine sediments and peaks at ~250 µM. Pore water pH decreases from a value of ~8.1 near the surface to a broad minimum of ~7.5 at 17–25 mbsf. Deeper than this depth, pore water pH increases to a value of ~8 and then decreases to ~7.5 again.

The depth profile of dissolved bromide (Br^-) is similar to the chloride (Cl^-) profile, although the profile of Br/Cl does reveal a slight enrichment in pore water Br^- relative to Cl^- with depth (Fig. F10A–F10B). This increase may be linked to release of Br^- during the mineralization of marine organic matter. Dissolved boron (B) decreases from ~375 to 35 µM with depth (Fig. F10C). The maximum in B/Cl in the upper 5–10 m of the sediment may be indicative of release of B from the brackish-marine sediments (Fig. F10D).

Mineral reactions

Sodium, potassium, magnesium, and calcium

Depth profiles of sodium (Na^+), potassium (K^+), and magnesium (Mg^{2+}) resemble those of chloride (Cl^-), suggesting strong control by seawater (Fig. F11A–F11C). The depth profile of Ca^{2+} is distinctly different, however, with a maximum concentration at ~20 mbsf (Fig. F11D). In the upper 10–20 m of the sediment, ratios of Na/Cl, K/Cl, and Mg/Cl (Table T7) are elevated relative to seawater, suggesting release of these cations from the sediment (Fig. F11E–F11G). Low Na/Cl, K/Cl, and Mg/Cl ratios relative to seawater values deeper than 10–20 mbsf may suggest removal of cations to a solid phase. Deeper than ~30 mbsf, salinities are so low that comparison of the ratios is no longer meaningful. Ratios of Ca/Cl in the pore water are always higher than the seawater Ca/Cl ratio and increase strongly downcore. This profile suggests that Ca^{2+} is released from the sediment to the pore water (Fig. F11H), possibly through ion exchange and/or mineral dissolution.

Silica, lithium, barium, and strontium

Concentrations of dissolved silica (H_4SiO_4) and lithium (Li^+) are elevated in the upper 10–15 m of the sediment (Fig. F12A–F12B). This is possibly the result of enhanced mineral weathering or, for H_4SiO_4, dissolution of diatoms in the brackish-marine sediments. A large peak in barium (Ba^{2+}) concentrations is observed between 10 and 20 mbsf, followed by a decline with depth (Fig. F12C). This trend is similar to that observed at Site M0059 and may be due to release of Ba^{2+} from the sediment through ion exchange or mineral dissolution linked to the intrusion of seawater into former freshwater sediments. Pore water strontium (Sr^{2+}) shows a maximum concentration at 20 mbsf, possibly also reflecting release from solid phases (Fig. F12D).

Sediment

Carbon content

The total carbon (TC) content at Site M0065 varies from ~0.4 to 4.4 wt%, with high values in the topmost part of the profile and a pronounced minimum at the transition from freshwater to brackish-marine conditions (Table T9; Fig. F13A). Highest total organic matter (TOC) values (~4 wt%) are observed in the uppermost ~10 m of the investigated profile, possibly suggesting enhanced primary productivity and preservation of organic matter during the deposition of the brackish-marine sediments. The underlying freshwater and glaciolacustrine deposits are characterized by low TOC values that typically do not exceed 0.5 wt% (Table T9; Fig. F13B).

The depth profile of the total inorganic carbon (TIC) content shows minimum values (<0.7 wt%) in the uppermost 15 m of the sediment profile (Table T9; Fig. F13C). Deeper than this depth, the TIC content steadily increases, resulting in values above 3 wt% at the base of the investigated sequence.

Sulfur content

The total sulfur (TS) content ranges from 0.1 to 1.7 wt% (Table T9; Fig. F13D). The generally high TS (>1%) values in the brackish-marine deposits at the core top might be a result of sulfate reduction and the subsequent formation of iron sulfides in the sediments. In contrast, the underlying freshwater and glaciolacustrine sediments, which are characterized by only low sulfate concentrations, generally have TS values varying between 0.10 and 0.14 wt%. Note that the TS content, similar to the TOC content, slightly increases deeper than ~40 mbsf.

Physical properties

This section summarizes the preliminary physical property results from Site M0065. Three holes were drilled at this site. Hole M0065A was drilled to 73.9 mbsf, Hole M0065B to 49.3 mbsf, and Hole M0065C to 47.9 mbsf. Hole M0065C was designated as a microbiology hole and was extensively subsampled onboard (see "Microbiology") prior to any physical properties measurements except Fast-track multisensor core logger (MSCL). For each hole, the uppermost

2 m was washed down to avoid potential chemical contamination (see **"Operations"**). We focused on the physical property data from Hole M0065A, which has the greatest penetration (Fig. **F14**), though the core recovery was very low from 46.6 mbsf because of changing coring methods from piston coring to open-hole intervals with spot hammer sampling (see **"Operations"**). Although all physical property measurements described in **"Physical properties"** in the "Methods" chapter (Andrén et al., 2015a) were conducted for Site M0065, thermal conductivity data are too sparsely distributed to exhibit any discernable downcore trend.

Natural gamma radiation

High-resolution natural gamma ray (NGR) values are relatively low (<10 cps) and increase progressively from the core top to the lower interval of lithostratigraphic Unit I (Fig. **F14;** see **"Lithostratigraphy"**), with few positive excursions observed. These generally low NGR values are interpreted as a result of high water content within organic-rich muds. At the Unit I/II boundary, NGR values decrease and then exhibit increasing values toward the base of lithostratigraphic Unit II (~15 cps). NGR exhibits relatively constant values in lithostratigraphic Subunit IIIa, with several negative excursions from the overall trend that might reflect the presence of silt intraclasts. NGR values decrease slightly (~12 cps) within lithostratigraphic Subunit IIIb. Lithostratigraphic Subunit IIIc is distinguished by gradually decreasing values toward the bottom of the hole. Variability in NGR likely reflects a coarsening-downward sequence from silty clay to medium sand through lithostratigraphic Subunit IIIc.

Shipboard magnetic susceptibility and noncontact resistivity

Magnetic susceptibility is overall generally low ($<5 \times 10^{-5}$ SI) and increases slightly toward the base of lithostratigraphic Unit I (Fig. **F14**). Magnetic susceptibility is higher in lithostratigraphic Unit II and remains relatively constant, except for an abrupt spike ($\sim 55 \times 10^{-5}$ SI) observed at ~10 mbsf. The upper interval of lithostratigraphic Subunit IIIa is distinguished by a peak in magnetic susceptibility. However, apart from this peak, magnetic susceptibility remains constant from ~15 mbsf to the base of lithostratigraphic Subunit IIIb. Several positive excursions occurring within lithostratigraphic Subunit IIIa, approximately every 3 m, do not appear to correspond to changes in lithology. With their regular occurrence at approximately the same interval as core runs (~3.3 m), they are possibly an artifact of coring. At the Subunit IIIb/IIIc boundary, magnetic susceptibility increases and then exhibits high and variable values that reflect changes in lithology (increase in silt and sand content; see **"Lithostratigraphy"**).

The noncontact resistivity (NCR) data exhibit a generally similar trend to magnetic susceptibility (Fig. **F14**). NCR values are very low in lithostratigraphic Units I and II and progressively increase toward the base of lithostratigraphic Subunit IIIa as a normal compaction trend. Similar to magnetic susceptibility, NCR exhibits higher amplitude and more variability in lithostratigraphic Subunit IIIc.

Color reflectance

Color reflectance, in particular a*, reflects downcore changes in lithology (Fig. **F14**). Lithostratigraphic Units I and II are characterized by low values (more green). At the Unit II/Subunit IIIa boundary, a* values increase sharply and remain high (>4, more red) and constant through lithostratigraphic Subunit IIIa. Values decrease to a mean value of ~1 (greenish) at the Subunit IIIa/IIIb boundary and remain relatively constant in lithostratigraphic Subunits IIIb and IIIc.

Density and *P*-wave velocity

Gamma density was measured at 2 cm intervals during the offshore phase of Expedition 347 (Fig. **F15**). Gamma density increases progressively from the core top to the base of lithostratigraphic Subunit IIIb. Gamma density exhibits a shift to higher values in Subunit IIIc and remains generally high (~2 g/cm^3) throughout lithostratigraphic Subunit IIIc. Discrete bulk density measurements conducted during the OSP correlate moderately well with the shipboard measurements ($r^2 = 0.69$; Fig. **F16**).

P-wave velocity was also measured at 2 cm intervals during the offshore phase of Expedition 347 (Fig. **F15**). *P*-wave velocity (MSCL) exhibits low and relatively constant values (~1000 m/s) from the core top to ~18 mbsf. Values are higher and highly variable in the middle interval of lithostratigraphic Subunit IIIa (~18–32 mbsf). The lower interval of lithostratigraphic Subunit IIIa, Subunit IIIb, and the upper interval of Subunit IIIc are all characterized by generally more constant values (~1500 m/s), observed in both the MSCL and discrete *P*-wave measurements. From ~39 mbsf to the bottom of Hole M0065A, *P*-wave velocity values are overall higher (>1600 m/s) than the upper section. However, there is a slight decreasing trend from ~39 to ~43 mbsf, where *P*-wave velocity increases again to the bottom of the hole to a high of ~1800 m/s. No significant correlation is observed between the shipboard *P*-wave velocity and the discrete *P*-wave measurements performed during the OSP.

Paleomagnetism

In accordance with the main objectives of the OSP paleomagnetic work, magnetic susceptibility measurements and rudimentary analyses of natural remanent magnetization (NRM) were made on discrete specimens of known volume and mass (see "**Paleomagnetism**" in the "Methods" chapter [Andrén et al., 2015a]). Discrete samples were taken from Holes M0065A (89 specimens), M0065B (19 specimens), and M0065C (9 specimens) for a total of 117 samples. Magnetic susceptibility ranges between 0.03×10^{-6} and 0.43×10^{-6} m^3/kg through the sequence, with values greater than 0.2×10^{-6} m^3/kg confined to Subunit IIIc (an interval varying from coarse fine to medium sand) and the upper part (16–13 mbsf) of Subunit IIIa. Paleomagnetic pilot samples recovered from Units I and II, considered to be Holocene in age, have inclinations that are consistent with the geocentric axial dipole (GAD) inclination value (i.e., 71°). The pilot samples located in Subunit IIIc, which is likely to be late glacial and contains slumped material, are characterized by poor magnetic stability, and this unit contains scattered inclination values between 0° and 30°.

Discrete sample measurements

A total of 117 discrete samples were obtained from Holes M0065A and M0065C. Samples were recovered at intervals of ~50 cm from inside the site splice.

Magnetic susceptibility

The results of the magnetic analyses are shown in Figure **F17.** Magnetic susceptibility (χ), which was normalized to sample mass, ranges between 0.03×10^{-6} and 0.43×10^{-6} m^3/kg. Samples taken from Subunits IIIc and IIIb have χ values between 0.1×10^{-6} and 0.43×10^{-6} m^3/kg. The overlying Subunit IIIa has χ values between ~0.1×10^{-6} and 0.15×10^{-6} m^3/kg, with a distinct peak at depths between 16 and 13 mbsf of 0.1×10^{-6} and 0.3×10^{-6} m^3/kg.

The χ of Unit II is variable and includes one interval (13–10 mbsf) in which the values decrease upcore from ~0.1×10^{-6} to 0.05×10^{-6} m^3/kg. From 10 mbsf to the top of the core (i.e., at ~2 mbsf; Unit I), values of χ are $<0.1 \times 10^{-6}$ m^3/kg and are relatively constant.

Sediment wet density and χ are not related to each other, although χ ranges over half an order of magnitude, which suggests that changes in the magnetic mineralogy and/or grain size are determining χ. Two trends are apparent in the biplot of χ versus NRM intensity, one that indicates high χ/NRM ratios and one that indicates low χ/NRM ratios. The samples from Subunit IIIc have high χ/NRM ratios.

Natural remanent magnetization and its stability

Results of the pilot sample demagnetization (Fig. **F18**) indicate that an alternating field (AF) of 5 mT is sufficient to remove a weak viscous remanent magnetization (VRM). Four different responses to the sequential AF demagnetization are displayed by samples from Site M0065. Category 1 includes the samples of the grayish brown silty clay with planar lamination that characterizes Subunit IIIc, and they lose 50% of their NRM intensity at AF <15 mT, with a small residual component left at 40 mT that is unaffected by more intense demagnetization levels. The univectorial diagram does not trend to the origin of the diagram. Category 2, which includes a sample from Subunit IIIa at 23.52 mbsf, is typified by a paleomagnetic vector that is moderately "hard," indicating high coercivity and demagnetized up to the maximum AF demagnetization level of 80 mT, with a vector that trends toward the origin of the orthogonal projection. Category 3 has a "softer" magnetic behavior, with the removal of a significant viscous remanence at the 5 mT AF demagnetization level. The sample demagnetizes relatively easily and loses 50% of its magnetization between 30 and 40 mT. It is univectorial and trends to the origin of the orthogonal plot. Category 4 shows the behavior of a specimen that is characterized by low coercivity and a quite "soft" behavior of demagnetization. About 50% of the magnetization is removed by 20 mT, and the univectorial diagram shows a distinct linear behavior, trending toward the origin of the diagram.

After removal of the viscous overprint the NRM intensity of the samples recovered from Site M0065 lies in the range between 0.07×10^{-3} and 150×10^{-3} A/m and there is a positive relationship with χ in Subunits IIIa, IIIb, and IIIc, in which large peaks in NRM intensity are reflected in the χ data, and also in Units II and I (Fig. **F17**).

Paleomagnetic directions

The directions of the paleomagnetic vectors are illustrated by the inclination data in Figure **F17.** The inclination data from Unit III are scattered, with many positive shallow values and few negative values. Only two samples from these three units approach the GAD prediction for this site location. In contrast, the inclination data from Units II and I group closer to the GAD prediction, but there is a bias toward higher values (i.e., between 14 to 12 mbsf spanning the boundary between Subunit IIIa and Unit II). It is notable that the samples taken from 10 to 2 mbsf Unit I, which have relatively low χ values, plot within a few degrees of the GAD prediction. The variable magnetic properties downhole and different categories of response to AF demagnetization probably preclude using the paleomagnetic data for relative dating purposes.

Microbiology

Hole M0065C was drilled specifically for microbiology, interstitial water chemistry, and unstable geochemical parameters at Site M0065. Counts of microbial cells were made by fluorescence microscopy using the acridine orange direct count (AODC) method and by flow cytometry (FCM) using SYBR green DNA stain during the OSP. Further counts by fluorescence microscopy will be conducted after the OSP using both acridine orange and SYBR green staining.

A total of 15 sediment samples were counted for microbial cell numbers on the ship and during the OSP (Table T10). Of these, 11 samples were enumerated using the flow cytometer, and all 15 samples were enumerated using the epifluorescence microscope counting technique.

The most striking observations for these data are that cell counts by AODC are extremely high in Unit I and that the two cell counting techniques do not produce similar results in the upper half of this hole (Fig. F19; see "Microbiology" in the "Site M0063" chapter for a similar pattern of results [Andrén et al., 2015b]). The uppermost cell count at 3.53 mbsf, by FCM, was 9.42×10^8 cells/cm^3, whereas 1.23×10^{10} cells/cm^3 were determined by AODC, a 13-fold difference. In the lower half of this hole, data from both counting techniques appeared similar. The minimum microbial populations were determined as 7.10×10^7 cells/cm^3 at 23.33 mbsf by FCM and 6.18×10^7 cells/cm^3 at 13.43 mbsf by AODC.

Regression analyses of both data profiles indicated different trends shallower and deeper than ~12 mbsf (Fig. F19). The decrease in cell numbers with depth was significantly steeper shallower than this depth compared to deeper than this depth both for FCM ($F = 8.67$; degree of freedom [df] = 1.7; $P < 0.025$) and for AODC ($F = 45.82$; df = 1.11; $P << 0.001$). In the upper 12 m the change in cell numbers with depth was approximately 2.3 times steeper for AODC compared to FCM. This compares to a difference of 2.4 times steeper in Hole M0063E (see "Microbiology" in the "Site M0063" chapter [Andrén et al., 2015b]). Deeper than 12 mbsf, regression lines from the two depth profiles were not significantly different from each other ($F = 0.577$; df = 1.11 [not significant]), which was confirmed by a paired sample t-test ($t = 0.598$; df = 6 [not significant]).

This is the same situation that was encountered in samples from Hole M0063E where in the upper part of the hole many of the cells were aggregated in clumps of "fluff," making accurate enumeration by either method difficult or impossible (see interpretation in "Microbiology" in the "Site M0063" chapter [Andrén et al., 2015b]), and this resulted in significant underestimation of cell numbers by FCM compared to AODC. An improved processing technique will need to be developed to deal with these samples, and it is possible that even higher concentrations of cells will be detected than already reported for this hole. The fluff is possibly bacterially derived exopolysaccharide causing cell clumping, and it is of note that this depth interval of difficult-to-count samples coincides with both the largest differences between the two counting techniques and the presence of organic-rich sediment (see "Geochemistry"; Figs. F13A, F19).

The profile break at 12 mbsf does seem to be related to sediment column stratigraphy, as this depth roughly correlates with the transition between the upper brackish-marine sediments and the lower late glacial lake clay deposits at the Unit II/III boundary. In the organic-rich sediments shallower than 12 mbsf, bacterial degradation of organic matter has produced a broad maximum in alkalinity that reaches 38 meq/L in the upper part of the hole compared to 4–5 meq/L in the lower half of the hole (see "Geochemistry"). The high cell numbers thus coincide with the interval of high degradation rate of organic matter. Conversely, salinity decreases more or less linearly from the sediment surface to ~30 mbsf and does not appear related to the cell profiles (Fig. F19).

As was reported for Sites M0059, M0060, M0061, and M0063, cell numbers were very high and, with one exception, all cell counts exceeded the upper prediction limit for the global regression (Fig. F19). The maximum deviation from the global regression was at 29.93 mbsf for the FCM profile with a 36-fold higher cell number, whereas for the AODC technique the greatest deviation was at 6.83 mbsf with a 370-fold higher number. It is of note that the cell density of 1.23×10^{10} cells/cm^3 at 3.53 mbsf is among the highest observed in all marine sediments examined by scientific drilling.

When the data from both techniques are plotted against each other, results from deeper than 12 mbsf cluster around the line of x = y (Fig. F20). Data are too clustered for a regression line to be calculated and compared to the x = y line. Results from shallower than 12 mbsf clearly deviate from the x = y line with higher numbers obtained by the AODC method.

Perfluorocarbon (PFC) tracer was detected in the liner fluid and exteriors of all cores, indicating continuous PFC delivery into the microbiology borehole (Table T11). Liner fluid PFC concentrations varied over 1–2 orders of magnitude (Fig. F21A), indicating variations in the rates of PFC delivery and mixing into the drilling fluid stream. Most of the measured PFC concentrations were below the target concentration of 1 mg PFC/L. Nonetheless, the liner fluid PFC concentrations are on average considerably higher than at the other three sites, remaining above 10^{-5} g PFC/L in all samples (apart from Core 2H) and in two cores (347-M0065C-3H and 4H) closely approaching the PFC target concentration. PFC was above detection in all core halfway samples and all but two interior samples (Cores 6H and 7H; Fig. F21B). As at Sites M0059 and M0060, contamination was relatively highest in the uppermost part of the hole (Core 347-M0065C-2H) and showed no depth- or lithology-related trend below (Figs. F19, F21C). Remarkably, PFC contamination was 2–3 orders of magnitude higher in several "core halfway" sections than core exteriors (Cores 7H, 10H, and 12H), a phenomenon that was only observed once across the three other microbiology sites (Core 347-M0063E-23H).

Compared to the other sites, Site M0065 has a higher fraction of cores that are suitable for microbiological analyses. No contamination could be detected in interiors of Cores 347-M0065C-6H and 7H. Moreover, Core 3H only showed marginal evidence of contamination, despite having the highest PFC concentration in the liner fluid of all cores, and Cores 9H, 10H, and 12H were calculated to have potentially fewer than 100 contaminant cells/cm^3 in core interiors (Table T11; Fig. F21D).

Stratigraphic correlation

At Site M0065 three holes were drilled: Holes M0065A (73.9 mbsf), M0065B (49.3 mbsf), and M0065C (47.9 mbsf). The uppermost 2 m of sediment was open holed at each location because of the possibility of chemical contamination in surface sediments (see "Operations"). Hole M0065C was a microbiology hole, and core material was partly consumed by subsampling to 34 meters composite depth (mcd). Composite depths for Site M0065 were based on correlation of magnetic susceptibility (Fig. F22). The correlation was checked against scanned core slab images as well as sedimentology, and continuity of the composite record was checked against downhole log data. All major features from Hole M0065A were correlated to downhole log data (Fig. F23). Based on this, within the uppermost 47.5 mcd, correlation was possible within a 0.1 m error margin. The depth offsets that define the composite section for Site M0065 are given in Table T12 (affine table). No compression or expansion corrections were applied to the data.

It was possible to construct one continuous splice for Site M0065 to 47.5 mcd (Table T13). Deeper core material was sampled for optically stimulated luminescence but was not logged through the MSCL because of the hammer sampling coring method acquiring very little core material.

Seismic units

Seismic sequence boundary-sediment core-MSCL log (magnetic susceptibility) correlations are shown in Figure F24. Two-way traveltime values for each lithostratigraphic unit boundary were calculated using sound velocity values measured during the OSP (*z*-axis velocities, see "Physical properties") (Table T14). Correlations are based on the integration of seismic data and lithostratigraphy (see "Lithostratigraphy"). Uncertainties in the time-depth function could have resulted in minor inconsistencies between seismic features, sedimentological observations from cores, and MSCL logs.

Seismic Unit I

Two-way traveltime: 0.128 ms

Lithology: organic-rich dark greenish clay with weak laminations (lithostratigraphic Unit I)

Depth: 2.00–9.18 mbsf (M0065A), 3.00–9.63 mbsf (M0065B), 2.00–9.22 mbsf (M0065C)

Unit I corresponds to the seismic unit that is transparent and weakly stratified. In sediment cores, this unit displays low magnetic susceptibility values.

Seismic Unit II

Two-way traveltime: 0.134 ms

Lithology: laminated gray to dark gray clay (lithostratigraphic Unit II)

Depth: 9.18–13.20 mbsf (M0065A), 9.63–13.85 mbsf (M0065B),

Unit II shows increasing magnetic susceptibility values downcore. A distinctive spike at 10 mbsf may indicate the presence of greigite (Fe_3S_4) magnetofossils, which have been reported from different various sites in the Baltic Sea (Reinholdsson et al., 2013). In the seismic profile, this spike corresponds to a well-defined reflector. This seismic unit is crudely stratified.

Seismic Unit III

Seismic Subunit IIIa

Two-way traveltime: 0.168 ms
Lithology: grayish brown laminated clay, massive to contorted (lithostratigraphic Subunit IIIa)
Depth: 13.20–36.05 mbsf (M0065A), 13.85–36.10 mbsf (M0065B)

Seismic Subunit IIIa shows slight rhythmic variations in magnetic susceptibility values. It also shows somewhat irregular internal structures, which could be related to deformation of originally laminated clay.

Seismic Subunit IIIb

Two-way traveltime: 0.169 ms
Lithology: dark gray laminated clay (lithostratigraphic Subunit IIIb)
Depth: 36.05–36.65 mbsf (M0065A), 36.10–36.80 mbsf (M0065B)

Seismic Subunit IIIb is difficult to correlate with a well-defined seismic unit. However, it approximately coincides with the strong reflector at the transition from seismic Unit III to seismic Unit IV.

Seismic Unit IV

Two-way traveltime: 0.182 ms
Lithology: laminated grayish brown silt and clay with sand content increasing downcore. The lowermost few meters consist of massive sand (lithostratigraphic Subunit IIIc)
Depth: 36.65–46.60 mbsf (M0065A), 36.80–49.20 mbsf (M0065B)

Unit IV is characterized by high magnetic susceptibility values that are quite variable, possibly reflecting variations in sand and silt content within the laminated fine-grained unit. In the seismic profile, the upper boundary of Unit IV roughly corresponds to a very strong reflector. In the lower part of Unit IV, several nonparallel reflectors can be seen and the unit seems to continue further down.

Downhole measurements

Logging operations

Hole M0065A

Hole M0065A was drilled to 73.9 m drilling depth below seafloor (DSF). In preparation for logging, the hole was circulated with seawater and the drill string was pulled back in the hole to 14 m wireline log depth below seafloor (WSF). Logging operations started in Hole M0065A with rigging up the Weatherford logging setup.

For downhole logging in Hole M0065A, two tool strings were deployed:

- gamma ray tool (MCG)/array induction tool (MAI) tool string, measuring natural gamma ray and electrical resistivity, and
- MCG/spectral gamma ray tool (SGS) tool string, measuring total gamma ray and spectral gamma ray.

The MCG/MAI tool string was lowered and downlogged to 41 m WSF. The hole was then uplogged to the seafloor. The tools provided continuous and good quality log data. The wireline depth to the seafloor was determined from the step increase in gamma ray values.

After this, the MCG/SGS tool string was lowered and reached only ~16 m WSF while downlogging.

The decision was taken to run in the hole with the drill pipe again to ~45 m DSF and do a wiper-trip of the hole. After this, the tool string with total gamma ray and spectral gamma ray was deployed again but only reached ~20 m WSF. After this unsuccessful attempt, logging operations were abandoned.

Hole M0065C

Hole M0065C was drilled to 47.9 m DSF. In preparation for logging, the hole was circulated with seawater and the drill string was pulled back in the hole to 13.2 m WSF. Logging operations started in Hole M0065C with rigging up the Weatherford logging setup.

For downhole logging in HoleM0065C, two tool strings were deployed:

- MCG/SGS/sonic sonde (MSS) tool string, measuring natural gamma ray, spectral gamma ray, and sonic velocity, and
- MCG/microimager (CMI) tool string, measuring total gamma ray and high-resolution electrical images.

The MCG/SGS/MSS tool string was lowered and downlogged to 40 m WSF. The hole was then uplogged to the seafloor. The tools provided continuous and good quality log data. The wireline depth to the seafloor was determined from the step increase in gamma ray values.

The MCG/CMI tool string was lowered to 40 m WSF with the calipers closed. The hole was then uplogged with open calipers at high resolution.

Hole M0065A logging units

Hole M0065A is divided into five units on the basis of the logs (Fig. F25). The uplog was used as the reference to establish the wireline log depth below seafloor depth scale.

Logging Unit 1: base of drill pipe to 20 m WSF

Logging Unit 1 is characterized by high values in NGR between 100 and 120 gAPI indicating high clay content. Resistivity is constantly increasing through this unit as a normal compaction trend.

Logging Unit 2: from 20 to 26 m WSF

After a sudden drop of NGR at 20 m WSF, natural gamma ray values slightly increase again with depth showing some large fluctuations at 23 m WSF. Resistivity is constantly increasing. The sudden drop in NGR can be explained by the clay/silt intraclasts as described in **"Lithostratigraphy"** for Subunit IIIa.

Logging Unit 3: from 26 to 34.1 m WSF

After a negative excursion at 26 m WSF and large fluctuations between 26 and 28 m WSF, NGR shows constantly high values through this logging unit. Resistivity increases with depth at a constant rate. Again these fluctuations can be due to the presence of clay/silt intraclasts.

Logging Unit 4: from 34.1 to 37.1 m WSF

NGR is characterized by large changes in this logging unit. Between 35 and 36 m WSF, NGR values are very high after a minimum of 60 gAPI at 34.1 m WSF. NGR shows a sudden drop again at 37.1 m WSF. Resistivity shows some oscillation in this logging unit but still generally increases with depth.

Logging Unit 5: from 37.1 to 41 m WSF

Logging Unit 5 is characterized by an increase in NGR after the natural gamma ray values dropped to 60 gAPI at 37.1 m WSF. Resistivity values are slightly decreasing and show invasion of bore fluid into the formation.

Hole M0065C logging units

Hole M0065C is divided into two units on the basis of the logs (Fig. F26). The uplog was used as the reference to establish the wireline log depth below seafloor depth scale.

Logging Unit 1: base of drill pipe to 18 m WSF

Logging Unit 1 is characterized by a constantly decreasing natural gamma ray. The sonic log stays constant in this logging unit. This decrease in NGR could correspond to the diminished organic content in lithostratigraphic Unit II (see **"Lithostratigraphy"**).

Logging Unit 2: 18–40 m WSF

In logging Unit 2, NGR values are constant with some fluctuations, possibly caused by the clay/silt intraclasts (lithostratigraphic Subunit IIIa; see **"Lithostratigraphy"**). There are no major changes in the sonic log. The calipers show that borehole conditions were very poor in this last logging unit.

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Figure F1. Graphic lithology log summary. Depths given represent lithostratigraphic boundaries in Holes M0065A (top of Unit 1 to top of Subunit IIIc) and M0065B (base of Subunit IIIc).

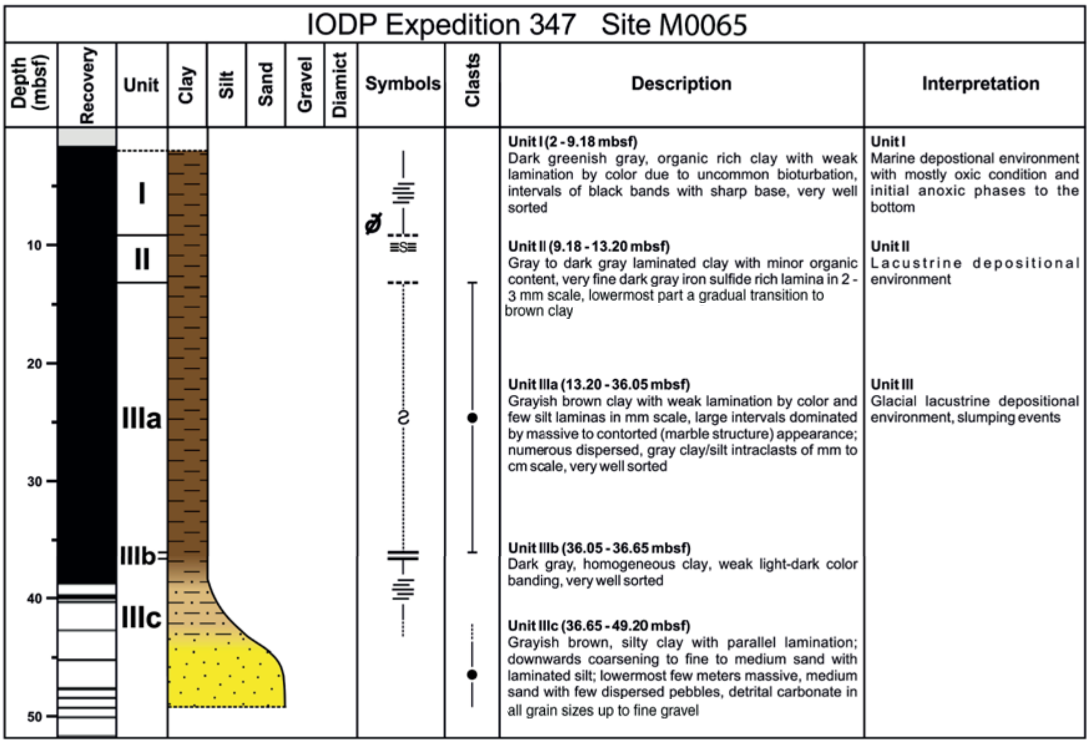


Figure F2. Examples of lithostratigraphic units, Hole M0065A. **A.** Unit I. **B.** Unit I. **C.** Unit II. **D.** Subunit IIIa. **E.** Subunit IIIb. **F.** Subunit IIIc.

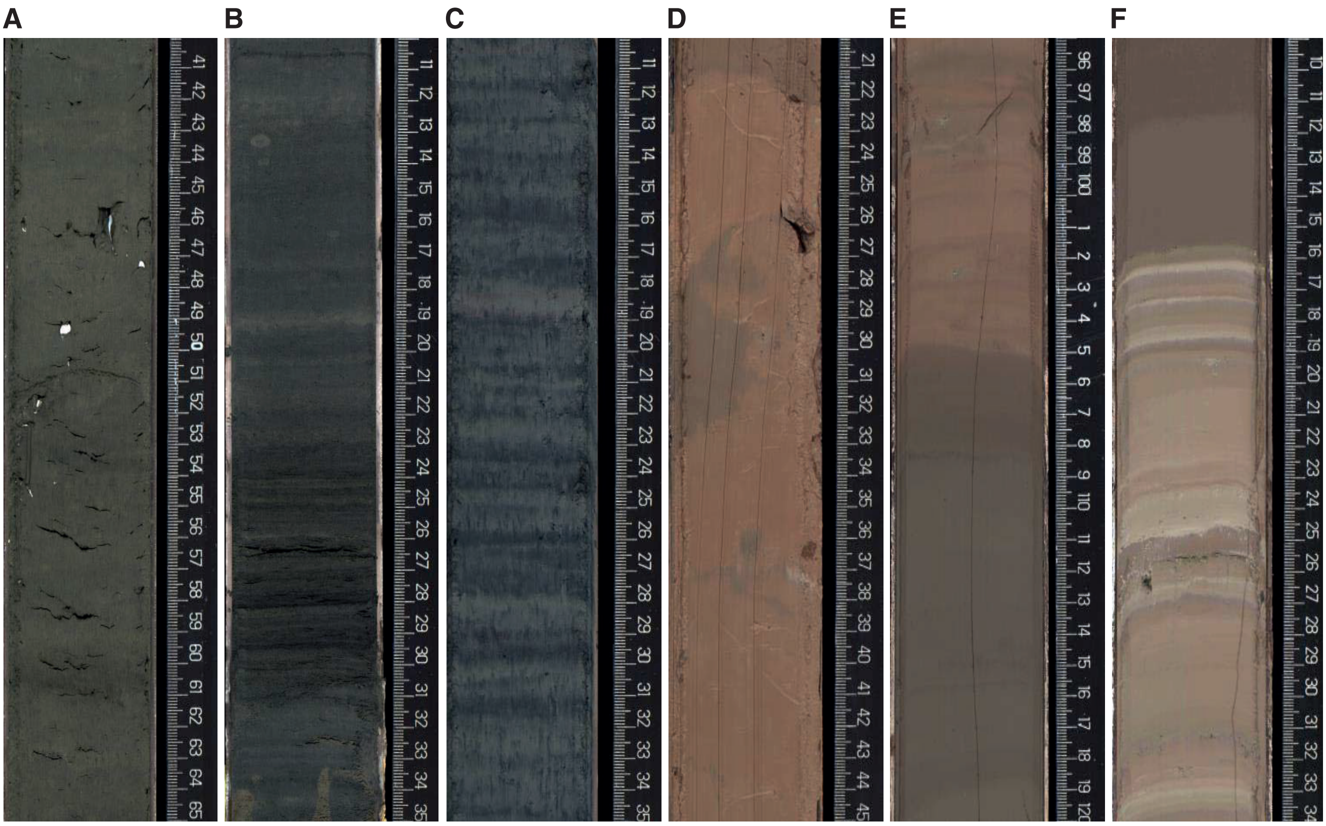


Figure F3. Analyzed levels and the relative proportion of diatom taxa showing different salinity requirements, Hole M0065A. Presence of sea ice related taxa and other siliceous microfossils recorded in the cores (red dots), as well as the number of taxa with planktonic and periphytic life forms, are also presented. Siliceous microfossil data are only qualitative presence/absence data and should be interpreted cautiously until quantitative data are generated.

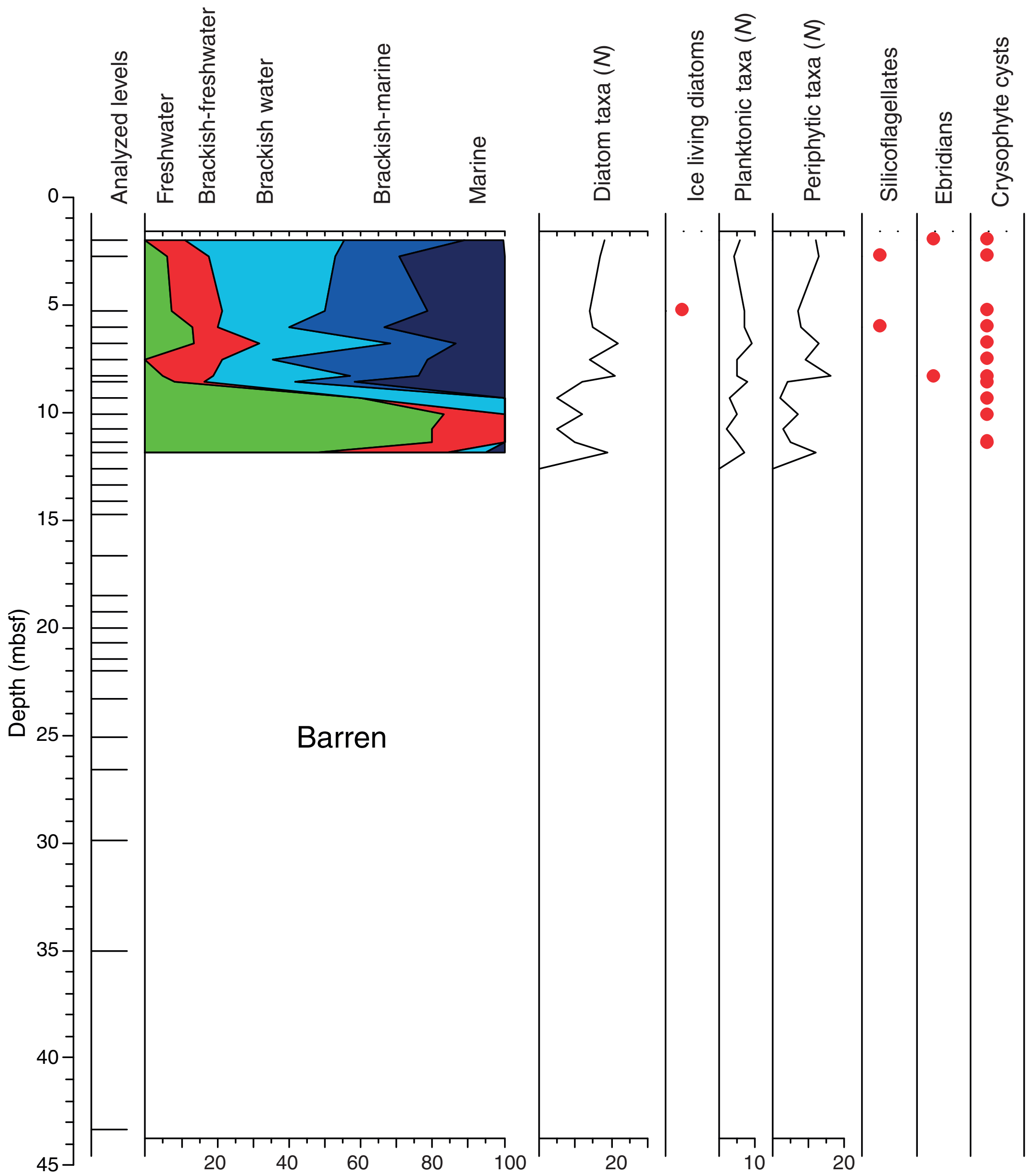


Figure F4. Abundance of benthic foraminifers based on the abundance classification defined in the "Methods" chapter (Andrén et al., 2015a), Site M0065. Increasing shading indicates abundances sufficient for faunal and/or geochemical analyses.

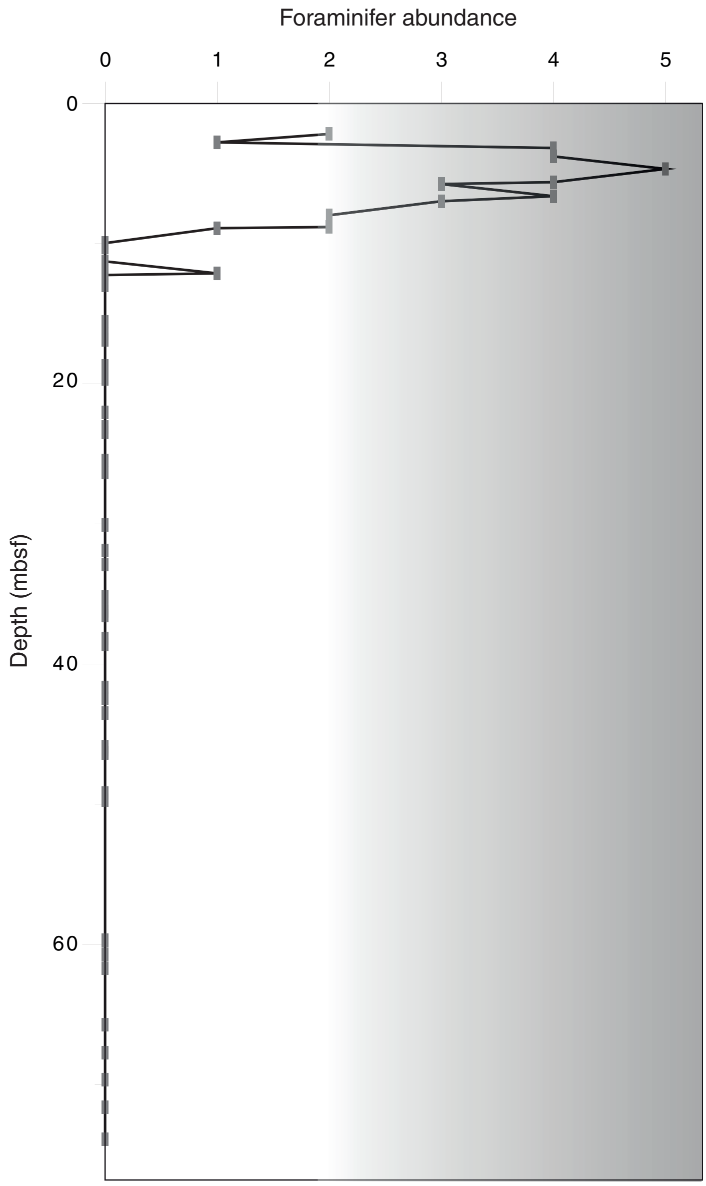


Figure F5. Ostracod abundance per sediment volume, Site M0065.

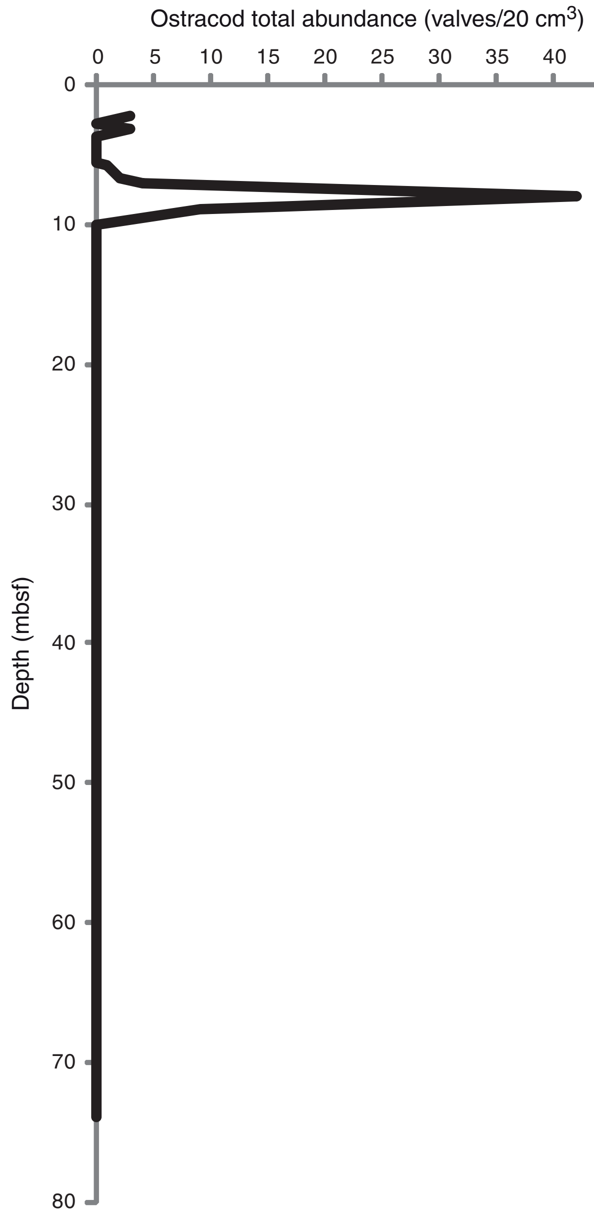


Figure F6. Palynomorphs encountered in Core 347-M0065A-2H. **1.** Chironomid jaw. **2.** *Quercus* pollen grain. Scale bars = 20 µm.

Figure F7. Pollen diagram with bisaccate pollen included in the reference sum, Hole M0065A. For all samples included in the diagram, >100 pollen grains have been counted.

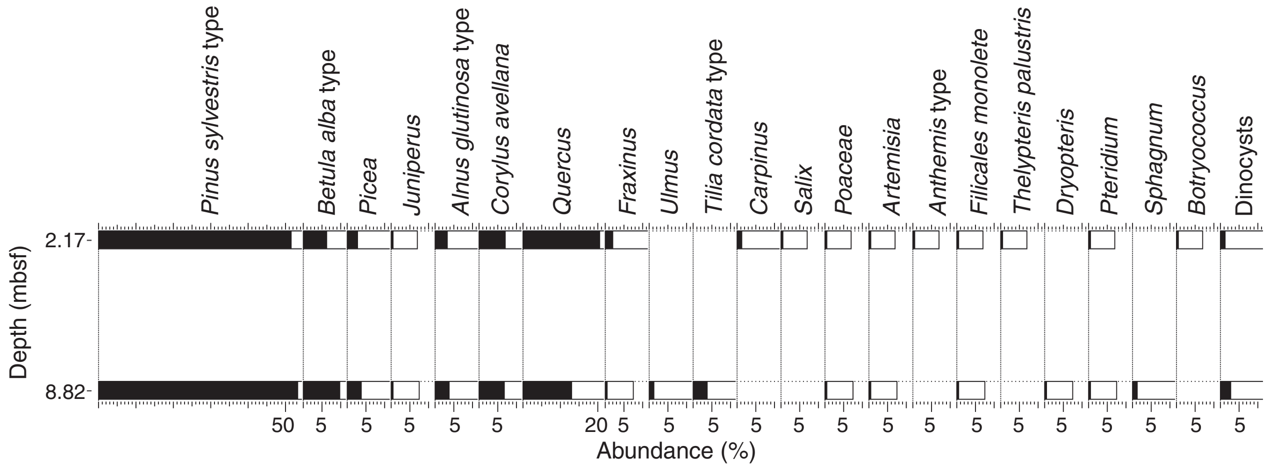


Figure F8. Concentrations of (**A**) chloride, (**B**) salinity by refractometer, (**C**) chloride-based salinity, and (**D**) alkalinity in interstitial water samples, Site M0065.

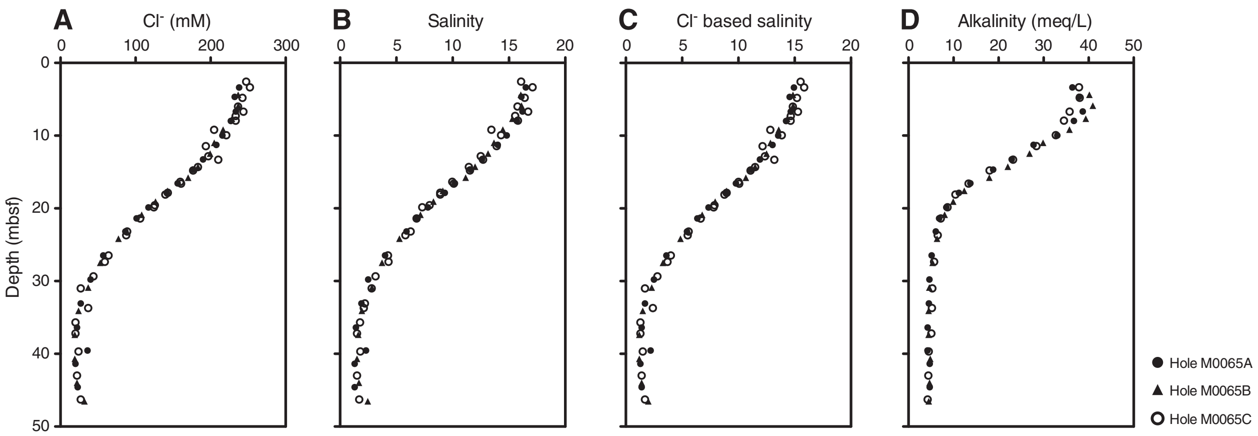


Figure F9. Concentrations of (**A**) methane, (**B**) sulfate, (**C**) sulfide, (**D**) ammonium, (**E**) phosphate, (**F**) iron, (**G**) manganese, and (**H**) pH from interstitial water samples, Site M0065.

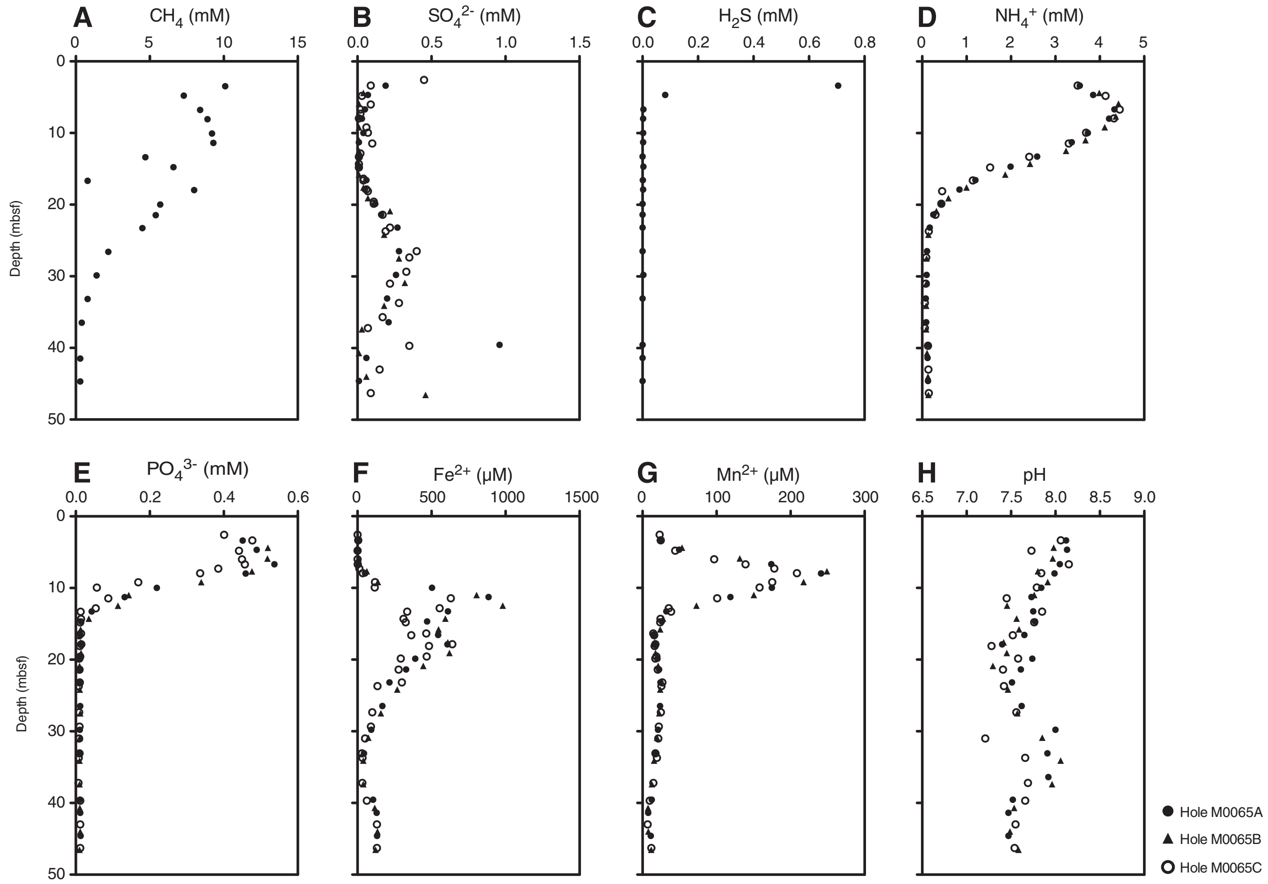


Figure F10. Concentrations and ratios of (**A**) bromide, (**B**) bromide/chloride, (**C**) boron, and (**D**) boron/chloride from interstitial waters samples, Site M0065. Dashed lines = seawater ratio.

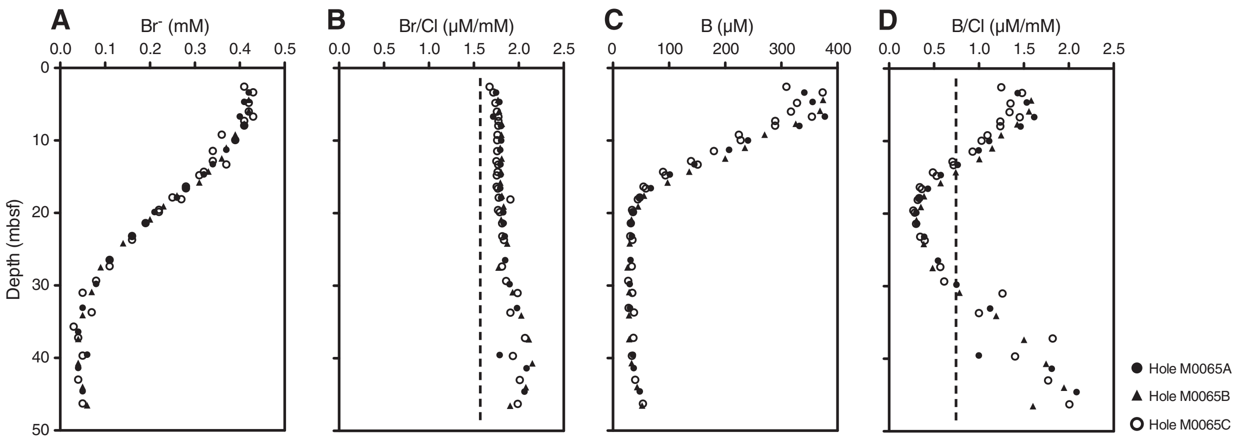


Figure F11. Concentrations and ratios of (**A**) sodium, (**B**) potassium, (**C**) magnesium, (**D**) calcium, (**E**) sodium/chloride, (**F**) potassium/chloride, (**G**) magnesium/chloride, and (**H**) calcium/chloride from interstitial water samples, Site M0065. Dashed lines = seawater ratio.

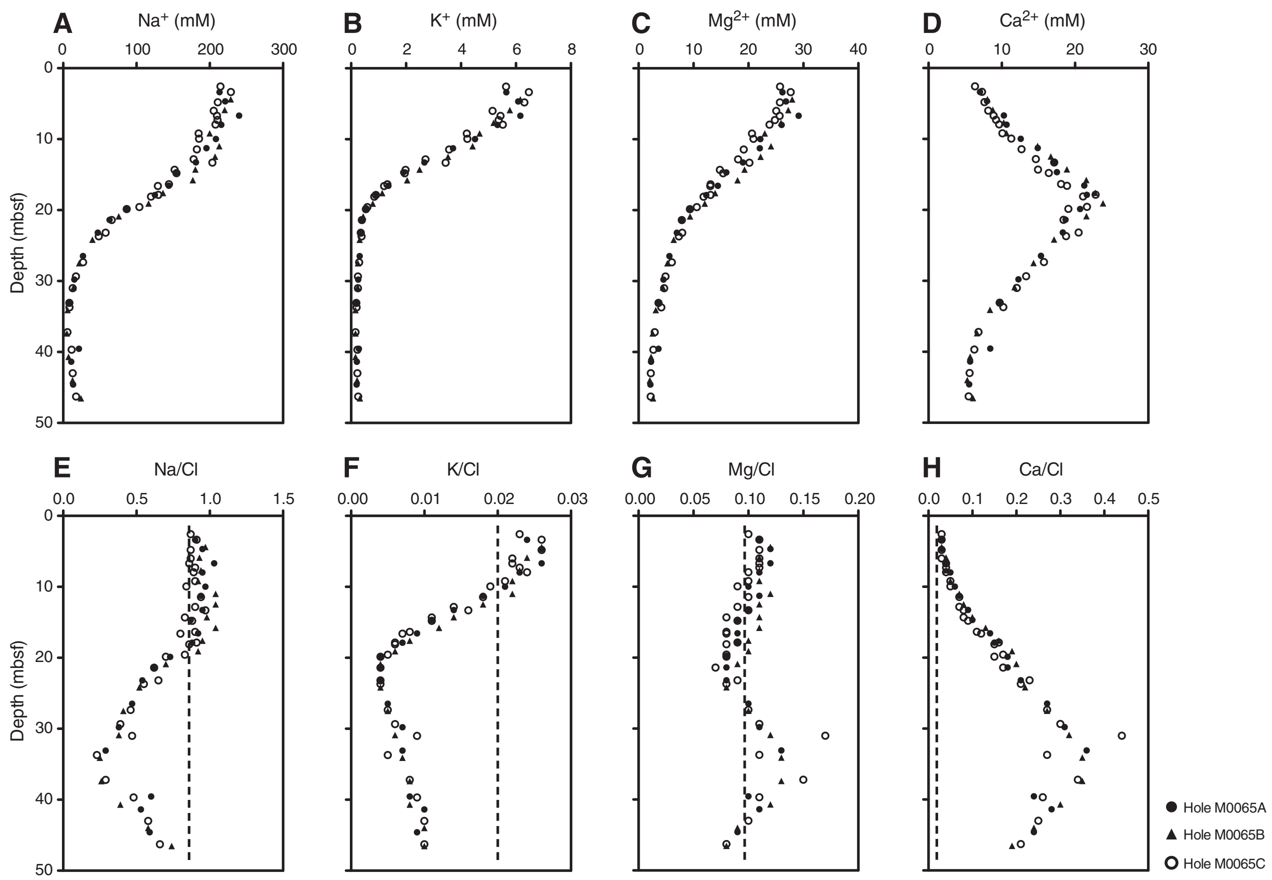


Figure F12. Concentrations of (**A**) dissolved silica, (**B**) lithium, (**C**) barium, and (**D**) strontium from interstitial water samples, Site M0065.

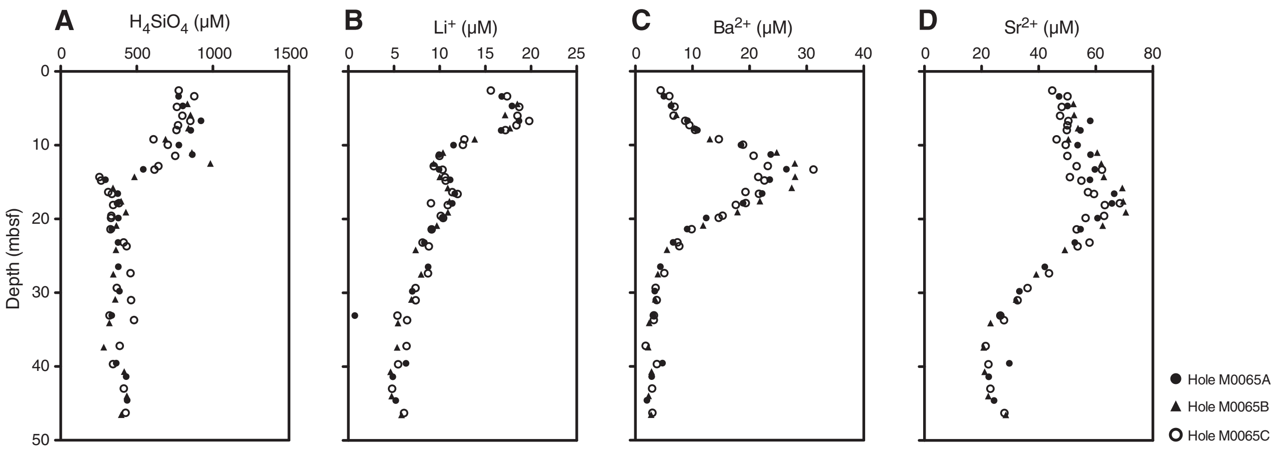


Figure F13. Sedimentary (**A**) total carbon (TC), (**B**) total organic carbon (TOC), (**C**) total inorganic carbon (TIC), and (**D**) total sulfur (TS) values, Site M0065.

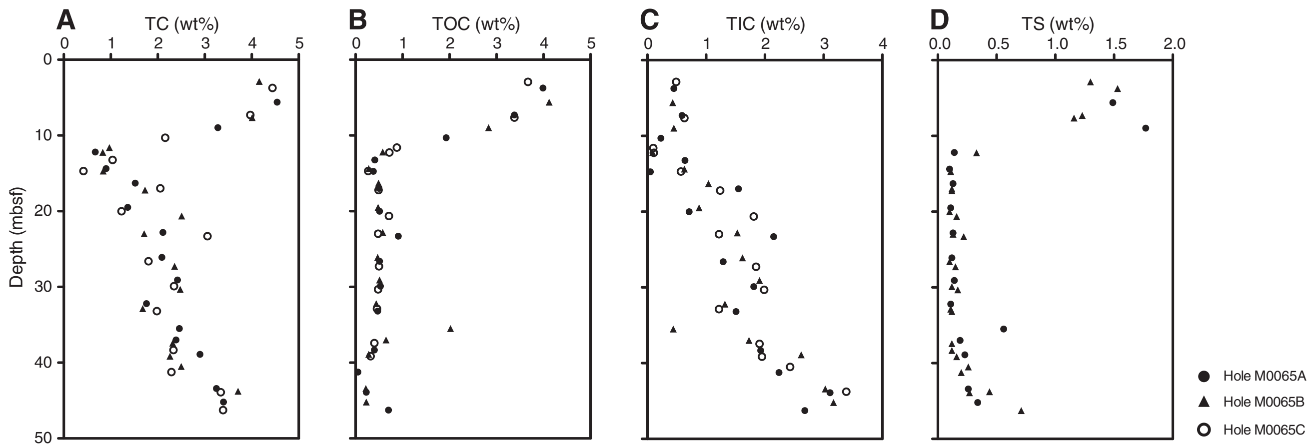


Figure F14. Natural gamma radiation (NGR) (cps), MSCL magnetic susceptibility (MS) (10^{-5} SI), MSCL noncontact resistivity (NCR) (Ωm), and color reflectance parameter a*, Hole M0065A.

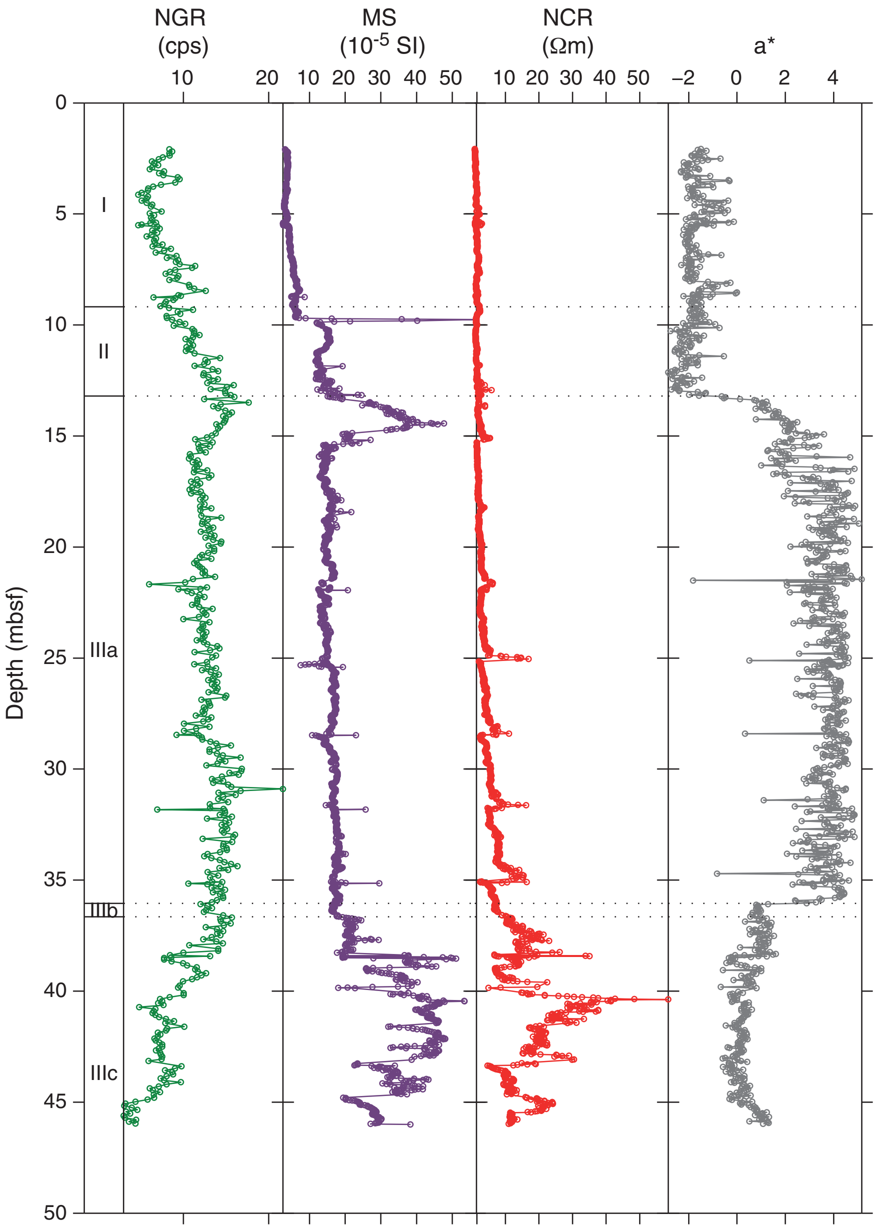


Figure F15. **A.** Gamma density (g/cm³) and discrete bulk density (g/cm³) measurements derived from pycnometer moisture and density analyses, Hole M0065A. **B.** MSCL *P*-wave and discrete velocity (m/s) measurements performed during the OSP, Hole M0065A.

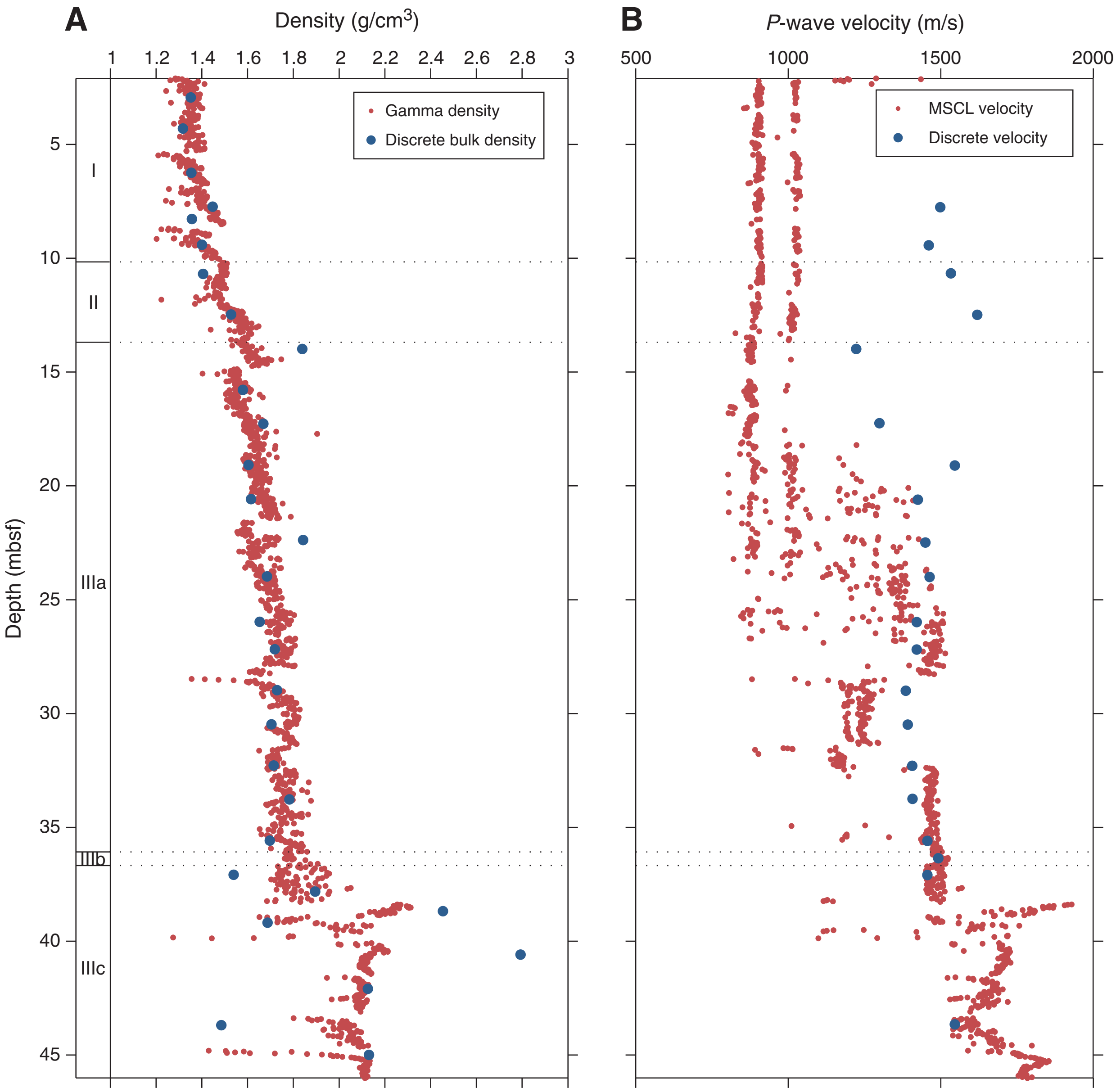


Figure F16. Correlation between gamma density (g/cm³) and discrete bulk density (g/cm³) measurements, Hole M0065A.

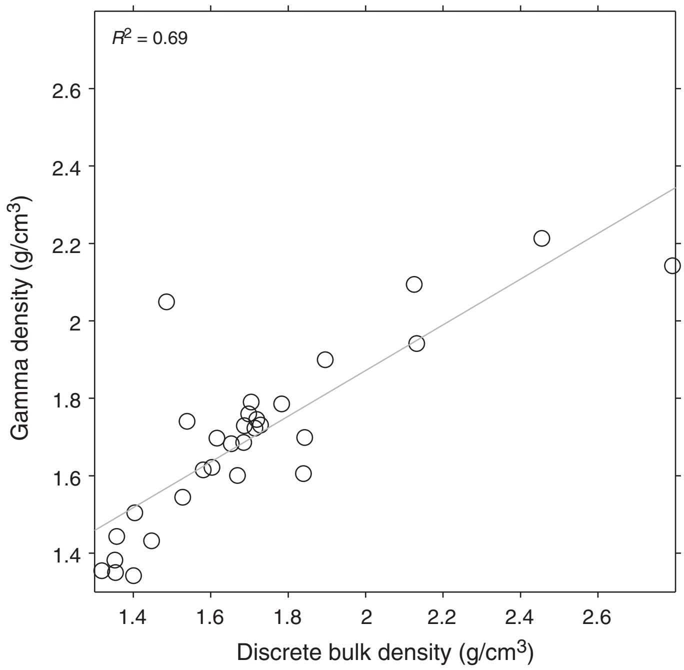


Figure F17. Plots and biplots of magnetic susceptibility (χ), natural remanent magnetization (NRM) intensity, and NRM inclination of discrete paleomagnetic samples, Holes M0065A and M0065C. Dashed line = geocentric axial dipole (GAD) prediction of inclination for the site latitude. AF = alternating field.

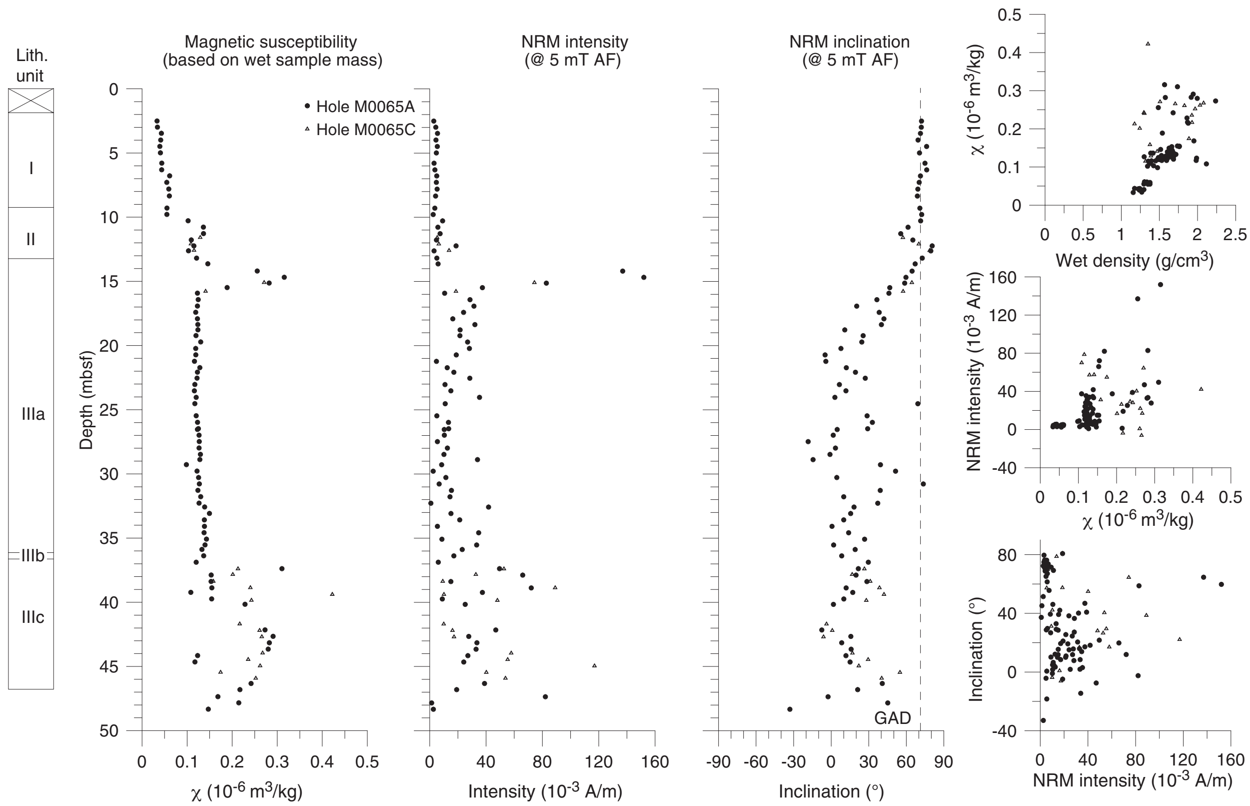


Figure F18. Plots of natural remanent magnetization (NRM) after alternating field (AF) demagnetization to 80 mT. **A.** Sample 347-M0065A-2H-2, 48 cm; 3.99 mbsf. **B.** Sample 347-M0065A-5H-2, 32 cm; 14.20 mbsf. **C.** Sample 347-M0065A-8H-1, 125 cm; 23.52 mbsf. **D.** Sample 347-M0065A-14H-2, 75 cm; 44.15 mbsf. Category 1 contains a very soft and shallow component, and the vector does not trend toward the origin. Category 2, 3, and 4 vectors trend toward the origin. More than 30% of the initial intensity of the Category 3 example remains after demagnetization at the 80 mT level. Open squares = vertical, solid squares = horizontal.

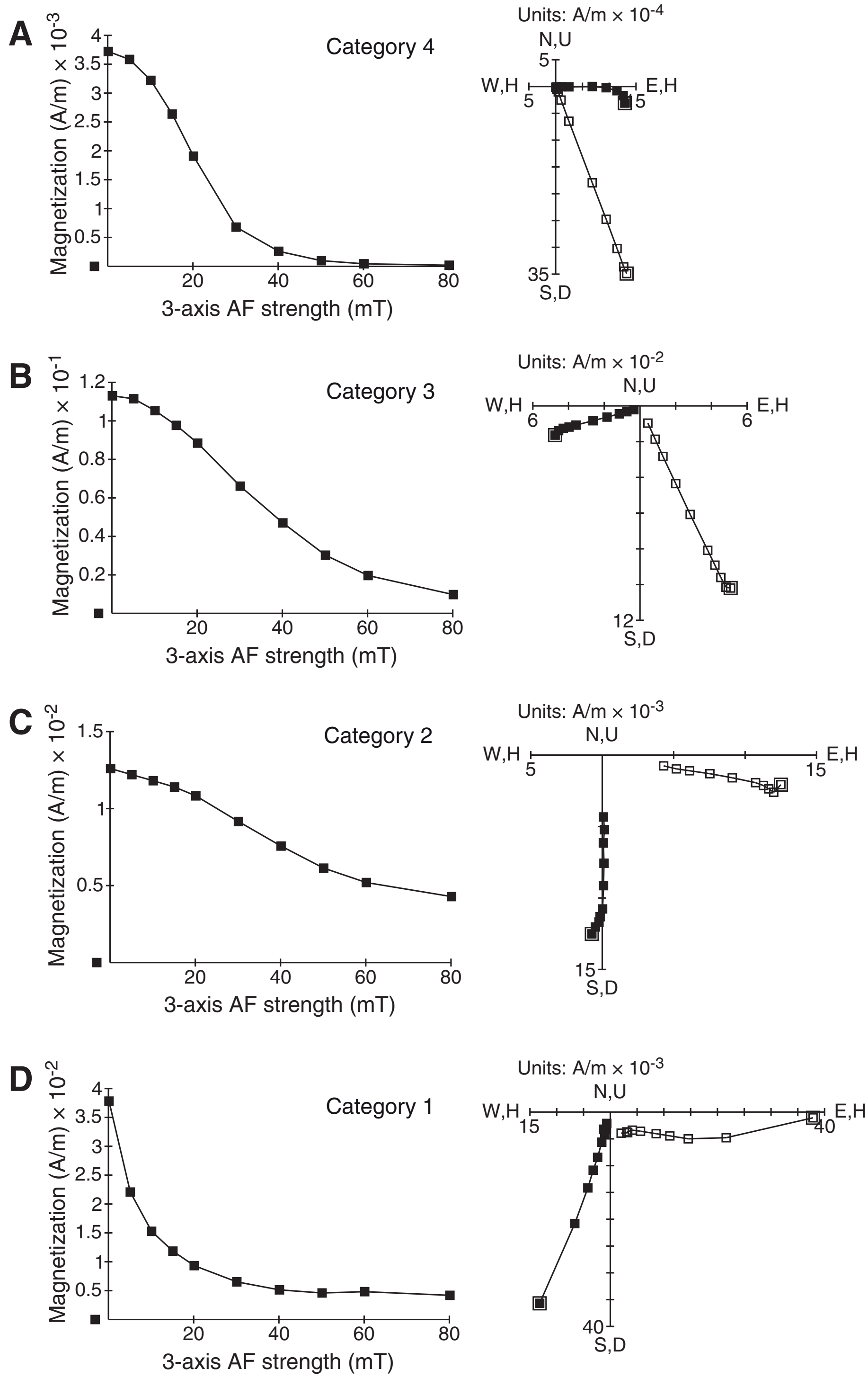


Figure F19. Plot of microbial cell abundances compared to chemical zonation and lithostratigraphy, Hole M0065C. **A.** Interstitial water alkalinity (blue dashed line) and salinity (red line). Green dashed line marks the boundary at ~12 mbsf; cell counting techniques produce similar results at deeper depths. **B.** Cell numbers obtained by flow cytometry (blue circles) and acridine orange direct count (red diamonds). Solid black line = global regression line of prokaryote cell numbers with depth, dashed lines = upper and lower 95% prediction limits for regression line (Roussel et al., 2008). Green dashed line marks the boundary at ~12 mbsf; cell counting techniques produce similar results at deeper depths. **C.** Lithology.

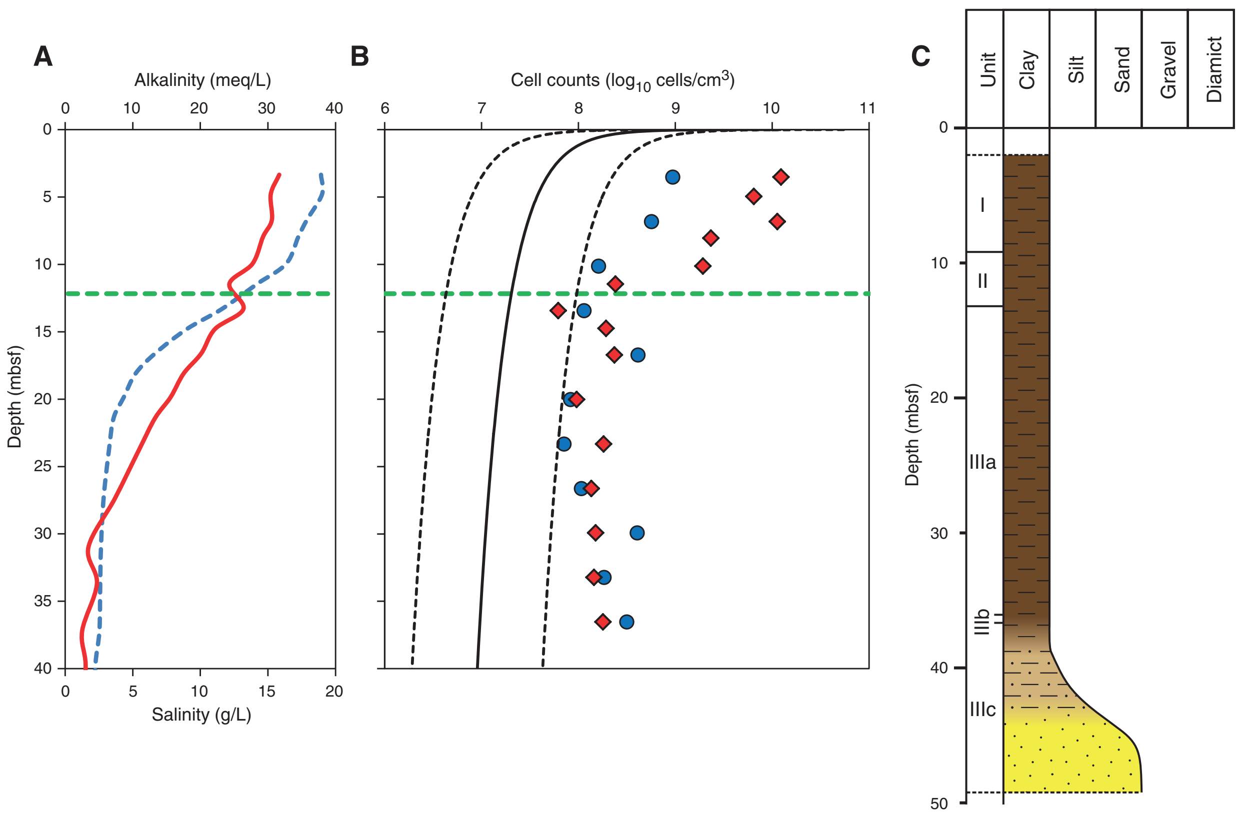


Figure F20. Comparison of paired counts between two methods of cell enumeration, Hole M0065C. Blue circles = results from deeper than 12 mbsf, green squares = results from shallower than 12 mbsf. Black dashed line = line of unity. FCM = flow cytometry, AODC = acridine orange direct count.

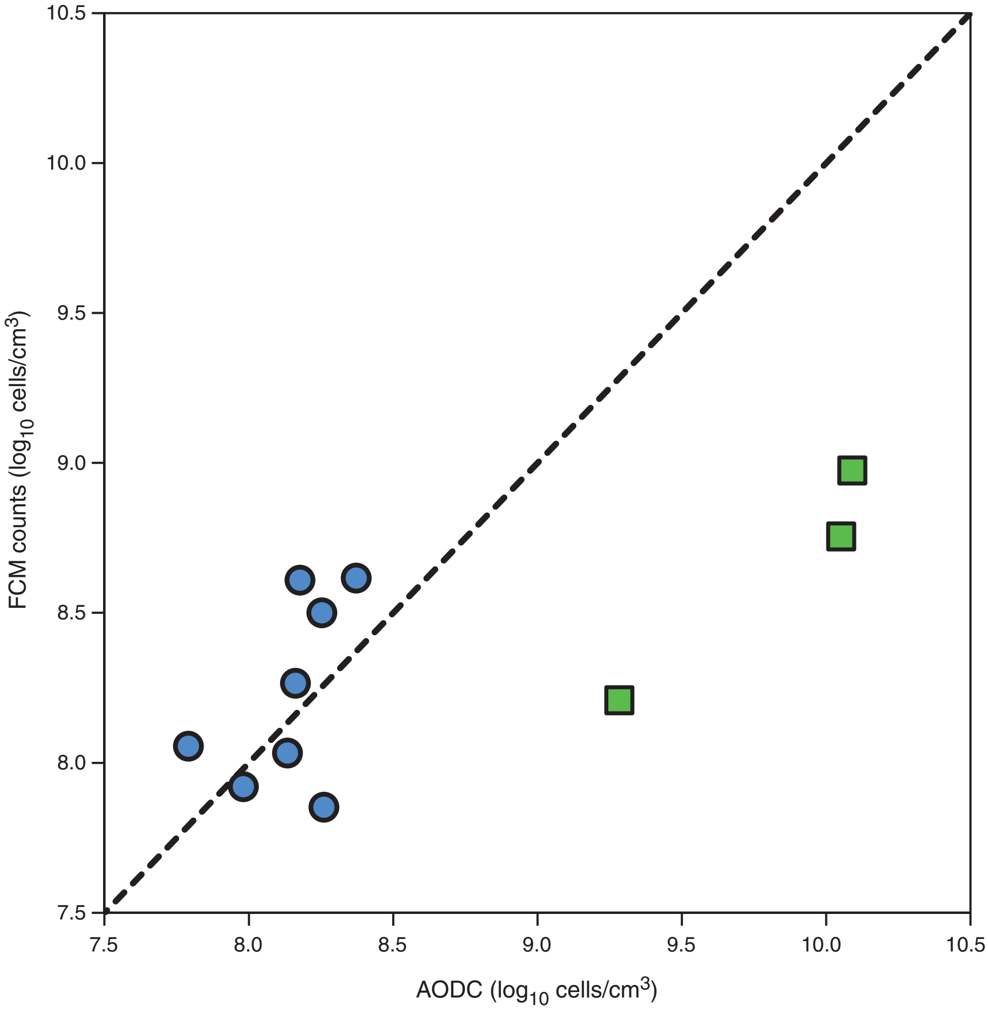
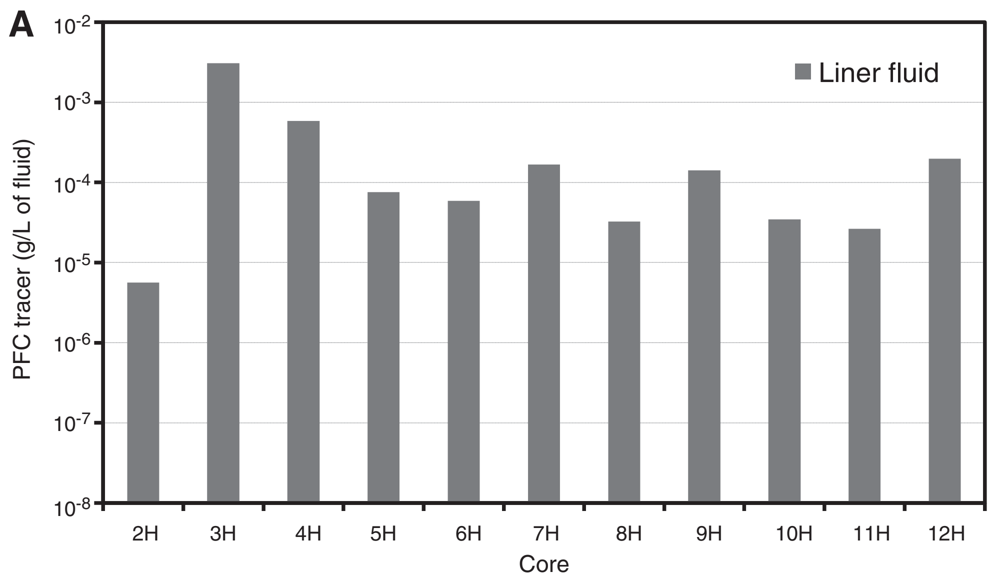


Figure F21. Plots of perfluorocarbon (PFC) tracer concentrations, Hole M0065C. **A.** Core liner fluid. **B.** Sediment core samples. (Continued on next page.)



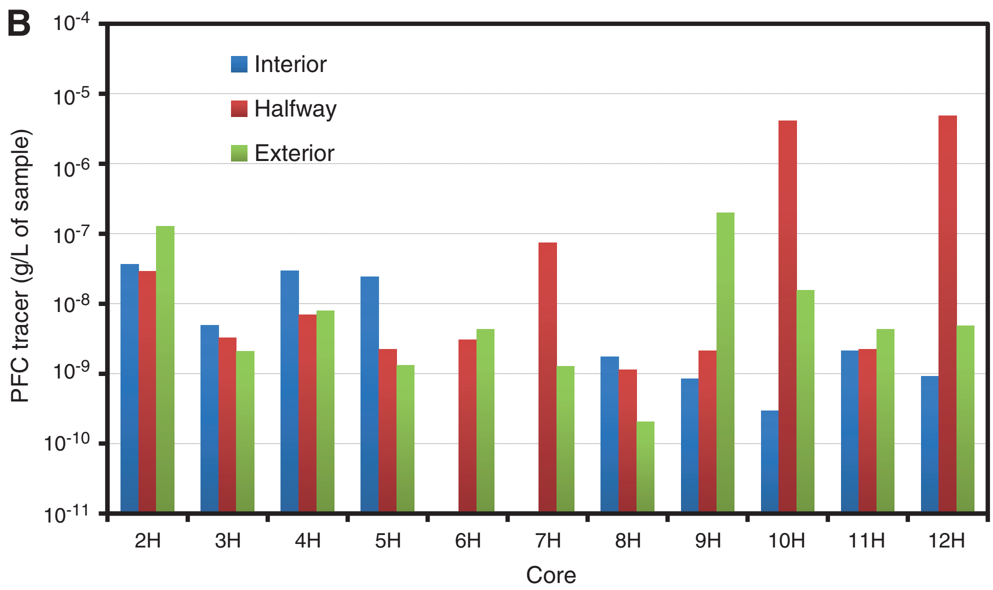


Figure F21 (continued). **C.** Estimated volume of liner fluid introduced into sediment cores shown as percentage of sediment core volume. **D.** Estimated potential number of contaminant cells per volume of sediment.

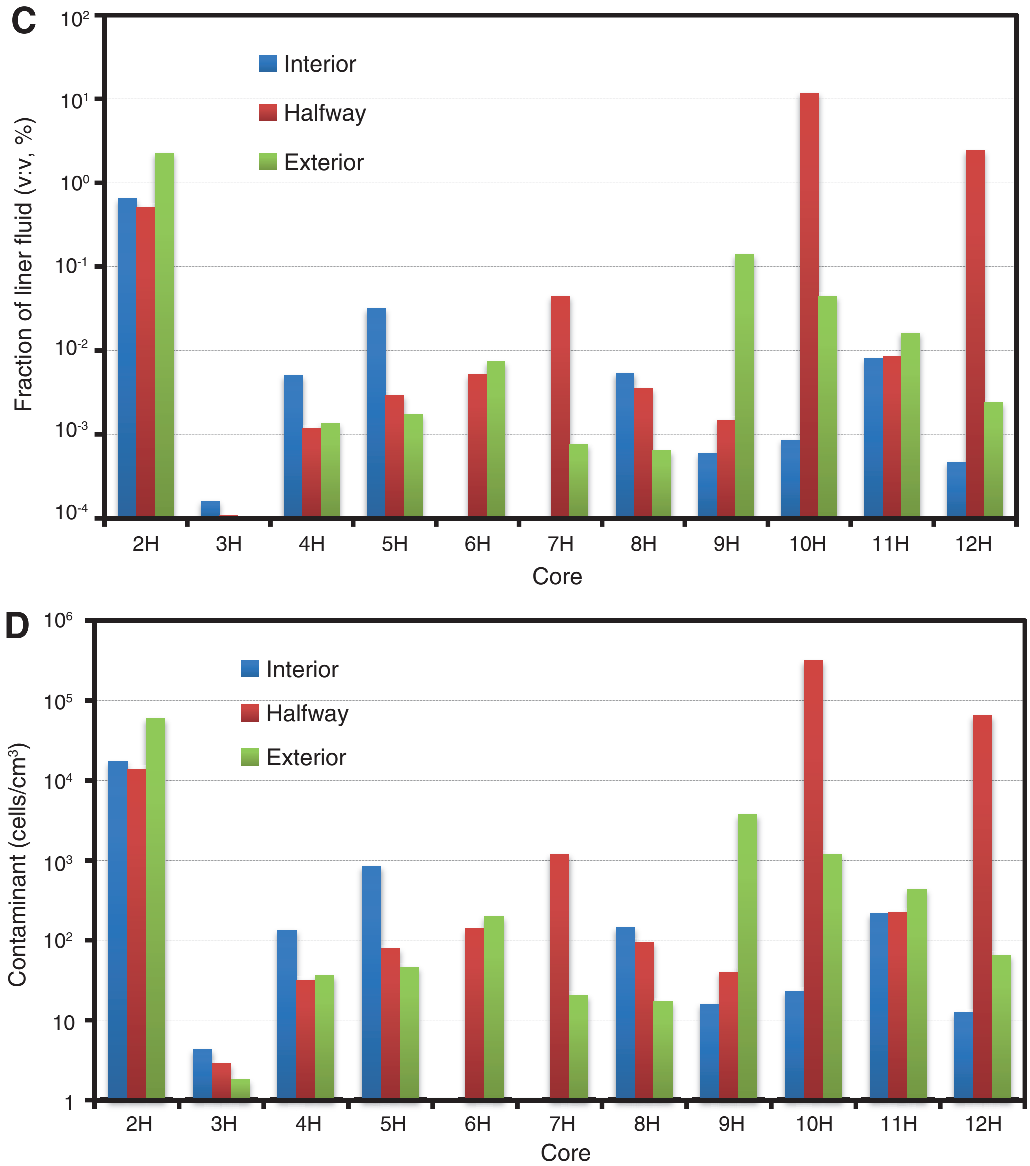


Figure F22. Plot of spliced magnetic susceptibility data, Hole M0065C.

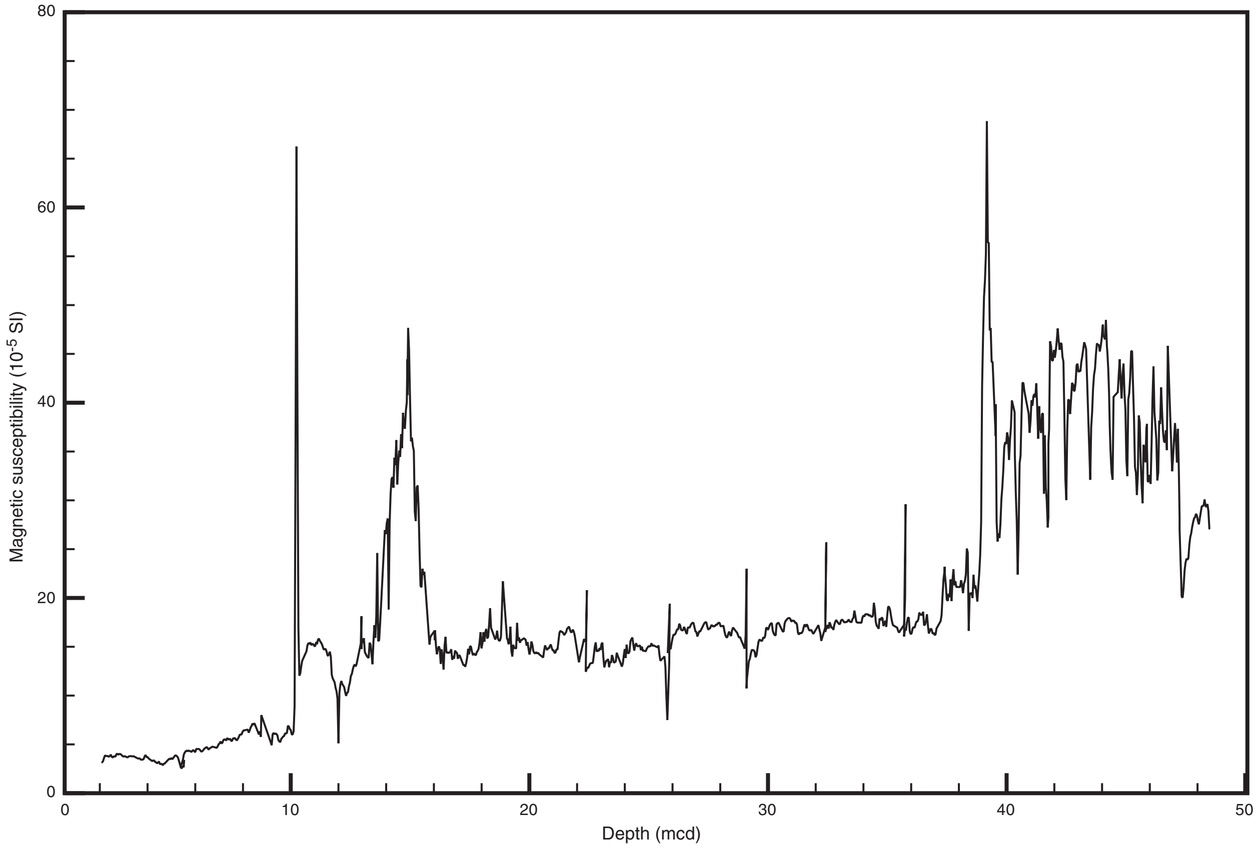


Figure F23. Comparison of smoothed downhole gamma ray and natural gamma ray measurements from core, Hole M0065A.

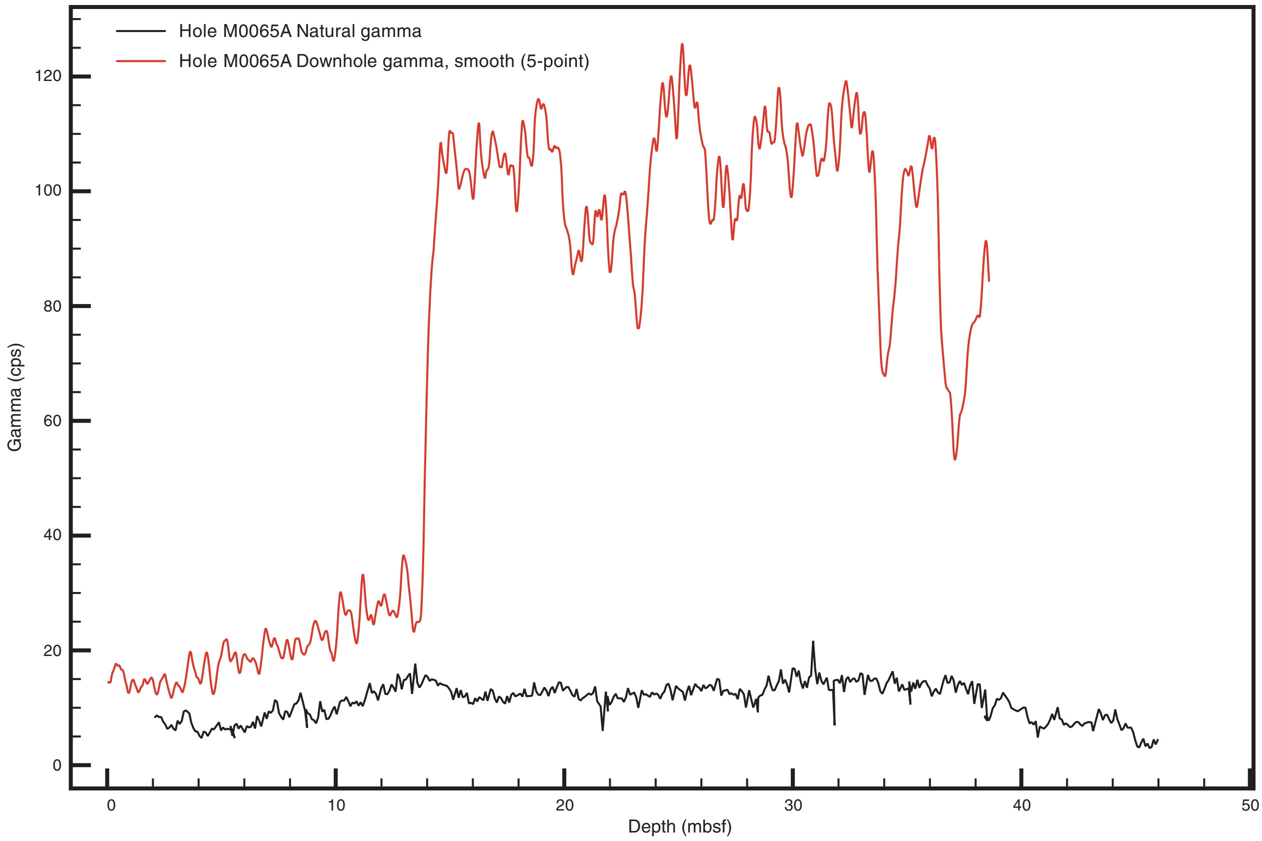


Figure F24. Correlation of seismic profile with lithostratigraphic boundaries and multisensor core logger magnetic susceptibility data, Site M0065. Precruise interpretation of seismic data is also shown: SF = seafloor, BH = Base Holocene, LG1 = Late Glacial 1 (HA), LG2 = Late Glacial II, BR = base depression.

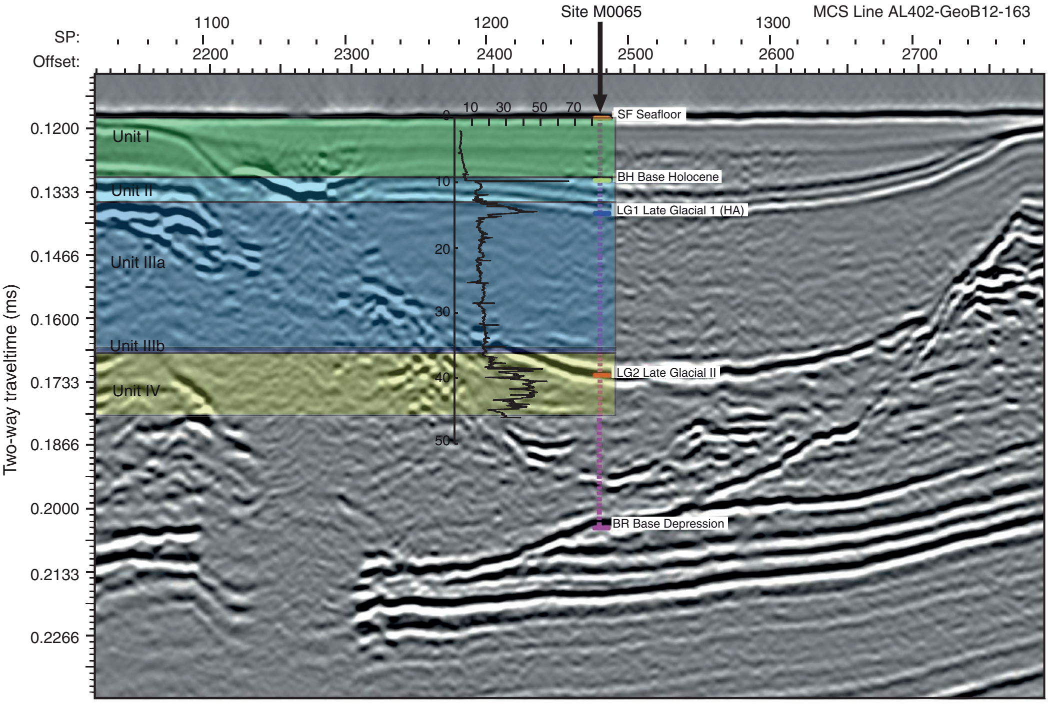


Figure F25. Gamma ray log and resistivity log, Hole M0065A. The drill pipe was set at 14 m WSF.

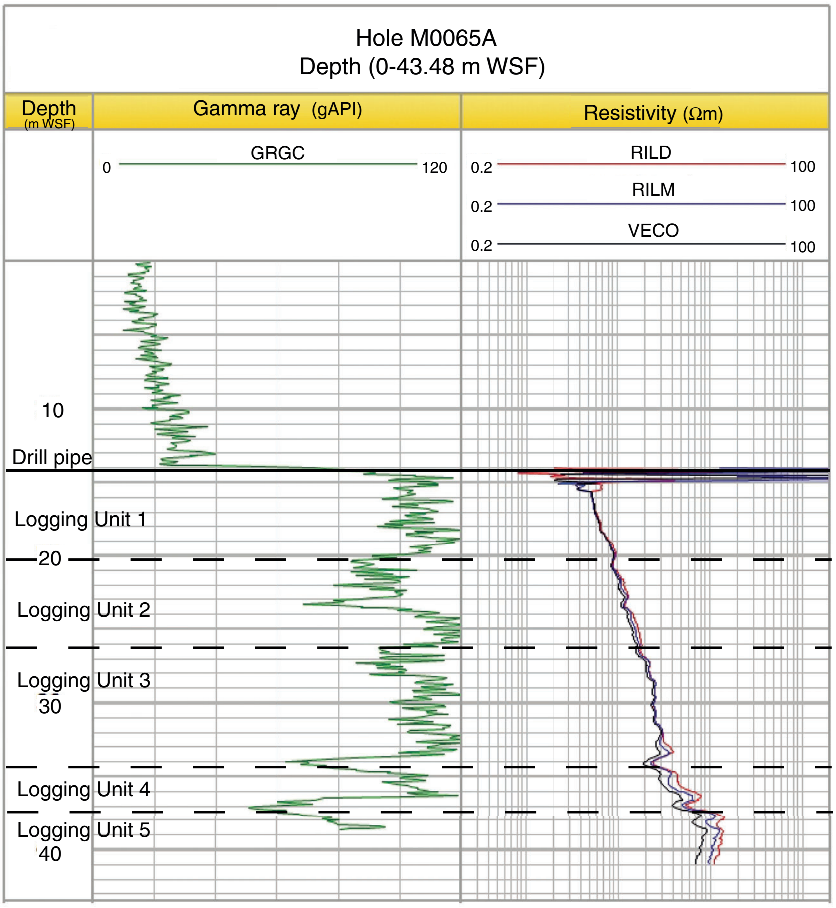


Figure F26. Gamma ray log, spectral gamma ray log, and sonic log, Hole M0065C. The drill pipe is set at 13.2 m WSF.

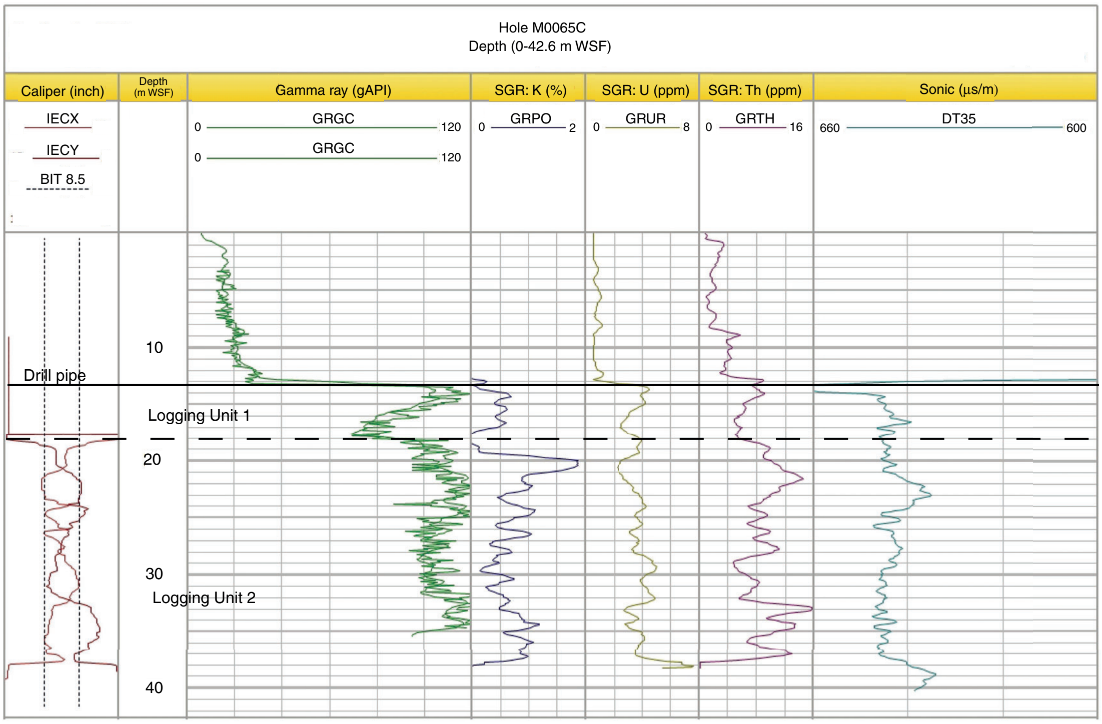


Table T1. Operations, Site M0065. (Continued on next two pages.)

Core	Coring method	Date (2013)	Time (UTC)	Depth (mbsf) Top	Depth (mbsf) Bottom	Recovered (m)	Recovery (%)	Mud type	Comments
347-M0065A-									
		23 Oct	1400						Arrived on site; built a differential GPS model
		23 Oct	1430						Lowered template into moonpool; checked bit and prepared for ROV survey
		23 Oct	1442						ROV in water and running down to seabed for predrilling survey
		23 Oct	1610						Derigged ROV and cleaned; prepared drill floor for operations
		23 Oct	1655						Lowered seabed template
		23 Oct	1715						Ran pipe
1O	NCA	23 Oct	1835	0.00	2.00	0.00	0	Seawater	Washed down through possible contaminants
2H	PCS	23 Oct	1850	2.00	5.30	3.61	109.39	Seawater	
3H	PCS	23 Oct	1920	5.30	8.60	3.52	106.67	Seawater	53 bar
4H	PCS	23 Oct	2000	8.60	11.90	3.52	106.67	Seawater	48 bar
5H	PCS	23 Oct	2035	11.90	15.20	3.67	111.21	Seawater	36 bar
6H	PCS	23 Oct	2115	15.20	18.50	3.52	106.67	Seawater	
7H	PCS	23 Oct	2212	18.50	21.80	3.53	106.97	Seawater	35 bar
8H	PCS	23 Oct	2240	21.80	25.10	3.68	111.52	Seawater	70 bar
9H	PCS	23 Oct	2325	25.10	28.40	3.43	103.94	Seawater	Did not appear to fire, even on second attempt, may have fired on the way down; collected a full sample
10H	PCS	24 Oct	0015	28.40	31.70	3.49	105.76	Seawater	55 bar
11H	PCS	24 Oct	0040	31.70	35.00	3.51	106.36	Seawater	65 bar
12H	PCS	24 Oct	0122	35.00	38.30	3.60	109.09	Seawater	50 bar
13H	PCS	24 Oct	0205	38.30	40.00	1.62	95.29	Seawater	110 bar and did not drop below 40 bar on release, hence not full stroke
14H	PCS	24 Oct	0255	40.00	43.30	3.45	104.55	Guar	70 bar
15H	PCS	24 Oct	0325	43.30	46.60	3.03	91.82	Guar	130 bar
16O	NCA	24 Oct	0507	46.60	49.60	0.00	0	Guar	Open hole to try and ascertain if in stones, only sand and clay evident
17S	HS	24 Oct	0720	49.60	49.70	0.10	100		Hammer sample 25 blows showed dense fine sand in hole
18O	NCA	24 Oct	0730	49.70	52.60	0.00	0	Guar	Open hole to next hammer sample interval
19S	HS	24 Oct	0838	52.60	52.65	0.05	100		Fine sand in hammer sample
20O	NCA	24 Oct	0904	52.65	55.60	0.00	0	Guar	
21S	HS	24 Oct	1000	55.60	55.70	0.10	100		
22O	NCA	24 Oct	1020	55.70	58.60	0.00	0	Guar	
23S	HS	24 Oct	1050	58.60	58.75	0.15	100		
24O	NCA	24 Oct	1115	58.75	59.60	0.00	0	Guar	
25S	HS	24 Oct	1140	59.60	59.70	0.10	100		
26O	NCA	24 Oct	1150	59.70	60.60	0.00	0	Guar	
27S	HS	24 Oct	1205	60.60	60.70	0.10	100		
28O	NCA	24 Oct	1225	60.70	61.60	0.00	0	Guar	
29S	HS	24 Oct	1215	61.60	61.70	0.10	100		
30O	NCA	24 Oct	1300	61.70	63.60	0.00	0	Guar	
31S	HS	24 Oct	1320	63.60	63.65	0.05	100		
		24 Oct	1345						Powerpack pressure release valve problem required shutdown
32O	NCA	24 Oct	1410	63.65	65.60	0.00	0	Guar	
33S	HS	24 Oct	1440	65.60	65.75	0.15	100		
34O	NCA	24 Oct	1455	65.75	67.60	0.00	0	Guar	
35S	HS	24 Oct	1520	67.60	67.75	0.15	100		
36O	NCA	24 Oct	1535	67.75	69.60	0.00	0	Guar	
37S	HS	24 Oct	1600	69.60	69.65	0.05	100		
38O	NCA	24 Oct	1615	69.65	71.60	0.00	0	Guar	
39S	HS	24 Oct	1635	71.60	71.62	0.02	100		
40O	NCA	24 Oct	1654	71.62	73.60	0.00	0	Guar	
41S	HS	24 Oct	1714	73.60	73.60	0.00	0		Slight show of chalk on inside of shoe; reran insert bit for short run and rehammer
42O	NCA	24 Oct	1720	73.60	73.80	0.00	0	Guar	Low flush rate to retain as much disturbed material as possible at the bottom for the hammer to collect

Table T1 (continued). (Continued on next page.)

Core	Coring method	Date (2013)	Time (UTC)	Depth (mbsf) Top	Depth (mbsf) Bottom	Recovered (m)	Recovery (%)	Mud type	Comments
43S	HS	24 Oct	1730	73.80	73.90	0.10	100		50 blows; bedrock in shoe
		24 Oct	1745						End of hole
		24 Oct	1750					Guar	Mud flush before pulling back to 3.4 mbsf for logging; changed to 12 m below seabed at drillers request
		24 Oct	1830						Set up logging tools
		24 Oct	1900						First logging run to 41.5 mbsf
		24 Oct	1940						Second logging run: hole collapsed at bottom of pipe; dismantled logging deck
		24 Oct	2030						Discussed possibility of wiper trip with Logging Staff Scientist and Co-Chief and agreed to attempt for second run; wiper trip for 3 pipes to clear hole for second logging run
		24 Oct	2110						Rerigged logging deck; 35 kt wind and building
		24 Oct	2120						Attempted second logging run, only achieved 5 m open hole
		24 Oct	2130						Recovered tools and dismantled logging deck
		24 Oct	2145						Tripped pipe
347-M0065B-									
		24 Oct	2230						On site; lowered seabed frame and added drill pipe
1O	NCA	24 Oct	2310	0.00	3.00	0.00	0	Seawater	Open hole first section to avoid possible contamination
2H	PCS	24 Oct	2314	3.00	6.30	3.62	109.7	Seawater	
3H	PCS	25 Oct	0005	6.30	9.60	3.66	110.91	Seawater	
4H	PCS	25 Oct	0048	9.60	12.90	3.37	102.12	Seawater	Core degassing a lot
5H	PCS	25 Oct	0126	12.90	16.20	3.53	106.97	Seawater	
6H	PCS	25 Oct	0210	16.20	19.50	3.45	104.55	Seawater	45 bar
7H	PCS	25 Oct	0258	19.50	22.80	3.59	108.79	Seawater	
8H	PCS	25 Oct	0338	22.80	26.10	3.54	107.27	Seawater	
9H	PCS	25 Oct	0440	26.10	29.40	3.43	103.94	Seawater	
10H	PCS	25 Oct	0455	29.40	32.70	3.51	106.36	Seawater	
11H	PCS	25 Oct	0600	32.70	36.00	3.50	106.06	Seawater	
12H	PCS	25 Oct	0635	36.00	39.30	3.41	103.33	Seawater	
13H	PCS	25 Oct	0705	39.30	42.60	3.14	95.15	Seawater	
14H	PCS	25 Oct	0740	42.60	45.90	3.35	101.52	Seawater	
15H	PCS	25 Oct	0820	45.90	46.90	0.84	84	Seawater	
16O	NCA	25 Oct	0855	46.90	48.90	0.00	0	Seawater	
17S	HS	25 Oct	0920	48.90	49.20	0.30	100		Sand with smearing of clay/silt
18S	HS	25 Oct	1000	49.20	49.30	0.10	100		
		25 Oct	1015						End of hole
		25 Oct	1015						Tripped pipe above seabed to allow bumping over to Hole M0065C
347-M0065C-									
		25 Oct	1110						On site; lowered seabed frame and added drill pipe
1O	NCA	25 Oct	1115	0.00	2.00	0.00	0	Seawater	Open hole first section to avoid possible contamination
2H	PCS	25 Oct	1125	2.00	5.30	3.75	113.64	Seawater	
3H	PCS	25 Oct	1205	5.50	8.60	3.60	116.13	Seawater	
4H	PCS	25 Oct	1330	8.60	11.90	3.64	110.3	Seawater	
5H	PCS	25 Oct	1420	11.90	15.20	3.68	111.52	Seawater	
6H	PCS	25 Oct	1509	15.20	18.50	3.50	106.06	Seawater	
7H	PCS	25 Oct	1636	18.50	21.80	3.44	104.24	Seawater	64 bar
8H	PCS	25 Oct	1730	21.80	25.10	3.54	107.27	Seawater	
9H	PCS	25 Oct	1823	25.10	28.40	3.39	102.73	Seawater	65 bar
10H	PCS	25 Oct	1921	28.40	31.70	3.36	101.82	Seawater	61 bar, no lower shoe sample
11H	PCS	25 Oct	2015	31.70	35.00	3.60	109.09	Seawater	62 bar
12H	PCS	25 Oct	2110	35.00	38.30	3.67	111.21	Seawater	
13H	PCS	25 Oct	2205	38.30	41.60	3.25	98.48	Seawater	60 bar
14H	PCS	25 Oct	2308	41.60	44.90	3.30	100	GS550	70 bar

Table T1 (continued).

Core	Coring method	Date (2013)	Time (UTC)	Depth (mbsf) Top	Depth (mbsf) Bottom	Recovered (m)	Recovery (%)	Mud type	Comments
15H	PCS	25 Oct	2340	44.90	47.90	2.87	95.67	GS550	150 bar and pressure stayed full until driller lifted the string
		26 Oct	0015						Drilling ended; prepared for logging
		26 Oct	0020						Filled hole with very heavy mud
		26 Oct	0040						Lifted drill string to 14 mbsf
		26 Oct	0120						Logging run started; reached 40 mbsf
		26 Oct	0220						Second logging string in the hole
		26 Oct	0310						Started lifting drill string with personnel in full PPE hosing potentially contaminated pipes down with water

HS = hammer sampler, NCA = noncoring assembly, PCS = piston coring system. ROV = remotely operated vehicle, PPE = personal protective equipment.

Table T2. Diatom species, Site M0065.

Taxonomic list
Marine taxa
Actinoptychus senarius (Ehrenberg) Ehrenberg
Dimeregramma minor (Gregory) Ralfs
Diploneis decipiens var. *parallela* A. Cleve
Hyalodiscus scoticus (Kützing) Grunow
Lyrella cf. *spectabilis* (Gregory) D.G. Mann
Opephora marina (Gregory) Petit
Opephora minuta (Cleve-Euler) Witkowski
Pseudosolenia calcar-avis (Schultze) B.G. Sundström
Thalassiosira eccentrica (Ehrenberg) Cleve
Thalassiosira oestrupii (Ostenfeld) Hasle
Toxarium undulatum Bailey
Brackish-marine taxa
Chaetoceros resting spores spp.
Cocconeis speciosa Gregory
Fallacia pseudony (Hustedt) D.G. Mann
Grammatophora oceanica Ehrenberg
Rhabdonema arcuatum (Lyngbye) Kützing
Rhabdonema minutum Kützing
Thalassionema nitzschioides (Grunow) Mereschkowsky
Brackish taxa
Achnanthes lemmermannii Hustedt
Amphora robusta Gregory
Brachysira aponina Kützing
Chamaepinnularia witkowskii (Lange-Bertalot and Metzeltin) Kulikovskiy and Lange-Bertalot
Cocconeis scutellum Ehrenberg
Cyclotella choctawhatcheeana Prasad
Diploneis didyma (Ehrenberg) Ehrenberg
Diploneis interrupta (Kützing) Cleve
Diploneis stroemii Hustedt
Epithemia adnata (Kützing) Brébisson
Fragilaria gedanensis Witkowski
Martyana schulzii (Brockmann) Snoeijs
Mastogloia pusilla Grunow
Navicula palpebralis Brébisson ex W. Smith
Navicula peregrina (Ehrenberg) Kützing
Paralia sulcata (Ehrenberg) Cleve
Planothidium quarnerensis (Grunow) Witkowski, Lange-Bertalot and Metzelin
Rhoicosphenia curvata (Kützing) Grunow
Thalassiosira proschkinae Makarova
Brackish-freshwater taxa
Actinocyclus octonarius var. *crassus* (W. Smith) Hendey
Amphora pediculus (Kützing) Grunow ex A. Schmidt
Aneumastus minor (Hustedt) Lange-Bertalot
Cymatopleura elliptica (Brébisson) W. Smith
Diploneis domblittensis (Grunow) Cleve
Diploneis smithii (Brébisson) Cleve
Epithemia turgida var. *westermannii* (Ehrenberg) Grunow
Fragilariopsis cylindrus (Grunow) Krieger
Gyrosigma acuminatum (Kützing) Rabenhorst
Melosira lineata (Dillwyn) Agardh
Navicula capitata var. *hungarica* (Grunow) R. Ross
Pseudostaurosira brevistriata (Grunow) Williams and Round
Thalassiosira baltica (Grunow) Ostenfeld
Freshwater taxa
Aneumastus tusculus (Ehrenberg) D.G. Mann and A.J. Stickle
Aulacoseira ambigua (Grunow) Simonsen
Aulacoseira subarctica (O. Müller) Haworth
Aulacoseira islandica (O. Müller) Simonsen
Cocconeis disculus (Schumann) Cleve
Cocconeis neodiminuta Krammer
Cocconeis pseudothumensis Reichard
Cyclotella rossii Håkansson
Cyclotella schumannii (Grunow) Håkansson
Encyonema minutum (Hilse) D.G. Mann
Fragilaria heidenii Østrup
Martyana martyii (Héribaud-Joseph) Round
Navicula jentzschii Grunow
Sellaphora pupula (Kützing) Mereschowsky
Staurosira venter (Ehrenberg) H. Kobayasi
Stephanodiscus cf. *alpinus* Hustedt
Stephanodiscus medius Håkansson
Stephanodiscus neoastraea Håkansson and Hickel
Stephanodiscus spp.
Tabellaria flocculosa (Roth) Kützing

Salinity affinities follows Snoeijs et al. (1993–1998). Diatom authorities according to AlgaeBase (www.algaebase.org).

Table T3. Diatoms, Hole M0065A. This table is available in oversized format.

Table T4. Foraminifers, Site M0065.

Hole, core, section, interval (cm)	Depth (mbsf) Top	Depth (mbsf) Bottom	Abundance	Number of species	*Elphidium albiumbilicatum*	*Elphidium excavatum clavatum*	*Elphidium excavatum selseyensis*	*Elphidium incertum*	*Elphidium williamsoni*	Other *Elphidium* and *Haynesina* spp.
347-										
M0065A-2H-1, 15–17	2.15	2.17	R	2		x	x			
M0065A-2H-1, 75–77	2.75	2.77	V	2		x				x
M0065B-2H-1, 15–17	3.15	3.17	C	4	x	x	x	x		
M0065B-2H-1, 76–78	3.76	3.78	C	4		x	x		x	x
M0065B-2H-2, 15–17	4.65	4.67	A	4		x	x		x	x
M0065A-2H-CC	5.59	5.61	C	2		x	x			
M0065C-2H-CC	5.73	5.75	F	2		x				x
M0065B-2H-CC	6.60	6.62	C	3		x	x			x
M0065A-3H-2, 15–17	6.95	6.97	F	2	x	x				
M0065B-3H-2, 15–17	7.95	7.97	R	3		x	x		x	
M0065A-3H-CC	8.81	8.82	R	1		x				
M0065C-3H-CC	8.88	8.90	V	1		x				
M0065B-3H-CC	9.92	9.96	B							
M0065A-4H-2, 15–17	10.25	10.27	B							
M0065B-4H-2, 15–17	11.25	11.27	B							
M0065A-4H-CC	11.90	12.12	V	1		x				
M0065C-4H-CC	12.20	12.24	B							
M0065B-4H-CC	12.80	12.97	B							
M0065A-5H-CC	15.24	15.57	B							
M0065B-5H-CC	16.40	16.43	B							
M0065A-6H-2, 15–17	16.84	16.86	B							
M0065A-6H-CC	18.46	18.72	B							
M0065B-6H-CC	19.60	19.65	B							
M0065A-7H-CC	22.00	22.03	B							
M0065B-7H-CC	23.07	23.09	B							
M0065A-8H-2, 15–17	23.45	23.47	B							
M0065A-8H-CC	25.45	25.48	B							
M0065B-8H-CC	26.32	26.34	B							
M0065A-10H-2, 15–17	30.05	30.07	B							
M0065A-10H-CC	31.86	31.89	B							
M0065B-10H-CC	32.89	32.91	B							
M0065A-11H-CC	35.19	35.21	B							
M0065B-11H-CC	36.19	36.20	B							
M0065A-12H-1, 122–124	36.22	36.24	B							
M0065A-12H-2, 3–5	36.53	36.55	B							
M0065A-12H-3, 15–17	38.15	38.17	B							
M0065A-12H-CC	38.56	38.60	B							
M0065A-14H-2, 15–17	41.65	41.67	B							
M0065B-13H-CC	42.43	42.44	B							
M0065A-14H-CC	43.45	43.50	B							
M0065B-14H-CC	45.75	45.90	B							
M0065B-15H-1, 20–22	46.10	46.12	B							
M0065A-15H-CC	46.29	46.31	B							
M0065B-15H-1, 41–43	46.31	46.33	B							
M0065B-15H-1, 43–45	46.33	46.35	B							
M0065B-17S-CC	49.17	49.20	B							
M0065A-17H-CC	49.64	49.70	B							
M0065A-25S-CC	59.64	59.70	B							
M0065A-27S-CC	60.64	60.70	B							
M0065A-29S-CC	61.65	61.70	B							
M0065A-33S-CC	65.64	65.75	B							
M0065A-35S-CC	67.65	67.75	B							
M0065A-37S-CC	69.63	69.65	B							
M0065A-39S-CC	71.60	71.62	B							
M0065A-43S-CC	73.85	73.90	B							

Abundance: A = abundant, C = common, F = few, R = rare, B = barren, V = very high.

Table T5. Distribution and abundance of ostracods, Site M0065.

Core, section, interval (cm)	Depth (mbsf)	Overall abundance/20 cm^3	Abundance (offshore samples, 5–30 cm^3)	*Cytheropteron latissimum*	*Robertsonites tuberculatus*	*Palmoconcha* spp.	*Paracyprideis* sp.	*Sarsicytheridea bradii*	Undetermined
347-M0065A-									
2H-1, 15–17	2.16	R		R				R	
2H-1, 75–77	2.76	B							
2H-CC, 28–30	5.59		B						
3H-2, 15–17	6.96	R				R			
3H-CC, 24–25	8.81		F			F			
4H-2, 15–17	10.26	B							
4H-CC, 0–22	11.90		B						
5H-CC, 0–33	15.24		B						
6H-2, 15–17	16.85	B							
6H-CC, 0–26	18.46		B						
7H-CC, 27–30	22.00		B						
8H-2, 15–17	23.46	B							
8H-CC, 34–37	25.45		B						
10H-2, 15–17	30.06	B							
10H-CC, 17–20	31.86		B						
11H-CC, 20–22	35.19		B						
12H-1, 122–124	36.23	B							
12H-2, 3–5	36.54	B							
12H-3, 15–17	38.16	B							
12H-CC, 23–27	38.56		B						
14H-2, 15–17	41.66	B							
14H-CC, 28–33	43.45		B						
15H-CC, 24–26	46.29		B						
17H-CC, 4–10	49.64		B						
25S-CC, 4–10	59.64		B						
27S-CC, 4–10	60.64		B						
29S-CC, 5–10	61.65		B						
33S-CC, 4–15	65.64		B						
35S-CC, 5–15	67.65		B						
37S-CC, 2–5	69.62		B						
39S-CC, 0–2	71.60		B						
43S-CC, 5–10	73.85		B						
347-M0065B-									
2H-1, 15–17	3.16	R			R		R		R
2H-1, 76–78	3.77	B							
2H-2, 15–17	4.66	B							
2H-CC, 21–23	6.60		R			R			
3H-2, 15–17	7.96		C		R	C			
3H-CC, 24–27	9.93		B						
4H-2, 15–17	11.26	B							
4H-CC, 13–17	12.93		B						
5H-CC, 25–28	16.40		B						
6H-CC, 16–21	19.60		B						
7H-CC, 28–30	23.07		B						
8H-CC, 22–24	26.32		B						
10H-CC, 23–25	32.89		B						
11H-CC, 29–30	36.19		B						
13H-CC, 4–5	42.43		B						
14H-CC, 0–15	45.75		B						
17S-CC, 27–30	49.17		B						
347-M0065C-									
2H-CC, 25–27	5.73		R			R			
3H-CC, 28–30	8.88		F			F			
4H-CC, 30–34	12.20		B						

Abundance: C = common, F = few, R = rare, B = barren.

Table T6. Interstitial water geochemistry, Site M0065. This table is available in **oversized format**.

Table T7. Calculated salinity and elemental ratios of interstitial waters, Site M0065. (Continued on next page.)

Core, section, interval (cm)	Type	Depth (mbsf)	Cl^- based salinity	Na/Cl (mM/mM)	Ca/Cl (mM/mM)	Mg/Cl (mM/mM)	K/Cl (mM/mM)	Br/Cl (µM/mM)	B/Cl (µM/mM)
347-M0065A-									
2H-1, 135–140	Rh	3.38	14.94	0.90	0.03	0.11	0.02	1.75	1.43
2H-2, 115–120	Rh	4.68	14.56	0.95	0.03	0.12	0.03	1.78	1.53
3H-1, 135–140	Rh	6.68	14.65	1.03	0.04	0.12	0.03	1.71	1.62
3H-2, 115–120	Rh	7.98	14.24	0.95	0.05	0.11	0.02	1.80	1.46
4H-1, 135–140	Rh	9.98	13.54	0.97	0.06	0.10	0.02	1.80	1.11
4H-2, 115–120	Rh	11.28	13.03	0.94	0.07	0.11	0.02	1.79	1.00
5H-1, 135–140	Rh	13.28	11.92	0.95	0.09	0.10	0.01	1.80	0.76
5H-2, 124–129	Rh	14.67	11.08	0.87	0.10	0.09	0.01	1.80	0.57
6H-1, 134–139	Rh	16.57	9.78	0.92	0.14	0.09	0.01	1.79	0.43
6H-2, 135–120	Rh	17.87	8.89	0.88	0.15	0.09	0.01	1.80	0.34
7H-1, 135–140	Rh	19.88	7.35	0.73	0.18	0.08	0.00	1.83	0.30
7H-2, 135–140	Rh	21.38	6.35	0.62	0.18	0.08	0.00	1.83	0.31
8H-1, 135–140	Rh	23.18	5.43	0.54	0.21	0.08	0.00	1.84	0.39
9H-1, 135–140	Rh	26.48	3.60	0.47	0.27	0.10	0.01	1.85	0.54
10H-1, 135–140	Rh	29.78	2.49	0.38	0.31	0.11	0.01	1.90	0.75
11H-1, 135–140	Rh	33.08	1.69	0.29	0.36	0.13	0.01	1.98	1.12
12H-1, 135–140	Rh	36.38	1.38	—	—	—	—	—	—
13H-1, 121–126	Rh	39.54	2.23	0.60	0.24	0.10	0.01	1.79	1.00
14H-1, 135–140	Rh	41.38	1.28	0.53	0.28	0.11	0.01	2.09	1.81
15H-1, 126–131	Rh	44.59	1.44	0.59	0.24	0.09	0.01	2.06	2.09
347-M0065B-									
2H-1, 135–140	Rh	4.38	14.85	0.97	0.03	0.12	0.03	1.77	1.58
2H-2, 135–140	Rh	5.88	14.86	0.93	0.04	0.11	0.02	1.78	1.56
3H-1, 135–140	Rh	7.68	14.33	0.94	0.04	0.11	0.02	1.81	1.43
3H-2, 135–140	Rh	9.18	13.59	0.92	0.05	0.11	0.02	1.81	1.25
4H-1, 135–140	Rh	10.98	12.85	1.04	0.07	0.12	0.02	1.79	1.15
4H-2, 135–140	Rh	12.48	12.50	1.04	0.08	0.11	0.02	1.81	1.00
5H-1, 135–140	Rh	14.28	11.49	0.98	0.10	0.11	0.01	1.80	0.74
5H-2, 135–140	Rh	15.78	10.66	1.04	0.13	0.11	0.01	1.79	0.57
6H-1, 135–140	Rh	17.58	8.95	0.95	0.16	0.10	0.01	1.81	0.39
6H-2, 135–140	Rh	19.08	7.94	0.92	0.19	0.10	0.01	1.83	0.35
7H-1, 135–140	Rh	20.88	6.78	0.70	0.20	0.09	0.00	1.80	0.31
8H-1, 135–140	Rh	24.18	4.85	0.52	0.22	0.08	0.00	1.87	0.39
9H-1, 135–140	Rh	27.48	3.34	0.41	0.27	0.10	0.00	1.78	0.48
10H-1, 145–150	Rh	30.88	2.30	0.38	0.32	0.12	0.01	1.93	0.78
11H-1, 135–140	Rh	34.08	1.50	0.25	0.35	0.13	0.01	2.03	1.19
12H-1, 135–140	Rh	37.38	1.20	0.26	0.35	0.13	0.01	2.11	1.50
13H-1, 135–140	Rh	40.68	1.20	0.39	0.30	0.12	0.01	2.15	1.75
14H-1, 135–140	Rh	43.98	1.39	0.58	0.24	0.09	0.01	2.08	1.95
15H-1, 59–64	Rh	46.52	2.03	0.74	0.19	0.08	0.01	1.90	1.60
347-M0065C-									
2H-1, 130–140	Sq	3.35	15.84	0.91	0.03	0.11	0.03	1.72	1.48
2H-2, 130–130	Sq	4.80	15.21	0.87	0.03	0.11	0.03	1.74	1.35
3H-1, 135–145	Sq	6.70	15.29	0.86	0.04	0.11	0.02	1.77	1.45
3H-2, 115–115	Sq	7.95	14.64	0.89	0.04	0.10	0.02	1.77	1.24
4H-1, 130–140	Sq	9.95	13.86	0.84	0.05	0.09	0.02	1.76	1.03
4H-2, 135–135	Sq	11.45	12.15	0.94	0.07	0.10	0.02	1.76	0.93
5H-1, 135–145	Sq	13.30	13.19	0.97	0.08	0.10	0.02	1.77	0.72
5H-2, 140–140	Sq	14.80	11.08	0.88	0.09	0.09	0.01	1.76	0.53
6H-1, 135–145	Sq	16.60	10.07	0.80	0.12	0.08	0.01	1.77	0.36
6H-2, 140–140	Sq	18.10	8.76	0.86	0.15	0.08	0.01	1.91	0.32
7H-1, 130–140	Sq	19.85	7.80	0.70	0.15	0.08	0.00	1.79	0.29
7H-2, 140–140	Sq	21.40	6.65	0.62	0.17	0.07	0.00	1.81	0.30
8H-2, 35–45	Sq	23.70	5.49	0.55	0.21	0.08	0.00	1.83	0.40
9H-2, 70–80	Sq	27.35	3.69	0.46	0.27	0.10	0.00	1.81	0.57
10H-2, 105–115	Sq	31.00	1.72	0.47	0.44	0.17	0.01	1.99	1.26
11H-2, 45–55	Sq	33.70	2.35	0.23	0.27	0.11	0.01	1.91	1.00
12H-2, 65–75	Sq	37.20	1.26	0.29	0.34	0.15	0.01	2.07	1.82
13H-1, 135–140	Sq	39.68	1.52	0.48	0.26	0.11	0.01	1.93	1.40
14H-1, 135–140	Sq	42.98	1.40	0.58	0.25	0.10	0.01	2.01	1.77
15H-1, 135–140	Sq	46.28	1.67	0.66	0.21	0.08	0.01	1.99	2.01

Table T7 (continued).

Core, section, interval (cm)	Type	Depth (mbsf)	Cl^- based salinity	Na/Cl (mM/mM)	Ca/Cl (mM/mM)	Mg/Cl (mM/mM)	K/Cl (mM/mM)	Br/Cl (µM/mM)	B/Cl (µM/mM)
347-M0065C-									
2H-1, 54–59	Rh	2.57	15.52	0.87	0.03	0.10	0.02	1.67	1.25
3H-1, 67–72	Rh	6.00	14.84	0.87	0.03	0.11	0.02	1.76	1.34
3H-2, 47–52	Rh	7.30	14.65	0.90	0.04	0.11	0.02	1.77	1.24
4H-1, 56–61	Rh	9.19	12.84	0.90	0.05	0.10	0.02	1.76	1.10
5H-1, 90–95	Rh	12.83	12.36	0.90	0.07	0.09	0.01	1.75	0.71
5H-2, 88–93	Rh	14.31	11.49	0.83	0.08	0.08	0.01	1.76	0.49
6H-1, 112–117	Rh	16.35	10.01	0.90	0.11	0.08	0.01	1.75	0.34
6H-2, 112–117	Rh	17.85	8.96	0.91	0.16	0.09	0.01	1.78	0.33
7H-1, 104–109	Rh	19.57	7.88	0.83	0.17	0.08	0.00	1.77	0.27
8H-1, 135–140	Rh	23.18	5.58	0.65	0.23	0.09	0.00	1.82	0.35
9H-1, 134–139	Rh	26.47	4.00	—	—	—	—	—	—
10H-1, 92–97	Rh	29.35	2.78	0.39	0.30	0.11	0.01	1.86	0.61
11H-1, 134–139	Rh	33.07	—	—	—	—	—	—	—
12H-1, 65–70	Rh	35.68	1.26	—	—	—	—	—	—

Rh = Rhizon sample, Sq = squeezed sample. — = no data are reported for samples with insufficient pore water volumes.

Table T8. Concentration of methane in interstitial water, Site M0065.

Core, section, interval (cm)	Depth (mbsf)	CH_4 (mM)
347-M0065A-		
2H-1, 145–150	3.48	10.1
2H-2, 125–130	4.78	7.3
3H-1, 145–150	6.78	8.4
3H-2, 125–130	8.08	8.9
4H-1, 145–150	10.08	9.2
4H-2, 125–130	11.38	9.3
5H-1, 145–150	13.38	4.7
5H-2, 134–139	14.77	6.6
6H-1, 144–149	16.67	0.8
6H-2, 125–130	17.97	8.0
7H-1, 145–150	19.98	5.7
7H-2, 145–150	21.48	5.4
8H-1, 145–150	23.28	4.5
9H-1, 145–150	26.58	2.2
10H-1, 145–150	29.88	1.4
11H-1, 145–150	33.18	0.8
12H-1, 145–150	36.48	0.4
14H-1, 145–150	41.48	0.3
15H-1, 136–141	44.69	0.3

Table T9. Total carbon (TC), total organic carbon (TOC), total inorganic carbon (TIC), and total sulfur (TS) in sediment, Site M0065.

Core, section, interval (cm)	Depth (mbsf)	TC (wt%)	TOC (wt%)	TIC (wt%)	TS (wt%)
347-M0065A-					
2H-1, 86–87	2.86	4.16	3.67	0.49	1.30
3H-2, 84–85	7.64	4.01	3.38	0.63	1.16
4H-3, 20–21	11.60	0.97	0.88	0.10	—
5H-1, 33–34	12.23	0.83	0.72	0.11	0.33
5H-2, 130–131	14.69	0.84	0.27	0.57	0.11
6H-2, 52–53	17.21	1.73	0.49	1.24	0.12
7H-2, 63–64	20.63	2.51	0.71	1.81	0.16
8H-1, 117–118	22.97	1.71	0.48	1.22	0.13
9H-2, 66.5–67.5	27.27	2.36	0.50	1.85	0.15
10H-2, 42–44	30.32	2.48	0.48	1.99	0.17
11H-1, 117–118	32.87	1.68	0.46	1.22	0.11
12H-2, 91–92	37.41	2.32	0.40	1.91	0.12
13H-1, 85–86	39.15	2.26	0.32	1.95	0.16
14H-1, 49–50	40.49	2.50	0.07	2.43	0.26
15H-1, 47–48	43.77	3.71	0.33	3.38	0.44
347-M0065B-					
2H-1, 74–75	3.74	4.44	3.99	0.45	1.53
3H-1, 100–101.5	7.30	3.97	3.38	0.59	1.23
4H-1, 70–71	10.30	2.16	1.93	0.23	—
5H-1, 33–34	13.23	1.04	0.41	0.64	—
5H-2, 33–34	14.73	0.42	0.38	0.05	—
6H-1, 79–80	16.99	2.05	0.50	1.55	0.12
7H-1, 50–51	20.00	1.23	0.51	0.71	0.10
8H-1, 50–51	23.30	3.06	0.91	2.15	0.22
9H-1, 50–51	26.60	1.80	0.51	1.29	0.10
10H-1, 50–51	29.90	2.34	0.53	1.81	0.12
11H-1, 50–51	33.20	1.98	0.47	1.51	0.12
12H-2, 82–83	38.32	2.33	0.40	1.93	0.12
13H-2, 44–45	41.24	2.29	0.05	2.24	0.20
14H-1, 130–131	43.90	3.34	0.23	3.11	0.27
15H-1, 37–38	46.27	3.39	0.70	2.68	0.71
347-M0065C-					
3H-1, 30–31	5.60	4.54	4.12	0.43	1.49
4H-1, 38–39	8.98	3.28	2.83	0.45	1.77
5H-1, 28–29	12.18	0.67	0.58	0.09	0.14
5H-2, 97–98	14.37	0.90	0.28	0.63	0.10
6H-1, 110–111	16.30	1.52	0.49	1.04	0.13
7H-1, 100–101	19.50	1.36	0.48	0.88	0.11
8H-1, 100–101	22.80	2.11	0.58	1.53	0.13
9H-1, 100–101	26.10	2.09	0.47	1.62	0.12
10H-1, 69–70	29.09	2.42	0.51	1.91	0.14
11H-1, 50–51	32.20	1.76	0.44	1.32	0.11
12H-1, 50–51	35.50	2.46	2.02	0.44	0.56
12H-2, 50–51	37.00	2.39	0.65	1.73	0.19
13H-1, 60–61	38.90	2.90	0.28	2.62	0.23
14H-2, 31–32	43.41	3.25	0.22	3.03	0.26
15H-1, 29–30	45.19	3.40	0.23	3.17	0.34

Table T10. Samples taken for cell counts by flow cytometry and acridine orange direct count (AODC), Hole M0059C.

Core, section	Depth (mbsf)	Cytometer counts (log cells/cm^3)	AODC (log cells/cm^3)
347-M0065C-			
2H-2, 3	3.53	8.97	10.09
2H-2, 146			9.81
3H-2, 3	6.83	8.75	10.05
3H-2, 126	8.06		9.37
4H-2, 3	10.13	8.21	9.29
4H-2, 136	11.46		8.38
5H-2, 3	13.43	8.06	7.79
5H-2, 136	14.76		8.29
6H-2, 3	16.73	8.62	8.37
7H-2, 3	20.03	7.92	7.98
8H-2, 3	23.33	7.85	8.26
9H-2, 3	26.63	8.03	8.14
10H-2, 3	29.93	8.61	8.18
11H-2, 3	33.23	8.26	8.16
12H-2, 3	36.53	8.50	8.25

Respective count data are presented in the last two columns in logarithmic format.

Table T11. Drilling fluid contamination, Hole M0065C.

Core	Depth (mbsf)	PFC (g/L)	LF fraction in sample	Contaminant (cells/cm^3)
347-M0065C-				
Core interior				
2H	3.45	3.67E–08	6.49E–03	1.73E+04
3H	6.75	4.95E–09	1.62E–06	4.32E+00
4H	10.05	2.95E–08	5.05E–05	1.35E+02
5H	13.35	2.41E–08	3.19E–04	8.51E+02
6H	16.65	BD	NA	NA
7H	19.95	BD	NA	NA
8H	23.25	1.75E–09	5.41E–05	1.45E+02
9H	26.55	8.53E–10	6.01E–06	1.60E+01
10H	29.85	2.96E–10	8.59E–06	2.29E+01
11H	33.15	2.14E–09	8.08E–05	2.16E+02
12H	36.45	9.22E–10	4.65E–06	1.24E+01
Core halfway				
2H	3.45	2.91E–08	5.15E–03	1.38E+04
3H	6.75	3.29E–09	1.07E–06	2.87E+00
4H	10.05	6.94E–09	1.19E–05	3.17E+01
5H	13.35	2.22E–09	2.94E–05	7.84E+01
6H	16.65	3.07E–09	5.23E–05	1.40E+02
7H	19.95	7.43E–08	4.45E–04	1.19E+03
8H	23.25	1.14E–09	3.53E–05	9.42E+01
9H	26.55	2.12E–09	1.49E–05	3.99E+01
10H	29.85	4.09E–06	1.19E–01	3.17E+05
11H	33.15	2.24E–09	8.46E–05	2.26E+02
12H	36.45	4.85E–06	2.45E–02	6.54E+04
Core exterior				
2H	3.45	1.28E–07	2.26E–02	6.05E+04
3H	6.75	2.09E–09	6.82E–07	1.82E+00
4H	10.05	7.96E–09	1.36E–05	3.63E+01
5H	13.35	1.31E–09	1.73E–05	4.63E+01
6H	16.65	4.34E–09	7.38E–05	1.97E+02
7H	19.95	1.29E–09	7.70E–06	2.06E+01
8H	23.25	2.07E–10	6.41E–06	1.71E+01
9H	26.55	1.99E–07	1.40E–03	3.74E+03
10H	29.85	1.55E–08	4.49E–04	1.20E+03
11H	33.15	4.31E–09	1.63E–04	4.34E+02
12H	36.45	4.81E–09	2.43E–05	6.48E+01
Liner fluid				
2H	3.45	5.65E–06	NA	NA
3H	6.75	3.06E–03	NA	NA
4H	10.05	5.85E–04	NA	NA
5H	13.35	7.56E–05	NA	NA
6H	16.65	5.88E–05	NA	NA
7H	19.95	1.67E–04	NA	NA
8H	23.25	3.23E–05	NA	NA
9H	26.55	1.42E–04	NA	NA
10H	29.85	3.45E–05	NA	NA
11H	33.15	2.65E–05	NA	NA
12H	36.45	1.98E–04	NA	NA
Drilling fluid				
3H	6.75	2.98E–07	NA	NA
3H	6.75	4.29E–05	NA	NA
9H	26.55	1.78E–05	NA	NA
9H	26.55	1.80E–05	NA	NA
9H	26.55	6.33E–07	NA	NA
13H	38.30	1.25E–06	NA	NA
13H	38.30	1.28E–06	NA	NA
15H	44.90	1.55E–04	NA	NA
15H	44.90	8.25E–05	NA	NA

Samples taken from interior, halfway or exterior positions in piston cores, in liner fluid and in drilling fluid. The contaminant cell numbers in samples represent an estimated potential maximum. PFC = perfluorocarbon tracer, LF = liner fluid. BD = below detection, NA = not applicable.

Table T12. Composite depth scale, Site M0065.

Core	Offset (m)	Top depth (mbsf)	Top depth (mcd)
347-M0065A-			
2H	0.00	2.0	2.00
3H	0.00	5.3	5.30
4H	0.47	8.6	9.07
5H	0.47	11.9	12.37
6H	0.47	15.2	15.67
7H	0.47	18.5	18.97
8H	0.47	21.8	22.27
9H	0.62	25.1	25.72
10H	0.62	28.4	29.02
11H	0.62	31.7	32.32
12H	0.62	35.0	35.62
13H	0.62	38.3	38.92
14H	1.89	40.0	41.89
15H	2.52	43.3	45.82
347-M0065B-			
2H	0.16	3.0	3.16
3H	0.22	6.3	6.52
4H	0.22	9.6	9.82
5H	–0.24	12.9	12.66
6H	–0.52	16.2	15.68
7H	–0.55	19.5	18.95
8H	–0.46	22.8	22.34
9H	–0.46	26.1	25.64
10H	–0.46	29.4	28.94
11H	–0.49	32.7	32.21
12H	0.47	36.0	36.47
13H	0.63	39.3	39.93
14H	0.44	42.6	43.04
15H	0.88	45.9	46.78
347-M0065C-			
2H	–0.16	2.0	1.84
3H	0.07	5.3	5.37
4H	0.47	8.6	9.07
5H	0.50	11.9	12.40
6H	0.60	15.2	15.80
7H	0.52	18.5	19.02
8H	0.61	21.8	22.41
9H	0.52	25.1	25.62
10H	0.62	28.4	29.02
11H	0.62	31.7	32.32
12H	0.35	35.0	35.35
13H	1.02	38.3	39.32
14H	1.02	41.6	42.62
15H	0.43	44.9	45.33

Table T13. Splice tie points, Site M0065.

Hole, core, section, interval (cm)	Depth (mbsf)	Depth (mcd)		Hole, core, section, interval (cm)
347-				347-
M0065A-2H-4, 22	5.40	5.40	Append	M0065A-3H-1, 10
M0065A-3H-4, 19	8.70	9.16	Append	M0065A-4H-1, 9
M0065A-4H-2, 100	11.35	11.57	Tie to	M0065B-4H-2, 24
M0065B-4H-3, 13	12.50	12.96	Tie to	M0065A-5H-1, 59
M0065A-5H-2, 102	15.13	14.89	Tie to	M0065B-5H-2, 72
M0065B-5H-4, 12	15.57	16.04	Tie to	M0065A-6H-1, 37
M0065A-6H-3, 43	18.60	19.07	Append	M0065A-7H-1, 10
M0065A-7H-4, 21	21.90	22.36	Append	M0065A-8H-1, 9
M0065A-8H-4, 30	25.18	25.80	Append	M0065A-9H-1, 8
M0065A-9H-4, 15	28.48	29.10	Append	M0065A-10H-1, 8
M0065A-10H-4, 13	31.78	32.40	Append	M0065A-11H-1, 8
M0065A-11H-4, 15	35.08	35.70	Append	M0065A-12H-1, 8
M0065A-12H-2, 28	36.93	37.40	Tie to	M0065B-12H-1, 93
M0065B-12H-2, 156	38.92	39.54	Tie to	M0065A-13H-1, 61
M0065A-13H-1, 141	39.31	40.34	Tie to	M0065C-13H-1, 101
M0065C-13H-2, 92	41.12	41.75	Tie to	M0065B-13H-2, 32
M0065B-13H-2, 136	40.90	42.80	Tie to	M0065A-14H-1, 90
M0065A-14H-2, 64	43.60	44.04	Tie to	M0065B-14H-1, 99
M0065B-14H-2, 134	45.45	45.88	Tie to	M0065C-15H-1, 54
M0065C-15H-2, 41	44.73	47.25	Tie to	M0065A-15H-1, 143

Table T14. Sound velocity data for lithostratigraphic units, Site M0065.

Unit	Thickness of unit (m)	Sound velocity (m/s)*	TWT (ms)	Depth (m)	Depth (mbsf)
Seafloor	87.0	1475	0.118	87.0	0.0
I	9.2	1409	0.131	96.2	9.2
II	4.0	1439	0.137	100.2	13.2
IIIa	22.8	1448	0.168	121.0	36.0
IIIb	0.7	1480	0.169	123.7	36.7
IV	9.9	1525	0.182	133.6	46.6

* = sound velocities are based on values measured during the OSP. TWT = two-way traveltime.

Appendix B Pernille 1 Well log description

G E U S

Report file no.

1807

PERNILLE-1

Pernille-1, Final well report

Copenhagen

01-11-1989

NORSK HYDRO UDFORSKNING a.s

FINAL WELL REPORT

WELL 5514/30-1, PERNILLE-1

LICENSE 5/86

November 1989

LIST OF CONTENTS

PREFACE

License 5/86 was awarded the Norsk Hydro Group on 24 June 1986.

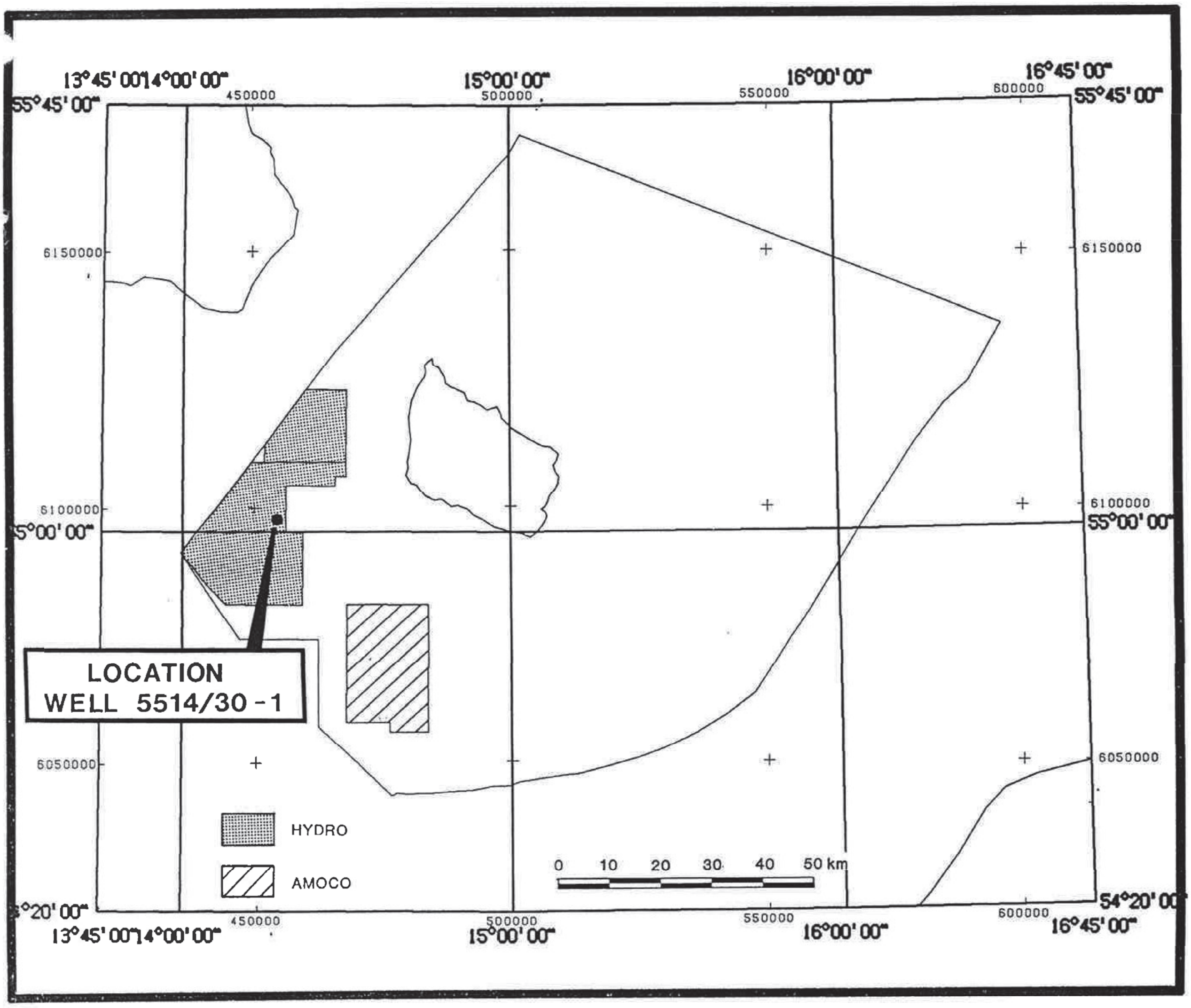
The license includes parts of blocks 5514/29, 5514/30, 5414/1 and 5414/2.

The group has the following composition:

Norsk Hydro Udforskning a.s (Operator)	19.5%
Enterprise Oil Denmark A/S	19.5%
Gas Council (Exploration) Ltd.	13.7%
Amerada Hess (Denmark) A/S	9.8%
DENERCO K/S	7.5%
Dansk Oliesøgning K/S	7.5%
Korn og Foderstof Kompagniet A/S	2.5%
Dansk Olie og Gas Produktion A/S (DOPAS)	20.0%

The well 5514/30-1 was drilled by Norsk Hydro Udforskning a.s on behalf of the group.

LOCATION MAP



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(ooo)
Norsk Hydro

General informations

Date 15/11-1989

System : BORE

Well: 5514/30-1
Field: BORNHOLM AREA — Country: DENMARK
Structure: RØNNE B — Licence: 5/86

2

LOCATION Coordinates: Surface : Target

		Surface	Target
UTM	N (m)	6096812.5	6096812.5
UTM	E (m)	456003.2	456003.2
Geographical	N	55 00'54.09"	55 00'54.09"
Geographical	E	14 18'43.14"	14 18'43.14"

Water depth : 44 m MSL. Rotary Table elevation: 36 m
Formation at TD: Silur, (MD) (m): 3212

Operator : HYDRO. Operators sheare (%) 19.5

Partners (Interests) :

ENTERPRISE OIL PLC.	19.5%
GAS COUNCIL EXPL.	13.7%
DANSK ENERGI CONS.	7.5%
DANSK OLIE SØGNING	7.5%
AMARADA HESS	9.8%
DOPAS	20.0%
K.F.K.	2.5%

RIG name : GLOMAR MORAY FIRTH 1
RIG contractor : GLOBAL MARINE
MUD contractor : PROMUD DANMARK APS
CEMENT contractor : HALLIBURTON
EL.LOGG contractor : SCHLUMBERGER INLAND
MUD LOGG contractor : EXLOG
Other contractors: MWD: TELECO

Total depth (m RKB):	Measured	Vertical
	3625 m	3625 m

TIME SUMMARY   Spudding date: 890406   Abandonment date: 890606

MainOp:	Moving	Drill	Form Eval	Prod test	Comp letion	Work over	Well service	Plug Aband	Down time
Hours :	30	1142	115	0	0	0	0	77	150
Days :	1.2	47.6	4.8	.0	.0	.0	.0	3.2	6.2
% :	2	75	8	0	0	0	0	5	10

TOTAL : 1512 hrs, 63 days

Hole and Casing record

Hole	Depth m,MD
30	105
26	788
17 1/2	1754
12 1/4	3352
8 1/2	3625

Casing	Depth m,MD
30	105
20	777
13 3/8	1740
9 5/8	3339

Well status :Permanently abandoned

SECTION A

G E O L O G Y

LIST OF CONTENTS SECTION A   PAGE

1. OBJECTIVES

Well 5514/30-1, Pernille-1, was drilled on the Rønne B structure in the Rønne Graben west of Bornholm. The structure is a rotated fault block on the Jurassic and Triassic level with structural closures on several levels from assumed Middle Jurassic to basement.

The primary objective of the well was:

- To test the hydrocarbon potential of postulated sandstones within the Triassic-Jurassic Rønne Formation on the Rønne B structure.

Secondary objectives were:

- To test the hydrocarbon potential of sandstones of other stratigraphic levels than the Rønne Formation.

- To test the hydrocarbon potential of a minor four-way dip closure at the assumed Base Upper Cretaceous level and obtain stratigraphical and lithological data from this level.

- To verify the seismic interpretation and establish confident well-to-seismic ties.

In addition the well would provide important geological and geophysical information in terms of stratigraphy, reservoir data, source rock composition and maturity from an area which has not previously been drilled.

The well was planned to be drilled 150 m into rocks of Paleozoic age which could be proven non prospective, or to a depth of 4200 m whichever came first. The prognosed TD was at 3206 m RKB in Silurian shales.

2. RESULTS

Well 5514/30-1, Pernille-1, was permanently plugged and abandoned without any shows of hydrocarbons encountered throughout the drilled sequence.

The well was drilled to a total depth of 3624.5 m RKB (driller) terminating in the Silurian Graptolite Mudstone Formation.

A TD core was cut from 3615 to 3624.5 m RKB (driller) with 100% recovery.

Several sandstones of variable reservoir quality were found between the Base Cretaceous and the Base Permian level, all 100% water saturated:

- The main target Rønne Formation (967 - 1552 m) contains 216 m net sand with an average porosity of 24.4%.
- The Lower Jurassic Hasle Formation (943 - 967 m) found underlying the Base Upper Cretaceous contains 17 m net sand with an average porosity of 23.9%.
- Triassic Redbeds (1552 - 2747 m) includes 248 m net sand with approximately 15% average porosity.
- Rocks of Lower Permian age (2787 - 3057 m) consists entirely of tight sandstones with an estimated 4% porosity.

Cutoffs used are: $\Phi < 12\%$
$V_{sh} > 40\%$
S_w: none

No porosity cutoff was used in the Lower Permian.

3. BIOSTRATIGRAPHY

The biostratigraphic evaluation of well 5514/30-1, Pernille-1, was carried out by The Robertson Group plc, Petroleum Division. Basic material used in the analysis was ditch cuttings, sidewall cores and conventional core samples. Furthermore, a gamma ray-resistivity-sonic log was made available. A summary of the chrono- and litho-stratigraphic division is shown in the table on page 6.

Down to 105 m RKB cuttings were returned to seabed, but Quaternary deposits are believed to make up the section from seabed to 95 m.

The Upper Cretaceous extends from 95 m to 943 m. The youngest sample analyzed at 105 m is of Upper Maastrichtian age. A complete, well dated sequence consisting of chalky limestones from Upper Maastrichtian to Lower Santonian - Coniacian makes up most of the Upper Cretaceous section. At 877 m a logbreak marks an unconformity followed by marls of Lower Cenomanian age down to the base of the Upper Cretaceous.

A major unconformity at 943 m separate the Upper Cretaceous from the underlying Lower Jurassic to Upper Triassic sandstones and claystones. The uppermost 24 m of sandstone possibly belong to the Hasle Formation, whereas the Rønne Formation makes up the remaining part. A Sinemurian to Rhaetian age is given, based on palynological evidence. The Jurassic - Triassic boundary thus lies within the Rønne Formation and is set at a log break at 1500 m. The first confident indications of a Rhaetian age occur at 1510 m. Reworked Carboniferous miospores occur frequently in the Rønne Formation.

The thick Triassic section (1552-2747m) below the Rhaetian consists of reddish sandstones and conglomerates with minor interbedded claystones. The section is barren of in situ microfossils and the age is based upon the lithology and the stratigraphic position between well dated Rhaetian and Upper Permian rocks. Palynomorphs of Upper Permian age found in the redbeds below 2552 m are considered reworked from the underlying rocks.

The Upper Permian from 2747 to 2787 m is well dated by abundant palynomorphs. The section consists of 40 m of greenish grey, calcareous claystones which are easily distinguished on the logs. These claystones are followed by reddish sandstones considered of Lower Permian age despite lack of paleontological evidence. The age is based on the stratigraphic position and the reddish colour typical of continental Rotliegendes sediments.

The base of the Permian is picked on a logbreak and colour change at 3057 m. This also coincides with a seismic marker and a dipmeter change.

The dating of the interval between the Base Permian and the sample at 3245 m, which gives a confident Silurian age, is very uncertain due to poor recovery and preservation of palynomorphs. The only age-diagnostic evidence comes from one single specimen of Knoxisporites cf. literatus recovered from the sidewall core at 3192 m which indicates a Lower Carboniferous age of this sample. Miospores recovered from sidewall cores at 3135 and 3179 m are non diagnostic, but show a preservational style and thermal maturity which is similar to the sample at 3192 m and very different from the Upper Permian palynomorphs. Thus, a Carboniferous age is tentatively ascribed to the interval from Base Permian to 3192 m.

The interval from 3192 m to 3212 m which can be distinguished on the wireline logs is considered to be of Lower Carboniferous age based on the sample at 3192 m. However, since this sidewall core was taken right at the upper boundary of the interval, it cannot be decided whether it represents the section above or below 3192 m. Miospores recovered from a ditch cuttings sample at 3210 support a Carboniferous age, but are not diagnostic. Therefore, it cannot be ruled out that the interval 3192-3212 m is older than Lower Carboniferous.

The top of the Silurian is chosen as the logbreak at 3212 m which is caused by a shift to a shale dominated lithology, although the first indication of a Silurian age comes from the sample at 3245 m. The lack of preserved palynomorphs in the interval above may be explained by Post-Silurian subaerial exposure and deep weathering of the upper part of the Silurian sequence causing oxidation of kerogen, which would destroy any palynomorphs. Post-Silurian exposure is in accordance with the inferred Lower Carboniferous age of the overlying section which implies a hiatus at 3212 m. The remaining Silurian section from 3245 to 3624.5 m (TD) is well dated, and reflects continuous deposition during Wenlock (Homerian to Sheinwoodian) down to TD. Recycled Ordovician acritarchs occur frequently throughout the interval.

fwr5514/30-1
HL

HYDRO

Copenhagen – Denmark

WELL: 5514/30-1 PERNILLE - 1

DEPTH RKB

ELEVATION KB: 36 m

NB! NOT TO SCALE
ALL DEPTH IN METERS (mRKB)

CHRONOSTRATIGRAPHY				LITHOSTRATIGRAPHY		
SYSTEM	SERIES/ STAGE	DEPTH m	THICKNESS m	GROUP	FORMATION/ MEMBER	
	SEABED					
QUAT.	NO DATA	80	15			
UPPER CRETACEOUS		95	10	CHALK GROUP EQUIVALENT		95
UPPER CRETACEOUS	UP. MAASTRICHTIAN	105	30	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	LO. MAASTRICHTIAN	135	30	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	LO. MAASTRICHTIAN – UPPER CAMPANIAN	165	120	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	UPPER CAMPANIAN	285	60	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	LOWER CAMPANIAN	345	115	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	SANTONIAN	460	215	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	LOWER SANTONIAN – CONIACIAN	675	202	CHALK GROUP EQUIVALENT		
UPPER CRETACEOUS	LOWER CENOMANIAN	877	66	CHALK GROUP EQUIVALENT	ARNAGER GREENSAND. EQ	877
LOWER JURASSIC	SINEMURIAN	943	91	BORNHOLM GROUP	? HASLE FM.	943
LOWER JURASSIC				BORNHOLM GROUP	RØNNE FORMATION	967
LOWER JURASSIC	HETTANGIAN	1034	466	BORNHOLM GROUP	RØNNE FORMATION	
U. TRIAS.	RHAETIAN	1500	52	BORNHOLM GROUP	RØNNE FORMATION	
TRIASSIC		1552	1195	"TRIASSIC GROUP"	KÅGERØD FORMATION	1552
U. PERM.		2747	40	ZECHSTEIN GP.		2747
LOWER PERMIAN		2787	270	ROTLIEGENDES GROUP		2787
? CARB.		3057	135	? "CARBONIFEROUS GROUP"		3057
? L. CARB		3192	20	? "CARBONIFEROUS GROUP"		
SILURIAN	WENLOCK – HOMERIAN	3212	140		GRAPTOLITE MUDSTONE FORMATION	3212
SILURIAN	WENLOCK – SHEIN – WOODIAN	3352	272.5		GRAPTOLITE MUDSTONE FORMATION	
		TD 3624.5				

4. LITHOSTRATIGRAPHY

The description of the lithostratigraphic units is based on ditch cuttings, sidewall cores and conventional cores. Additionally, information from wireline and MWD logs is used to define unit boundaries.

4.1 QUATERNARY 80-95m.

This interval was drilled without returns, but from the site survey is was seen to consist of dark grey to olive grey silty clays with minor fine to medium grained sand.

4.2 CRETACEOUS 95-943m.

UPPER CRETACEOUS 95-943m.

CHALK GROUP EQUIVALENT 95-943m.

95-877m.

The upper limit of this interval is taken from the site survey since the first cuttings were sampled from 105m.

The interval consists of white to light grey chalky limestone, generally firm to moderately hard, becoming harder in the lowermost 50 m. It is locally argillaceous, especially from 500 to 750m. Glauconite and minor pyrite is common and chert occurs near the top and base. Microfossils are abundant along with traces of macrofossils. Traces of quartz sand and pebbles are found in the uppermost part.

The interval represents a continuous section from Coniacian - Lower Santonian to Upper Maastrichtian.

Arnager Greensand Equivalent 877-943m.

The top of the Arnager Greensand Equivalent is easily recognized by a sudden increase in the gamma ray along with a drop in resistivity and sonic velocity.

It consists generally of marl varying in colour from light grey and light olive grey to dark greenish grey and brown grey. The marl is soft to firm and occasionally very silty. Glauconite and traces of mica, microfossils and shell fragments occur.

The interval is dated Lower Cenomanian. This is consistent with the age of the Arnager Greensand on the island of Bornholm which has been used as lithostratigraphic reference for this interval.

4.3 JURASSIC 943-1500m.

LOWER JURASSIC 943-1500m.

BORNHOLM GROUP 943-1552m.

?Hasle Formation 943-967m.

The top of the assumed Hasle Formation is picked at a clear drop in resistivity and sonic velocities immediately below a peak in the gamma ray.

Loose to soft, light grey sand makes up the Formation. The sand consists of fine to medium, moderately to well sorted, clear to milky quartz grains, with a minor argillaceous matrix. Traces of glauconite, pyrite, carbonaceous material and coal fragments occur.

The presence of glauconite points to a marine environment of deposition and together with the other characteristics of the sand, a correlation with the Hasle Formation on Bornholm has tentatively been made. This makes the Hasle Formation slightly diachronous since it is dated Sinemurian in the well and Pliensbachian on Bornholm. Alternatively, the interval may be incorporated in the underlying Rønne Formation.

Rønne Formation 967-1552m.

967-1167m.

An abrupt increase in the gamma ray and resistivity marks the top of this interval.

The lithology is predominantly clay with interbedded and interlaminated sand. The clay is medium grey to olive grey at the top and becomes dark grey to brown grey towards the base. It is soft, often sticky with traces of mica and carbonaceous material, and generally non to slightly calcareous. The sand consists of loose, generally fine to medium grained, moderately sorted, clear quartz with traces of pyrite, mica and coal fragments. Both sand and clay may grade into silt-dominated lithologies.

Occasional stringers of limestone are seen in the lower part of the interval, presumably as calcite cemented horizons rather than discrete beds. It is light yellowish brown to light grey, microcrystalline and very hard, giving rise to peaks on the sonic log.

Coal is described, mainly near the base of the interval, occurring both as fragments in the sandy parts and as separate thin beds.

The interval forms the upper part of the Rønne Formation and is dated Hettangian to Sinemurian.

1167-1500m.

This interval show lithologies much similar to the overlying section, but with a higher proportion of sand and only minor interbeds of clay. The boundary is picked where the sonic shows a shift from rapidly alternating velocities to more constant and higher values.

The composition of the sand is generally as above except that traces of feldspar, glauconite and mafic minerals are described. Furthermore, it is locally calcite cemented, forming friable to hard sandstone. Towards the base the sand/sandstone tends to become finer grained and better sorted. The clay displays generally darker colours than above, ranging from olive-, brown- and medium dark grey to occasionally brown- and olive black. The hardness is firm due to increased compaction.

Thin coal seams occur, especially around 1350 m. The coal is often impure, grading into very carbonaceous claystone.

This part of the Rønne Formation is of Hettangian age.

4.4 TRIASSIC 1500-2747m.

UPPER TRIASSIC 1500-1552m.

1500-1552m.

The upper boundary of this interval is set at a sharp logbreak marking the onset of relatively high and constant gamma ray and resistivity values.

It consists of claystone with minor interbeds of sandstone. The claystone shows various shades of olive- and brown grey to olive- and brown black. It is firm to moderately hard, with varying content of silt and traces of very fine sand, mica and carbonaceous material, non to moderately calcareous. The sandstone is medium light grey to olive grey and consists of subangular, moderately sorted quartz of fine to very fine grain size, grading to siltstone. It is firm to moderately hard cemented with dolomitic and silicious cement.

This interval forms the basal part of the Rønne Formation and is of Rhaetian age.

TRIASSIC UNDIFFERENTIATED 1552-2747m.

"TRIASSIC GROUP" 1552-2747m.

Kågerød Formation 1552-2747m.

1552-1631m.

A marked drop in sonic velocities associated with a minor decrease in resistivity and density values defines the top of the interval.

The lithology is claystone, varicoloured from pale red and greyish orange pink, becoming moderately reddish brown and -orange downwards, minor greenish and olive grey and -brown. It is firm to moderately hard, moderately silty increasing towards the base and non to moderately calcareous. Traces of spherical dolomite nodules are reported. Occasional thin beds of white to very light grey argillaceous limestone occur within the claystone.

The interval is barren of fossils, but it is believed to represent the uppermost part of the Triassic redbeds of the Kågerød Formation.

1631-1920m.

A logbreak from relatively stable to highly fluctuating resistivity values is chosen as the top of this interval. It consists predominantly of sand/sandstone with minor interbeds of claystone and stringers of limestone.

The sand/sandstone consists of poorly sorted, sub angular quartz grains, ranging from fine to very coarse. The grains are often reddish stained, loose or embedded in a reddish brown argillaceous matrix with traces of calcareous or silicious cement. Feldspar is common which, together with the argillaceous matrix, account for the high gamma ray values seen in the sand. Beds of conglomerate may occur within the sand from 1770 m, as indicated by the presence of common quartzite fragments in the cuttings.

The claystone is moderately to dark reddish brown or occasionally greenish grey, firm to moderately hard and moderately to very calcareous. Locally it grades into siltstone.

Stringers of white to very light grey and greenish grey limestone, often sandy or argillaceous, probably represent horizons of calcite cemented sandstone or claystone. Traces of white, hard, brittle anhydrite occur in the lower 50 m of the interval.

The age is undifferentiated Triassic.

1920-2068m.

The top of this interval is defined by a shift to lower density values and a good shale separation on the LDL/CNL log coinciding with an increase in gamma ray and more uniform resistivity values.

The interval consists of claystone with interbeds of sandstone and minor siltstone. The sandstone interbeds are most frequent in the lower part of the interval.

The claystone is predominantly moderately to dark reddish brown, moderately brown to grey brown, occasionally greenish grey to pale green. It is firm to moderately hard with a blocky texture, slightly to very calcareous and generally slightly to moderately silty. Locally, it grades to siltstone and very fine sandstone in thin laminae.

The sandstone is composed of clear to milky quartz grains, often reddish brown stained. The grain size is coarsening downwards, from predominantly very fine to medium in the upper part to fine to very coarse, locally grading to conglomerate, in the lower part. The grains are poorly sorted, subrounded, and loose to occasionally well cemented with calcite cement. Traces of mica are found.

The sandstone locally grades into siltstone; greyish brown to moderately brown, occasionally light greenish grey, moderately hard to hard, blocky, argillaceous, non to slightly calcareous.

A few stringers of limestone occur in the lower part of the interval. It is off-white to light grey, firm, blocky, slightly argillaceous, microcrystalline with occasional quartz inclusions.

2068-2464m.

This interval is initiated by a prominent increase in the gamma ray associated by a minor increase in sonic velocity.

The lithologies are much similar to the previous interval but in different proportions, being dominated by sandstone with only occasional interbeds of claystone and limestone.

The sandstone is both physically and chemically immature, with a poorly sorted grain size distribution ranging from fine to very coarse, grading to conglomerate in parts. The grains are mainly reddish stained quartz with locally abundant feldspar, minor lithic fragments and traces of mafic minerals and calcite, possibly as caliche nodules. The sandstone is firm to locally hard calcite cemented with a reddish brown argillaceous matrix.

The claystone is moderately to dark reddish brown, firm to moderately hard, blocky, slightly to very silty, locally grading to siltstone and slightly calcareous. It contains traces of anhydrite: white to very light grey, firm, microcrystalline, amorphous to blocky texture and argillaceous.

Stringers of limestone occur mainly in the lower half of the interval. The limestone is white to very light grey, locally mottled reddish brown, microcrystalline, moderately hard to hard with a blocky texture.

2464-2747m.

This interval only differs from the overlying in the sense that it is almost exclusively composed of sandstone, with claystone interbeds restricted to the lowermost 50 m only. The top of the interval is picked at a logbreak in the gamma ray.

In addition to the characteristics described from the previous interval the sandstone is reported to contain traces of mica and locally rare plant roots. The claystone with traces of anhydrite is similar to the above section.

The interval forms the basal part of the Triassic redbeds of the Kågerød Formation.

4.5 PERMIAN 2747-3057m.

UPPER PERMIAN 2747-2787m.

ZECHSTEIN GROUP 2747-2787m.

The top of the Permian is marked on the wireline logs by a fall in the gamma ray and an increase in the resistivity.

The Zechstein Group is composed of claystone; medium dark grey to light grey to greenish grey, firm to moderately hard, blocky to subfissile, generally slightly silty, very silty in the uppermost part and shows traces of micromica and micropyrite. The claystone is very calcareous grading to marlstone in parts. Locally, it is rich in carbonaceous material with traces of coal fragments.

The age is undifferentiated Upper Permian.

LOWER PERMIAN 2787-3057m.

ROTLIEGENDES GROUP 2787-3057m.

The upper boundary of the Rotliegendes Group is characterized by a sudden increase in both gamma ray, resistivity and density and of higher sonic readings.

The lithology is mainly sandstone with occasional interbeds of claystone and siltstone. The sandstone is dark reddish brown and composed of clear to milky, occasionally orange to red stained quartz grains, very fine to very coarse, sometimes grading to conglomerate, angular to subrounded and very poorly sorted. In addition it contains minor to abundant fragments of quartzite and traces of igneous and gneiss fragments, feldspar, mica, iron oxides and carbonaceous material. It is poorly cemented with both siliceous and calcareous cement and contains an argillaceous and minor silty matrix.

The clay- and siltstone is moderately to dark reddish brown, dark grey to brown grey, moderately hard to hard, blocky, generally silica cemented, locally calcite cemented, minor sandy with traces of mica and mafic minerals. Much of the clay- and siltstone probably occur as matrix in the sandstone and conglomerate rather than in discrete beds.

Traces of anhydrite are described; white with minor black streaks, firm to soft and generally microcrystalline but with occasional gypsum crystals.

The undifferentiated Lower Permian age is based on stratigraphic position and lithology.

4.6 ?CARBONIFEROUS 3057-3212m.

"CARBONIFEROUS GROUP" 3057-3212m.

3057-3192m.

The top of the assumed Carboniferous is shown by an abrupt change in log character of both the gamma ray, resistivity, LDL/CNL and sonic log.

The dominating lithology is siltstone with interbedded claystone/shale and traces of sandstone. The siltstone is dark reddish brown to very dusky red to black red, occasionally brownish grey to very dark grey, moderately hard to hard with a blocky texture. It is poorly sorted, generally sandy, grading to very fine sandstone, with an argillaceous matrix. The cement may be both siliceous and calcareous.

The claystone is moderately to dark reddish brown to very dark red, firm to moderately hard, subfissile to platy or blocky. It is non to moderately calcareous, and locally silty and micromicaceous. It may contain thin laminae of white to grey orange pink, microcrystalline limestone. Towards the base of the interval the claystone becomes more fissile, grading into shale.

In addition to the siltstone which may grade into very fine sandstone traces of coarser sandstone is also reported. It consists of poorly sorted, angular to rarely rounded, fine to coarse quartz grains, moderately brown to orange stained. Minor constituents are mica and traces of feldspar and quartzite fragments as well as an argillaceous matrix.

A Carboniferous age is tentatively given to the interval.

? LOWER CARBONIFEROUS

3192-3212m

The upper limit of this interval is set at an abrupt increase in the resistivity along with a minor increase in the sonic velocity.

The interval consists of silty sandstone alternating with shale. The sandstone is medium grey to brownish grey consisting of poor to moderately sorted, subangular quartz of very fine to silty grainsize, grading to siltstone. It is moderately hard, moderately calcite cemented and contains an argillaceous matrix and traces of mica.

The shale is described as medium dark grey to greyish black, brownish grey to brownish black, moderately hard to hard, fissile to subfissile, slightly to moderately silty, micromicaceous and slightly to very calcareous.

A questionable Lower Carboniferous age is given to this interval.

4.7 SILURIAN 3212-3624.5m (TD).

Graptolite Mudstone Formation 3212-3624.5m (TD).

An increase in the gamma ray coinciding with a drop in resistivity represents the top of the Silurian.

fwr5514/30-1
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The Graptolite Mudstone Formation consists of shale with minor sand- and siltstone. The shale is medium dark grey to grey black, dusky yellowish brown to brownish grey, fissile to subfissile, moderately hard to hard, slightly to moderately silty, non to moderately calcareous and micromicaceous. Occasional carbonaceous streaks and pyrite nodules occur, mainly around 3400 m. It is locally fractured with veins filled with calcite. The shale may alternate with minor claystone which is slightly lighter in colour, more blocky and more silty.

The sandstone/siltstone is medium to medium dark grey, occasionally brownish grey to light olive grey and consists of quartz, ranging in size from predominantly silt to very fine sand, moderately sorted, in an argillaceous matrix. It is mainly calcite cemented, moderately hard to hard with traces of mica. Lamination is seen locally.

The interval is of Wenlock age, Sheinwoodian to Homerian.

5. HYDROCARBON SHOWS

Evaluation of hydrocarbon shows at the wellsite was carried out in a conventional manner. Below the 20" casing shoe at 105 m a complete hydrocarbon total gas detector (50 units = 1%) was operational together with a gas chromatograph for automatic and continuous gas analysis recorded as ppm by volume of C1 through nC4.

5.1 Gas record

Total gas readings were very low throughout the drilled section, generally less than 0.05% C1 and never exceeding 0.2%. Traces of C2 were recorded in the intervals 1815 - 1875 m and 3300 - 3624.5 m (TD). No heavier components were found.

5.2 Oil stain and fluorescence.

No shows were recorded on cuttings, sidewall cores or conventional cores in this well.

6. CORING

6.1 Conventional cores

A single core was cut in the well. The core was cut in shales of the Silurian Graptolite Mudstone Formation from 3615 m to TD at 3624.5 m (drillers depth) with a 100% recovery.

A detailed description of the core is given in Appendix I and also shown on the bottom of the completion log.

6.2 Sidewall cores

Four runs of sidewall cores were carried out covering the interval from 790 to 3349 m with a total of 120 samples requested. The results are summarized in the table below. A full description of each sample is given in Appendix II.

Run #	Asked	Shot	Misfire	Empty	Lost	Recovery
1 A	30	29	1	0	1	28
1 B	30	30	0	6	0	24
2 C	30	17	13	2	0	15
2 D	30	30	0	3	1	26
Total	120	106	14	11	2	93

7. WIREELINE AND MWD LOGGING

7.1 Wireline logs

The table below shows the type of log, date, interval and run no. for each log run in well 5514/30-1.

LOG	DATE	INTERVAL (m)	RUN NO.
DIL/LSS/GR	23.04.89	1751 - 775	1 A
LDL/CNL/GR	23.04.89	1752 - 775	1 A
SHDT/GR	23.04.89	1749 - 775	1 A
CST	24.04.98	1745 - 1238	1 A
CST	24.04.89	1232 - 790	1 B
DIL/LSS/GR/SP	22.05.89	3351 - 1738	2 B
LDL/CNL/GR	23.05.89	3350 - 1738	2 B
SHDT/GR	23.05.89	3350 - 1738	2 B
CST	23.05.89	3349 - 3051	2 C
CST	23.05.89	3201 - 1862	2 D
CBL/VDL	23.05.89	1732 - 472	2 A
DIL/LSS/GR/SP	02.06.89	3615 - 3338	3 C
LDL/CNL/GR	02.06.89	3612 - 3338	3 C
SHDT/GR	03.06.89	3622 - 3338	3 C
CBL/VDL	02.06.89	3336 - 2990	3 B
Vel. survey/ Checkshots	03.06.89	3617 - 795	3 A

7.2 MWD logs

A MWD log was run by Teleco from 105 to 1715 m, for continuous measurement of gamma ray, resistivity, rate of penetration and weight on bit. The resistivity tool failed from 1510 to 1715 m.

The MWD log replaced wireline logging from 105 m and down to the shoe depth for the 20" casing at 777 m (775 m loggers depth).

7.3 Bottomhole temperatures from logs

The bottom hole temperatures measured at each log run are listed in the table below.

LOG RUN #	DEPTH (m)	RECORDED TEMPERATURE (°C) t1	t2	t3	TIME SINCE CIRC. (hr:min)	CIRC. TIME (hr:min)
DIL/LSS 1A	1751	55.5	55.5	55.5	6:45	1:50
LDL/CNL 1A	1752	55.5	56	56	12:00	1:50
SHDT 1A	1749	56	56	56.5	18:00	1:50
DIL/LSS 2B	3351	72	72	72	5:00	3:00
LDL/CNL 2B	3350	73	73	73	14:35	3:00
SHDT 2B	3350	75.5	75.5	75.5	21:15	3:00
DIL/LSS 3C	3615	75.5	75.5	75.5	7:10	8:25
LDL/CNL 3C	3612	77.8	77.8	77.8	11:20	8:25
SHDT 3C	3622	75.3	75.3	-	6:19	5:00
CHECKSHOTS	3617	76.6	76.6	76.6	10:15	5:00

fwr5514/30-1
HL

8. STANDARD STUDIES

The biostratigraphical evaluation and analysis of thermal maturity was carried out by The Robertson Group plc, Petroleum Division and the results are presented in the report:

Norsk Hydro 5514/30-1 offshore Bornholm,
Baltic sea well:
Biostratigraphy of the interval 105m-3624.1m,
Thermal maturity of the interval 2755m-3624m

A petrophysical evaluation was made by Norsk Hydro and the results are given in:

Petrophysical evaluation report,
Well 5514/30-1 (Pernille-1)

Conventional core analysis was done by The Geological Survey of Denmark:

Conventional Core Analysis for Norsk Hydro
Well No.: 5514/30-1
Core Photos

Note that the report consists of photos of the core only.

9. SPECIAL STUDIES

A 1-D basin modelling of the Rønne Graben based on well 5514/30-1 and two pseudowells was performed by Norsk Hydro Research Centre. The results are presented in:

ID basin modelling of Pernille-1 and selected points in the Rønne Graben, Denmark

Norsk Hydro Research Centre also made a geochemical evaluation of the well:

Petroleum Geochemistry
Well: 5514/30-1 (Pernille-1)

APPENDIX I

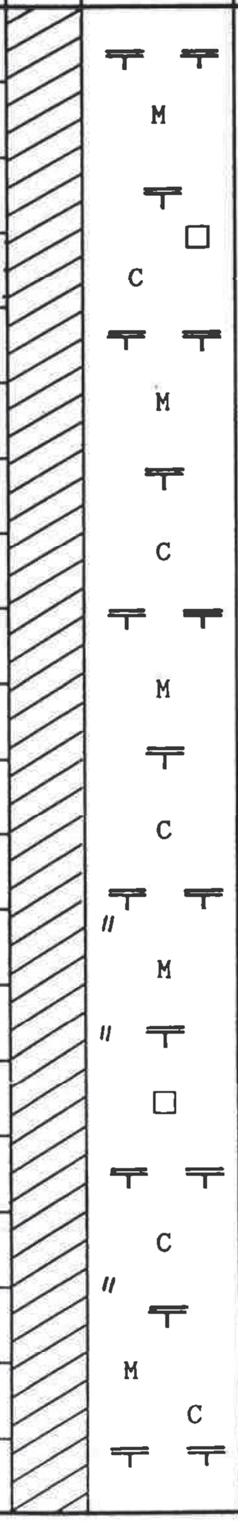
Norsk Hydro

Note: Fibre glass inner barrel used - core descriptions made every one meter only.

Well no.		Core no's
5514/30-1	Core report	1

Interval	Area	Cut	Date
3615 - 3620m	Baltic Sea	3615 - 3624.5m	02.06.89

Scale	Well R.K.B.	Recovery	Geologist
1:25	36m	9.5m 100%	Eide/Simpson



Depth scale	Depths (m)	Lithological descriptions	Shows
3615	3615	**Sh:** dk - m gy, hd - v hd, fis, occ blky, earthy, tr wxy tex, tr carb mat, micromic, tr dism Pyr, sl - non calc	No shows
3616	3616	**Sh:** a/a, sl more ang brk	
3617	3617	**Sh:** a/a	
3618	3618	**Sh:** gy blk - dk gy, hd - v hd, fis - subfis, hk - ang brk, spltry, plty, wxy tex, micromic, carb - v carb, sl - non calc w/ lt - m gy Slst strk & lam	
3619	3619	**Sh:** a/a	
3620			

Norsk Hydro

Note: Fibre glass inner barrel used - core descriptions made every one meter only.

Well no.		Core no's
5514/30-1	**Core report**	1

Interval	Area	Cut	Date
3620 - 3624.5m	Baltic Sea	3615 - 3624.5m	02.06.89
Scale	**Well R.K.B.**	**Recovery**	**Geologist**
1:25	36m	9.5m 100%	Eide/Simpson

Depth scale	Re-covery	Lithological column	Depths (m)	Lithological descriptions	Shows
3620			3620	Sh: gy blk, hd - v hd, ang - hk brk, fis - subfis, spltry, carb, wxy tex, sl - non calc, micromic	No shows
3621			3621	Sh: a/a	
3622			3622	Sh: dk gy - gy blk, hd, fis - subfis, earthey - wxy tex, sl - non calc, micromic, tr dism Pyr, carb Calc vn in frac: wh, anhed - euhed	
3623			3623	Sh: a/a	
			sealed sample		
			3623.5	Sh: a/a, spltry	
3624			3624.1	Sh: a/a, w/ Calc vn along frac, micromic	
3624.5			3624.55	Sh: dk gy - blk, hd - v hd, fis, spltry, carb strks, occ slty lam, micromic, sl - non calc	

APPENDIX II

HYDRO

Service company: Schlumberger	
Asked:	30
Shot	29
Lost	0
Empty:	0
Misfire:	1
Samples recovered:	29
Geologist: Bang/Ladegaard	

Side wall core descriptions

Well no: 5514/30-1	Licence: DK 5/86	Run no: 1A	Date: 24.04.89	Page No: 1 of 2

tr:trace – M:medium – G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
1	1745	2	Slst: lt - mod brn, Qtz, pr srtd, mod hd, arg, tr vf - f sd, calc cmt, w/ intbd Lst: wh - v lt gy, f - m xtl, frm - mod hd, arg.						
2	1710	3	Lst: wh - v lt gy, mod hd, blky, gen microxln, abn Qtz, f - m, occ crs, grd calc cmt Sst.						
3	1674	2	Lst: wh - lt grn gy - grn gy, microxln, mnr crptoxln, mod hd, blky, mnr m - crs Qtz g, sl arg.						
4	1638	3	Sd: lt gy - lt grn gy, Qtz, f - m, ang - subrnd, pr srtd, sft, arg, pr cmt, calc in mtx.						
5	1629	3	Sd: m lt gy - lt brn gy, Qtz, m - f, subang - subrnd, pr srtd, sft, abn mtx, calc & arg mtx, non - v sl cmt						
6	1605		Misfire						
7	1581	4	Clyst: vgt m gy & mod - dk rd brn, sft - frm, slty, in pt non calc, in pt mod calc.						
8	1555	3.5	Clyst: brn blk - olv gy, frm, in pt mod hd, sl stky, mod slty, non calc.						
9	1552	4	Clyst: dusky yel - lt olv brn, frm, in pt mod hd, slty, tr f sdy, mod calc.						
10	1546	4	Clyst: gy brn, frm, sl slty, non calc.						
11	1544	5	Clyst: olv blk - brn blk, frm - mod hd, tr slty, non calc.						
12	1542	5	Clyst: vgt olv gy & lt olv brn, frm, in pt mod hd, sl slty, non calc						
13	1536	3.5	Clyst: gy blk, frm, sl fis, sl slty, non calc.						
14	1526	3	Clyst: m gy - m dk gy, frm, slty, tr Mica, non calc.						
15	1514	2.5	Sst: m lt gy, Qtz, alt vf & f lam, ang - subrnd, mod srtd, frm, slty, arg mtx, tr dk min.						
16	1510	3	Slty Clyst: m dk gy, frm. tr vf sdy. tr Mica. sl calc.						
17	1483	3	Sdy Slst: m dk gy, Qtz, mod hd, arg mtx, mod silic cmt, tr dk min, tr Mica, non calc, fnt lam, loc vf sdy grd Sst.						
18	1467	5	Clyst: brn gy - olv gy, sft, sl stky, v slty, tr vf sdy, non calc, loc grd Slst.						

HYDRO

Service company: Schlumberger	
Asked:	30
Shot	29
Lost	0
Empty:	0
Misfire:	1
Samples recovered:	29
Geologist: Bang/Ladegaard	

Side wall core descriptions

Well no: 5514/30-1	Licence: DK 5/86	Run no: 1A	Date: 24.04.89	Page No: 2 of 2

tr:trace — M:medium — G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
19	1455	4	Slst: m dk gy, Qtz, pr srtd, frm, arg mtx, loc vf sdy, abn carb, tr mica, w/ mnr strk Sd: lt gy, vf - f, lse.						
20	1447	4.5	Sst: m dk gy, Qtz, vf, gen subang, pr srtd, frm, slty, abn arg mtx, pr cmt, tr carb, non calc, fnt lam.						
21	1414	2	Sd: v lt gy - lt gy, Qtz, gen f, ang - subang, mod - w srtd, lse - fri, mnr arg mtx, slty, abn carb in lam						
22	1394	2.5	Sd w/ intbd Clyst lam: Sd: v lt gy, Qtz, f, ang - subrnd, w srtd, lse - fri, tr arg mtx, tr dk min, tr						
			mica, pr vis intgran por. Clyst: olv gy, frm, slty, tr - abn carb, non calc.						
23	1391	2	Clyst: olv gy - m dk gy, frm - mod hd, slty, tr carb, sl calc, w/ mnr strk Sst: wh, Qtz, gen f, subrnd, mod strd, frm - hd, calc cmt.						
24	1370	2	altg Sd & Slst in f lam, tr fnt ripples:						
			Sd: v lt gy, Qtz, vf - f, ang - subrnd, mod srtd, lse, mnr arg mtx, tr carb. Slst: dk gy - gy blk, frm, arg, abn Qtz, abn carb, sl calc.						
25	1349	5	Clyst: m gy, frm, in pt v slty grd Slst, in pt sl slty, non calc, w/ mnr lam of vf Sd						
26	1318	2.5	Clyst: brn gy - olv gy, frm, slty, tr carb, non calc, w/ intbd Sd: v lt gy, Qtz, vf - f, subrnd, w srtd, lse, rr tr arg mtx, gd vis por.						
27	1295	3	Clyst: m dk gy, frm, v slty, abn carb, abn Qtz, tr Mica, w/ mnr lam of Sd: wh, Qtz, vf - f, w srtd, lse, rr tr arg mtx, gd vis por.						
28	1290		Lost						
29	1287	5	Slst: m dk gy, Qtz, pr srtd, frm - mod hd, abn arg mtx, abn carb, non calc, w/ mnr Lst: wh - v lt gy, microxln, hd.						
30	1238	5	Clyst: lt - m lt gy, in pt dk yel orng, sft - frm, sl slty, tr Mica, tr carb, non calc.						

HYDRO

Service company:	Schlumberger
Asked:	30
Shot	30
Lost	0
Empty:	6
Misfire:	0
Samples recovered:	24
Geologist:	Bang/Ladegaard

Side wall core descriptions

Well no:	Licence:	Run no:	Date:	Page No:
5514/30-1	DK 5/86	1B	24.04.89	1 of 2

tr:trace – M:medium – G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
31	1232	2.5	Sd: alt lam lt olv gy - lt brn gy, dusky yel brn, Qtz, vf - slty, subang, mod srtd, sft, arg mtx, tr Mica, tr Fldsp, tr carb, tr mafic min, no - v pr vis por.						
32	1214	2	Sd: olv gy - brn gy, mnr mm lam v lt gy, Qtz, vf - slty, subang, mod srtd, sft, arg mtx in olv - brn gy, tr Mica, tr Fldsp, tr carb, tr dk min, no vis por.						
33	1202	2.5	Sd: dusky yel brn, intlam w/ lt olv gy - lt brn gy, Qtz, vf - slty, subang, mod srtd, sft, arg mtx, tr Mica, tr Fldsp, tr carb, tr mafic min, no vis por.						
34	1168	2.5	Sd: dusky yel brn, Qtz, vf - slty, subang, mod strd, sft, arg mtx, tr Mica, tr Fldsp, tr carb, tr mafic min, no vis por.						
			alt w/ Sd: lt olv gy, Qtz, vf - f, subang, w srtd, tr Fldsp, rr carb, gd vis por.						
35	1164	0	Empty						
36	1145	3.5	Sd: dusky yel brn, Qtz, vf - slty, subang, mod srtd, sft, arg mtx, tr Mica, tr Fldsp, tr carb, tr mafic min, no vis por.						
			intlam w/ Sd: lt olv gy, Qtz, vf - f, subang, w srtd, tr Fldsp, rr carb, gd vis por.						
37	1125	0	Empty						
38	1113	3	Slt: dusky yel brn, crs grd vf Sd, sft - frm, arg, tr Mica, tr carb, tr micronod Pyr agg.						
39	1104	4	Slt: dusky yel brn, v arg grd Cly, sft - plas, com Mica, tr carb, tr micropyr, tr mafic min.						
40	1082	4	Cly: dusky yel brn, sft - plast, v slty grd Slt, tr Mica, tr carb, tr micronod Pyr, tr mafic min.						
41	1075	3	Sd: dusky yel brn, Qtz, vf - slty, subang - ang, pr srtd, sft, arg mtx, tr Mica, tr carb, no vis por.						
			intlam w/ Sd: lt brn gy - brn gy, Qtz, vf - tr f, subang - ang, mod - w srtd, sft, tr arg mtx, tr Mica, tr mafic min.						
42	1068	4.5	Sd: dusky yel brn, Qtz, vf - slty, subang - ang, pr srtd, sft, arg mtx, tr Mica, tr carb, no por.						
43	1062	.4	Cly: lt brn gy - lt olv gy, sft - plast, mod slty, tr vf sdy, rr Mica, rr carb.						
44	1054	0	Empty						
45	1034	3.5	Cly: pl yel brn, sft - plast, mod slty, non calc.						

HYDRO

Service company: Schlumberger	
Asked:	30
Shot	30
Lost	0
Empty:	6
Misfire:	0
Samples recovered:	24
Geologist: Bang/Ladegaard	

Well no: 5514/30-1	Side wall core descriptions
Licence: DK 5/86	Run no: 1B
Date: 24.04.89	Page No: 2 of 2

tr:trace — M:medium — G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
46	1023	2.5	Sd: olv gy - brn gy, Qtz, vf, subang - ang, mod srtd, sft, arg mtx, v slty, tr Mica, tr carb, no por.						
47	1002	0	Empty						
48	982	0	Empty						
49	972	3	Slt: gy brn - dusky yel brn, crs grd vf Sd, sft, arg mtx, tr Mica, tr carb, tr mafic min.						
50	960	3	Sd: v lt gy - lt gy, clr - mlky, Qtz, f, subang, w srtd, sft, kaol mtx, tr arg strk, tr carb, tr Pyr, tr mafic min, tr Glau, pr vis por.						
51	955	3	Sd: v lt gy - lt gy, clr - mlky, Qtz, f, subang, w srtd, sft, kaol mtx, tr arg strk, tr carb, tr Pyr, tr mafic min, tr Glau, mod vis por.						
52	940	2.5	Mrl/Lst: grn gy - dk grn gy, vf rexlzd Calc, sft - frm, blky, arg mtx, com micronod Pyr agg, gd tr ang Calc microfoss spic, gd tr Glau, tr Mica.						
53	917	2	Mrl/Lst: brn gy - dk grn gy, vf rexlzd Calc, fri - firm, blky, arg mtx, tr Glau, tr Mica, com microfoss spic, tr radiolaria sph.						
54	905	2.5	Mrl/Lst: dk grn gy, vf rexlzd Calc, fri - frm, blky, arg mtx, tr Glau, tr Mica, tr microfoss spic, tr radiolaria sph.						
55	895	0	Empty						
56	879	5.5	Cly: dk grn gy, frm, v calc grd Mrl, tr Glau, sl - mod slty, abn microfossils: wh - pk gy, rods < 1 mm x 0.2 mm, pshexagonal, xln, also hexagonal plates,						
			pt connected, tr radiolaria sph.						
57	837	1.5	Chk: wh - v lt gy, frm - mod hd, tr hd, blky, brit, mass, non - v sl arg, mod cmt, microxln.						
58	830	2	Chk: wh - v lt gy, hd - v hd, blky, brit, mass, non - v sl arg, w cmt, microxln.						
59	810	2	Chk: lt gy, mod hd, blky, mass, sl - mod arg, mod cmt, microxln.						
60	790	2	Chk: lt gy, mod hd, blky, mass, sl - mod arg, mod cmt, microxln.						

HYDRO

Service company:	Schlumberger
Asked:	30
Shot	17
Lost	0
Empty:	2
Misfire:	13
Samples recovered:	15
Geologist:	Bang/Ladegaard

Side wall core descriptions

Well no: 5514/30-1	Licence: DK 5/86	Date: 23.05.89	Run no: 2C	Page No: 1 of 2

tr:trace — M:medium — G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
61	3349	2	Slst: intlam lt gy - m dk gy, frm - mod hd, mass, crs grd vf Sst, v calc grd Mrl, tr micromic, mod arg, tr calc microvn.						
62	3345.5	2.5	Clyst: altn lam m gy - dk gy, frm - mod hd, mass, mod - v slty, tr micromic, mod - v calc.						
63	3337.5	2.5	Sh: gy blk, fis - subfis, frm - mod hd, mod slty, mod - v calc, tr micronod Pyr, tr carb,						
64	3327.5	3.5	Sh: dk gy - gy blk, fis - subfis, frm - mod hd, mod slty, mod - v calc, tr micronod Pyr, tr carb, tr slick.						
65	3323	1	Sst: lt gy - lt olv gy, Qtz, vf - slty grd Slst, subang, sph, mod srtd, mod hd - hd, arg mtx, calc mtx, tr Mica, no vis por.						
66	3294.5	4.5	Sh: dk gy - brn blk, subfis - fis, mod hd - hd, sl - mod slty, mnr mod - v slty, tr micromic, sl - mod calc.						
67	3280.5	1.5	Sh: dk gy - brn gy - gy blk, subfis, hd - v hd, mod - v slty, tr micromic, mod - v calc.						
68	3275	1.5	Sh: lt gy - m dk gy, subfis, mod hd - hd, sl - mod slty, tr micromic, v calc.						
69	3260.5	1.5	Sh: m gy - lt brn gy, fis - subfis, mod hd, mod - v slty, abn micromic, v calc.						
70	3244.5	2	Sh: dusky yel brn, fis, mod hd, mod slty, tr micromic, v calc.						
71	3232.5	3.5	Clyst: m gy - m dk gy, frm - mod hd, mass, v slty grd Slst, micromic, mod calc.						
72	3225.5	5	Sh: dk gy - dusky yel brn, fis, mod hd - hd, mod slty, tr - com micromic, non calc.						
73	3212.5	2.5	Sst: lt gy - m gy - lt olv gy, Qtz, vf - slty grd Slst, subang, sph, mod srtd, mod hd, arg & calc mtx, com Mica, sl lam, no por.						
74	3207.5	2.5	Sh: gy blk - brn blk, subfis, mod hd, mod slty, tr micromic, v calc.						
75	3204.5	1.5	Sst: lt brn gy - brn gy, Qtz, vf - slty grd Slst, mass - sl subfis, frm - mod hd, arg mtx, mod calc cmt, silic cmt, no vis por.						
76	3195.5	0	Empty						
77	3193	0	Empty						
78	3179		Misfire						

HYDRO

Service company:	Schlumberger
Asked:	30
Shot	17
Lost	0
Empty:	2
Misfire:	13
Samples recovered:	15
Geologist:	Bang/Ladegaard

Side wall core descriptions

Well no: 5514/30-1	Licence: DK 5/86	Run no: 2C	Date: 23.05.89	Page No: 2 of 2

tr:trace — M:medium — G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
79	3135		Misfire						
80	3106.5		Misfire						
81	3067.5		Misfire						
82	3050.9		Misfire						
83			Misfire						
84			Misfire						
85			Misfire						
86			Misfire						
87			Misfire						
88			Misfire						
89			Misfire						
90			Misfire						

HYDRO

Service company:	Schlumberger
Asked:	30
Shot	30
Lost	1
Empty:	3
Misfire:	0
Samples recovered:	26
Geologist:	Bang/Simpson

Well no: 5514/30-1

Side wall core descriptions

Licence: DK 5/86

Run no: 2D

Date: 23.05.89

Page No: 1 of 2

tr:trace — M:medium — G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
91	3201.7	1.5	Sst: m gy - brn gy, Qtz, vf - slty, subang, sph, pr - mod srtd, mod hd - hd, arg mtx, mnr calc cmt, com Mica, no vis por.						
			mnr Lst vn: wh - gy orng pk, mass, microxln, sl arg.						
92	3195	2	Sh: m dk gy - brn gy, mod hd - hd, subfis, sl - mod slty, micromic, v calc, lam.						
93	3191.9	3.5	Clyst: m dk gy - brn gy, hd, mass, sl - mod slty, tr micromic, mod calc.						
94	3183	2.5	Clyst: olv gy, mod hd - hd, mass - subfis, sl - mod slty, tr micromic, non calc.						
95	3179	2	Slst: brn gy, mod hd - hd, sub fis - fis, sl mod arg, grd vf Sst, tr micromic, sl - mod calc.						
96	3158	1	Sh: mod brn, mod hd, subfis - fis, v slty, tr micromic, tr vf sdy, mod calc.						
97	3135	1.5	Clyst: dusky yel brn - gy brn, mod hd, subfis - blky, mod - v slty, w/ vf Sst: mod orng pk - pl rd brn, sl mod calc.						
98	3106.5	0	Empty						
99	3101.8	1	Slst: mod rd brn - dk rd brn, frm, arg, blky, mod - v calc, tr Sst: Qtz, vf - f, subang, hd - v hd, w cmt, calc cmt, silic cmt, arg mtx						
			tr Lst nod: wh - gy orng pk, microxln, sft - frm, non - sl arg.						
100	3076	0	Empty						
101	3067.5	1	Lst: mod yel brn, hd, plty, abn f Qtz g, Mica.						
102	3059	2.5	Clyst: mod rd brn - dk rd brn, frm, mod slty, blky, non - sl calc, lam, Lst: wh - gy orng pk, sft, microxln, blky, non - sl arg.						
103	3057	3	Clyst: gy rd - dk rd brn w/ rd spots, mod hd, mass - subfis, sl - mod slty, non calc.						
104	3051	2	Slst: dk rd brn, frm, blky, arg, tr vf Sst, v calc grd Mrl.						
105	2793.5	3	Sst: dk rd brn, speck, Qtz, vf - v crs, ang - subang, tr subrnd, sph - elg, v pr srtd, frm, mass, arg mtx, Fldsp, sed frag, ign frag, Mica, tr calc cmt.						
106	2787.5	3.5	Clyst: m dk - dk gy, frm - mod hd, mass, sl slty, tr micromic, non calc.						

HYDRO

Service company:	Schlumberger
Asked:	30
Shot	30
Lost	1
Empty:	3
Misfire:	0
Samples recovered:	26
Geologist:	Bang/Simpson

Side wall core descriptions

Well no: 5514/30-1	Licence: DK 5/86	Run no: 2D	Date: 23.05.89	Page No: 2 of 2

tr:trace – M:medium – G:good

No:	Depths: mRKB	Rec: cm	Lithology	Flu tr	Flu M	Flu G	Cut tr	Cut M	Cut G
107	2752.5	2.5	Clyst: m gy - grn gy, mass - subfis, frm, sl plast, mod - v slty, tr micromic, v calc grd Mrl.						
108	2708	2	Clyst: dk rd brn, frm - plast, mass, mod - v slty, tr micromic, tr Anhy: microxln, m - crs xln.						
109	2689	2	Sst: dk rd brn, Qtz, f - vf, tr m, tr crs, subang, sph - elg, v pr srtd, arg mtx, tr calc cmt, tr Fldsp, tr plt roots, tr Anhy, no vis por.						
110	2660	2.5	Sst: mod rd brn, Qtz, vf - f, ang - subang, sph, pr - mod srtd, arg mtx, tr Fldsp, tr Mica, bed.						
111	2645	2	Sst: dk rd brn, speck wh, Qtz, f - m, tr crs, tr vf, subang - ang, tr subrnd, pr srtd, mod hd - fri, mass, arg mtx, tr Fldsp, non calc, tr Anhy, no vis por.						
112	2601	2	Sst: dk rd brn, speck wh, Qtz, f - m, subang - ang, pr srtd, mod hd - fri, mass, arg mtx, tr Fldsp, tr clyst clasts, tr Anhy, non calc, no vis por.						
113	2576.5	2.5	Sst: dk rd brn, speck wh, Qtz, f - m, subang - ang, pr srtd, frm - fri, mass, arg mtx, com Anhy, tr Fldsp, non calc, no vis por.						
114	2545	0	Empty						
115	2476.5	4	Sst: dk rd brn, speck wh, Qtz, vf - v crs, ang - subang, sph, v pr srtd, frm, mass, arg mtx, tr Fldsp, sl calc, sed frag.						
116	2285	3.5	Clyst: mod rd brn - dk rd brn, frm, mass, sl - mod slty, non calc.						
117	2227.5	2	Sst: mot dk rd brn, wh - v lt gy, Qtz, gen f - m, tr crs - v crs, subang - ang, sl elg, mass, arg mtx, mnr calc cmt, tr Anhy, tr Fldsp, tr ?Kaol, no vis por.						
118	2097.5	2	Sst: dk rd brn - v dusky rd, Qtz, vf - v crs, ang - subang, sph, v pr srtd, frm, mass, arg mtx, tr Fldsp, non calc.						
119	1951.8	0	Lost						
120	1862.5	4	Clyst: dk rd brn, frm, mass, mod - v slty, sl - mod calc.						

APPENDIX III

HYDRO WELL SUMMARY

Coord: 55 00 54.09 N 14 18 43.14 E
UTM: N 6096812.4 m E 456003.2 m
ne: 33, with Control Meridian 15°E
Line: NH 87B - 101 SP. 236
Rig: GLOMAR MORAY FIRTH I
Waterdepth: 44 m.
Stopped in: Shales of Silurian age

On location: 05.04.89
Spudded: 06.04.89
At T.D.: 01.06.89
Completed: 06.06.89
T.D. Driller: 3624.5 m.
T.D. Logger: 3623.0 m.
Wireline Logging: Schlumberger.
Mudlogging: Exlog.

WELL
5514/30-1
PERNILLE-1

COUNTRY
DENMARK

OPERATOR Norsk Hydro

LICENCE 5/86

TARGETS

Primary: LOWER JURASSIC/UPPER TRIASSIC SANDSTONE OF THE RØNNE FORMATION
Secondary: THE ENTIRE PRE-CRETACEOUS SECTION

OWNED BY

Norsk Hydro/ Enterprise/ Gas Council/ Amerada Hess/ DOPAS/ DENERCO/ Dansk Oliesøgning/ KFK

RESULTS

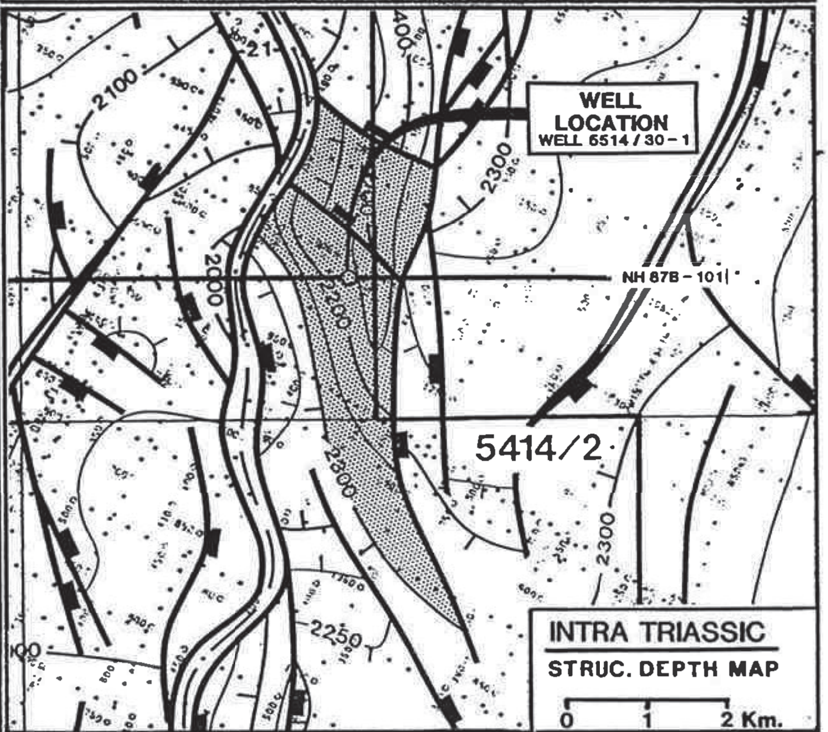
The Rønne Fm. was found waterwet in the interval 967 to 1552m. All deeper prospective sections were found waterwet.
P & A as a dry well.

CASING

30" At 105 m.
20" At 777 m.
3 At 1740 m.
9 At 3339 m.

CORES

TD. CORE
3615.0-3624.5 m.
100 % REC.



GAS RECORD

105- 791m: 0.03-0.07% C_1
791-1646m: 0.01-0.17% C_1
1646-1790m: 0.00-0.03% C_1
1790-2065m: 0.00-0.12% C_1
2065-2457m: 0.01-0.30% C_1
2457-2810m: 0.01-0.10% C_1
2810-3255m: 0.01% C_1
3255-3352m: 0.01-0.03% C_1
352-3368m: 0.11-0.15% C_1
3368-3624.5m: 0.01-0.08% C_1

CST

Run	Interval	Shot/rec
1.A	1238-1745 m.	29/28
1.B	790-1232 m.	30/24
2.C	3195-3349 m.	17/15
2.D	1862.2-3201.7 m.	30/26

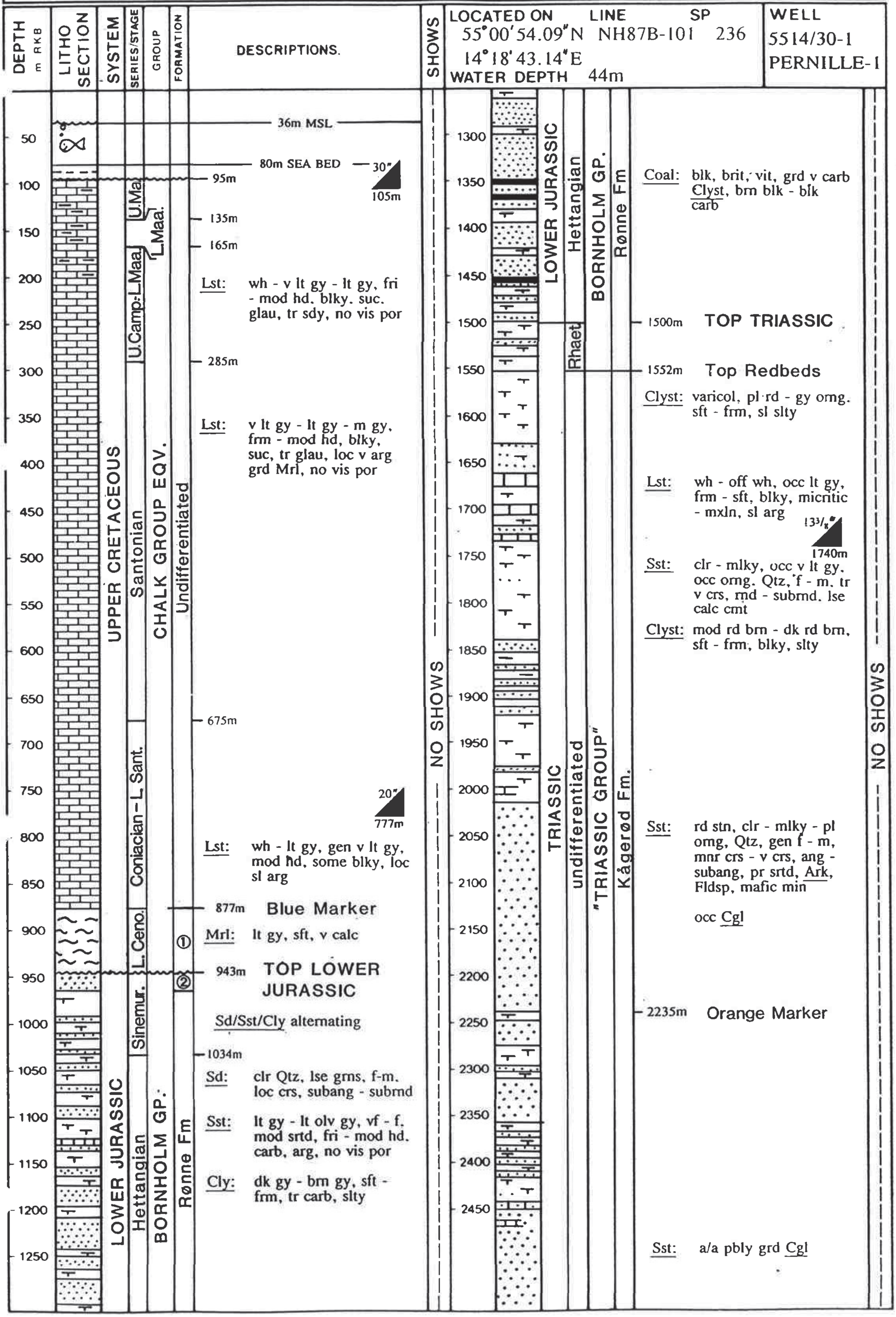
LOGS

MWD	105-1715m	
DIL/ LSS/ GR/ SP	775-1751m 1738-3351m 3338-3615m	1.A 2.B 3.C
LDL/ CNL/ CAL/ GR	775-1752m 1738-3350m 3338-3612m	1.A 2.B 3.C
SHDT/ GR	775-1749m 1738-3350m 3338-3622m	1.A 2.B 3.C
Velocity survey/ Checkshots	795-3617m	3.A

OIL SHOWS

No shows of hydrocarbons were recorded throughout the drilled sequences.

GEOLOGICAL WELL SUMMARY



GEOLOGICAL WELL SUMMARY

LOCATED ON	LINE	SP	WELL
55°00'54.09"N 14°18'43.14"E	NH87B-101	236	5514/30-1 PERNILLE-1
WATER DEPTH 44m			

Columns: DEPTH m RKB | LITHO SECTION | SYSTEM | SERIES/STAGE | GROUP | FORMATION | DESCRIPTIONS. | SHOWS

Depth scale: 2550, 2600, 2650, 2700, 2750, 2800, 2850, 2900, 2950, 3000, 3050, 3100, 3150, 3200, 3250, 3300, 3350, 3400, 3450, 3500, 3550, 3600, 3650, 3700, 3750

System: TRIASSIC; U.P.; LOWER PERMIAN; CARBONIFEROUS?; SILURIAN

Series/Stage: L?; U. Wenlockian; L. Wenlockian

Group: ZEC; ROTLIEGENDES GP

Formation: Graptolite Mudstone Fm

Shows: NO SHOWS

DESCRIPTIONS.

Sst: clr - mlky, mod rd orng, Qtz, f - m - crs - v crs, pr srtd, ang - subang, tr silic cmt, lithic frag, pbly, mnr Fldsp, mnr mafic min, Ark, occ Cgl

2747m

Mrl/Clyst: lt gy, sft - frm

2787m

Sst: clr - mlky, pred stn'd m rd brn - rd orng, Qtz, f - crs, pred m, occ v crs - pbly, ang - occ sub rnd, pr srtd, gen lse, silic + calc cmt, rare Qtzt, Fldsp, Gnes, Musc + Biot, no vis por

3057m Green Marker

Slst: dk rd brn - dusky rd, occ brn blk, mod hd - occ hd, blky, non - sl calc - dol, arg, micromic

3192m

Sst/Slst: rd brn, f - m

3212m TOP SILURIAN

Sh: dk gy - gy blk, mod hd, fis - subfis, mod slty grd Slst

9⅝ 3329m

3352m

intbd Sst/Slst: m gy - m lt gy, tr dusky brn - dk rd brn, Qtz, vf - slty, hd, no vis por

TD CORE from: 3615.0m
to: 3624.5m

TD DRILLER 3624.5m
TD LOGGER 3623.0m

①: Arnager Greensand Equivalent

②: Hasle Fm.

SECTION B

OPERATIONS

0022q
sn,BEn/agi

LIST OF CONTENT

SECTION B

0022q
sn,BEn/agi

0022q
sn,BEn/agi

1. LOCATION SURVEY

The site survey for well 5514/30-1 was performed by Master Survey from December 9th to 16th 1988. A geotechnical coring down to 27.5 m below seabed was performed by Fugro Mc clelland from December 16th to 18th 1988.
The following is a summary of the seabed and sub-seabed conditions at the location, based on the site survey and the geotechnical coring.

Water depth:	Varying from 77 meters (RKB) to 82 meters (RKB) in the surveyed area. At location, it was found to be 80 meters (RKB).
Seabed slope:	Negligable.
Seabed sediments:	Soft, sandy sediments.
Sub-seabed geology (cored):	

80.1 m - 80.2 m (RKB):	Clay, silty-sandy, very soft.
80.2 m - 82.8 m (RKB):	Sand, fine, silty (channel sand)
82.8 m - 86.1 m (RKB):	Clay, silty, very soft.
86.1 m - 95.1 m (RKB):	Clay, silty, sandy, content of gravel and possible boulders at the base (at 95 m).

95.1 m - 105.0 m (RKB): Chalk, stiff to hard, frequent chips of chert.

Seabed hazards:	The prognosed channel sand at the location did not cause any problem when jacking up the rig.
Sub-seabed hazards:	No high amplitude anomalies was prognosed and no shallow gas was penetrated.
	The prognosed boulders layer at 95 m (RKB) caused problem during driving of the 30" conductor (Reduced penetration). It might also have influenced the collapse of the 30" drive shoe.
H_2S:	No occurence of H_2S was detected in the well.

0022q
sn,BEn/agi

2. POSITIONING OF THE RIG

The well was located on the seismic line NH 87B-101, shot point 236.

Planned position of the well:

Geographical	UTM
55° 00' 53.4" N	6 096 794.1 mN
14° 18' 43.9" E	456 016.6 mE

319 simultaneous 4 satellite GPS measurements were used to postion the rig. The reference station was placed at Hammeren lighthouse on Bornholm.

Final position of the well:

Geographical	UTM
55° 00' 54.09" N	6 096 812.4 mN
14° 18' 43.14" E	456 003.2 mE

The rig heading was 14.5° and the distance from the intended location was 23 meters in direction 323.1°.

3. OPERATION RESUME

3.1 Summary of operations

Well 5514/30-1 was drilled with the jack-up rig "Glomar Moray Firth I". The rig was taken over by Norsk Hydro 05.04.89 at 00:01 hrs. when it was jacked to drilling draft.

36" section:

The seabed was tagged at 80 m and the 30" conductor was driven down from 80 m to 104.5 m where no further penetration was possible.

When cleaning out the formation inside the 30" conductor, using 17 1/2" bit and 26" holeopener, it was not possible to pass the 30" muline landing runs at 77 m. The 26" holeopener was found to be 1/2" overgauged.
The holeopener was changed and the 30" conductor was cleaned out, but it was not possible to pass the 30" shoe at 104 m. The tension system was installed and a flange was welded onto the 30" conductor and the diverter was nippled up.

26" section:

This section was planned to be drilled in one run using 17 1/2" bit, MWD and 26" holeopener. Due to the hard formation experienced in the previous section, it was decided to drill 17 1/2" pilothole. The pilot hole was drilled to 787 m in one run. A negative attempt was made to drill out of the 30" shoe using a 24" holeopener.
A 24" taper mill was then used to mill out the 30" shoe which had been damaged during hammering.
The pilot hole was opened in one run from 17 1/2" to 24" using a 24" holeopener down to 788 m. Due to tight hole, KCl was added to the mud and the mudweight was increased to 1.25 r.d.
To ensure safe running of the 20" casing, it was decided to open up the hole to 26" using a 26" underreamer. The 20" casing was run and cemented with the shoe at 777 m.

17 1/2" section:

The cement and 3 m new formation was drilled. A leak off test equivalent to 1.81 r.d. was preformed on 791 m. 17 1/2" hole was then drilled from 791 m to 1263 m. While pulling out for bit change the hole was tight from 1197 m to 992 m, and from 992 m to 777 m the hole was backreamed. 17 1/2" hole was drilled further to 1508 m where the mudweight was increased from 1.16 r.d. to 1.20 r.d. to stabilize the hole. Some mudlosses appeared due to sandplugged shaker screens. The screens was changed out to courser type (50 mesh at bottom).

Tight spots were washed and reamed from 1378 m to 1387 m while running in with a new bit. 17 1/2" hole was then drilled from 1508 m to 1715 m. Tight hole was backreamed from 1615 m to 1417 m while tripping out for bitchange. While running in the hole with new bit, tight hole was washed and reamed from 1688 m to 1715 m and 7 m fill was found on bottom. 17 1/2" hole was then drilled to 1754 m which was decided to be the setting depth for the 13 3/8" casing. The planned depth for the section at 2100 m was changed due to changes in the original geological prognosis.
Five logruns were run at T.D.:

Run no.1: DIL/LSS/GR/SP
Run no.2: LDL/CNL/CAL/GR
Run no.3: SHDT
Run no.4: CST
Run no.5: CST

After a wipertrip, the 13 3/8" casing was run and cemented with the shoe at 1740 m.

12 1/4" section:

A leakoff test equivalent to 2.00 r.d. mudweight was performed at 1757 m. 12 1/4" hole was drilled to 2476 m in three bitruns. Tight hole was washed and reamed from 2188 m to 2225 m on the second trip for bitchange. Tight spots were also encountered at 2254 m and 2235 m when pulling out on the third bit tip, and the hole was washed and reamed from 2041 m to 2064 m on the trip in. Stuck pipe was worked free at 2433 m and washing continued to 2476 m. The mudweight was increased from 1.24 r.d. to 1.28 r.d. to stabilize the hole.
12 1/4" hole was then drilled from 2476 m to 2851 m in four bitruns. Some reaming were performed while tripping in with new bits. At 2851 m, a roller reamer was picked up and tight hole was reamed from 2774 m to 2851 m. Drilling then proceeded to 3139 m in three bitruns, where the string was pulled due to a loss in the pump pressure.

A washout was found in the 8" drillcollars. Drilling continued to 3178 m where a new washout was found in the 5" heavy weight drillpipe. A 3rd washout occured in the 8" jar at 3200 m. After drilling to 3217 m, a loss in torque was observed. 95 meters of the bottom hole assembly was found left in the hole due to a twist-off in a drill-collar box. The fish was retrieved with an overshot. 12 1/4" hole was then drilled to 3352 m and it was deceided to run casing. The following logs were run:

Run no.1:	DIL/LSS/GR/SP
Run no.2:	LDL/CNL/CAL/GR
Run no.3:	SHDT
Run no.4:	CST
Run no.5:	CBL/VDL
Run no.6:	CST.

The CST-log was rerun due to a tool failure on the first run.

The 9 5/8" casing was circulated down the last 30 meters and was cemented with the shoe at 3339 m.
The top cement plug did not bump.

<u>8 1/2" section:</u>

Cement was drilled out from 3267 m to 3303 m and 3 m new formation was drilled. A leakoff test equivalent to 1.84 rd mudweight was performed at 3355 m. 8 1/2" hole was drilled to 3368 m and further to 3425 m after a bitchange. At this depth the string was pulled due to a pressure drop, and a washout was found in the 5" heavy weight drillpipe. Drilling continued to 3498 m where a single shot survey was run on wireline. The survey tool got stuck in a cross-over below the jar. The wireline parted, and the drill-string had to be pulled.
The mudweight was increased from 1.29 r.d. to 1.32 r.d. due to increasing pore pressure. 8 1/2" hole was drilled further from 3498 m to 3615 m where a loss in pump pressure was observed.

A washout was found in the 5" heavy weight drillpipe. Finally, a core was cut from 3415 m to 3625 m and this was decided to be T.D. of the well.

The following logs were run:

Run no.1: DIL/LSS/GR/SP
Run no.2: CNL/LDL/CAL/GR
Run no.3: CBL/VDL
Run no.4: SHDT
Run no.5: VSP, checkshots.

A wipertrip was performed after run no.3, and the mudweight was increased from 1.32 r.d. to 1.35 r.d. due to tight hole caused by increasing pore pressure.

The well was then permanent plugged and abandoned and the rig given over to Global Marine the 6th of June 1989 at 24:00 hours.

0022q
sn,BEn/agi

((((ooo) Norsk Hydro	3.2 Daily report — System : BORE	Date 13/7-1989
	Well: 5514/30-1	
	Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8	
	Setting depth m,MD: 105 | 777 | 1740 | 3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
1	0	0		24:00	Skidded the upper and lower substructure packages to drilling position and rigged it up. Rig at drilling air gap at 00:01 Hrs. Rig on day rate at 00:01 Hrs.
2	104	1.03		03:30	Rigged up the substructure and the floor.
				07:30	Picked up and racked back heavy weight drill pipe and drill collars.
				14:00	Rigged up to drive 30" conductor.
				17:00	Ran the 30" conductor to the mudline at 80 m.
				19:30	Picked up the hammer and the drive sub.
				20:00	The 30" conductor fell free to 90 m.
				22:00	Drove the 30" conductor from 90 m to 104.5 m.
				24:00	Rigged up the Texas deck. Broke out and laid down the top 30" joint.
3	105	1.03	1.05	00:30	Laid down the drive sub and the hammer.
				02:30	Rigged up to hang off the 30" conductor on the BOP hoist.
				06:30	Picked up 26" bottom hole assembly and ran in the hole.
				07:30	Was not able to pass the 30" landing ring at 77 m.
				13:00	Worked to pass the mudline landing ring without success. Pulled out of the hole and changed out the 26" hole opener and ran back in the hole. The 26" bottom hole opener was 1/2" overgauge.
				16:30	Cleaned out the 30" conductor from 80 m to 105 m.
				18:00	Repaired the top drive torque wrench.
				19:30	Attempted to work the hole opener through the 30" shoe at 104 m.
				21:30	Pulled out of hole and laid down the 26" hole opener and the 17 1/2" bit.
				23:30	Laid down hammer equipment and rigged up the 30" tensioner system.
				24:00	Prepared to weld pad eyes on the 30" conductor.
4	105	1.03	1.05	01:30	Welded pad eyes on the 30" conductor.
				03:30	Raised the reaction plate against pad eyes to support the 30" conductor.
				04:30	Cut the 30" conductor.
				06:00	Landed the 30" flanges on the 30" conductor and weld it on.
				07:00	Moved the 30" diverter into position.
				12:00	Made up the diverter to the 30" flange.

((((ooo) Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				17:00	Landed the diverter and installed the diverter piping.
				21:00	Installed the bell nipple and the flow lines.
				21:30	Laid down the slings and rigged up to pick up 17 1/2" bottom hole assembly.
				24:00	Picked up the 17 1/2" bottom hole assembly.
5	634	1.03	1.14	02:00	Ran in the hole.
				03:00	Function tested the diverter.
				24:00	Drilled 17 1/2" pilot hole from 105 m to 634 m.
6	787	1.03	1.14	02:30	Drilled 17 1/2" pilot hole from 634 m to 705 m.
				03:00	Pulled out and reamed from 675 m to 690 m.
				06:00	Drilled 17 1/2" pilot hole from 705 m to 787 m.
				06:30	Circulated.
				11:00	Pulled out of the hole.
				15:00	Repaired the top drive torque arrester.
				16:30	Made up 24" hole opener and ran in the hole to 105 m.
				17:30	Repaired the flow line.
				18:30	Attempted to work the hole opener through the 30" shoe at 104 m without success.
				20:30	Pulled out of the hole and laid down the hole opener assembly. Picked up a 24" tapered mill and ran in the hole to 105 m.
				22:00	Milled on the 30" shoe.
				24:00	Pulled out of the hole and laid down the milling assembly. Picked up a 24" hole opener assembly and ran in the hole to 105 m.
7	787	1.03	1.16	00:30	Opened 17 1/2" pilot hole to 24" from 105 m to 115 m.
				02:30	Pulled out of the hole. Picked up 17 1/2" stabilizer and ran in the hole.
				07:30	Opened 17 1/2" pilot hole to 24" hole from 115 m to 314 m.
				09:30	Tripped to pick up more drill collars.
				24:00	Opened 17 1/2" pilot hole to 24" hole from 314 m to 680 m.
8	788	1.03	1.16	05:30	Opened up the 17 1/2" pilot hole to 24" hole from 680 m to 787 m. Drilled 1 m of new hole to 788 m.

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1	Date 13/7-1989

Casing Size (in):	30	20	13 3/8	9 5/8	
Setting depth m,MD:	105	777	1740	3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				06:30	Circulated the hole clean.
				07:00	Pulled out of the hole to 712 m. The hole was tight. Max. over pull was 70 ton.
				19:00	Pulled out of the hole. Backreamed and circulated out to the shoe.
				24:00	Made up new bottom hole assembly with 24" hole opener and 26" underreamer and ran in the hole to 105 m.
9	788	1.03	1.16	17:00	Underreamed 24" hole to 26" from 105 m to 785 m.
				19:00	Circulated and conditioned the mud.
				21:00	Performed a wiper trip to 105 m.
				22:00	Underreamed the hole from 105 m to 150 m.
				23:00	Ran in the hole from 150 m to 785 m.
				24:00	Circulated and conditioned the mud for the 20" casing.
10	788	1.03		02:00	Continued to condition the mud.
				04:30	Pulled out of the hole.
				05:00	Laid down the bit, the hole opener and the underreamer.
				06:00	Made up the mud line suspension and the running tool.
				07:00	Rigged up to run the 20" casing.
				15:00	Ran the 20" casing. Landed the casing in the 30" landing ring. with the float shoe at 777 m and the float collar at 761 m.
				15:30	Laid down the casing handling equipment.
				18:30	Made up the cement stinger and ran in the hole to the float collar.
				20:00	Rigged up the cement lines and stung into the float collar. Circulated the annulus volume.
				22:00	Made up and ran 2 stands of 1.66"CS Hydrill wash pipe between the 30" conductor and the 20" casing.
				24:00	Cemented the 20" casing.
11	788	1.03		02:00	Finished cementing the 20" casing.
				04:30	Pulled out of the hole with the cement stinger and rigged down the cement lines
				05:00	Circulated the 30" X 20" annulus clean.
				06:30	Rigged down the wash pipe lines. Pulled out of the hole and laid out the wash string.
				09:30	Nippled down the diverter, the riser and the flow line. Picked up the riser and made a rough cut on the 20" casing.

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8 Setting depth m,MD: 105 | 777 | 1740 | 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				14:30	Laid down the diverter, the bell nipple and the valves.
				19:00	Made a final cut on the 30" conductor and the 20" casing. Installed the "A" section well head and welded the section onto the 20" casing.
				24:00	Nippled up the Gray crossover spool and the 21 1/4" BOP.
12	791	1.03	1.16	05:00	Continued to nipple up the 21 1/4" BOP and installed the bell niple.
				06:00	Function tested the BOP.
				08:00	Changed the bottom rams to 5".
				11:30	Tested the casing and the BOP to 88 bar.
				13:00	Laid out the test plug and ran the wear bushing.
				15:00	Picked up a 60' core barrel and racked back in the derrick.
				21:30	Made up 17 1/2" bottom hole assembly. Tested Teleco MWD tool and ran in the hole to 761 m.
				23:00	Drilled the float collar and the float shoe and cleaned the rat hole.
				23:30	Drilled 3 m of new formation to 791 m.
				24:00	Circulated and conditioned mud for leak off test.
13	1182	1.03	1.16	00:30	Continued to circulated prior to perform leakoff test.
				01:30	Performed a leakoff test equivalent to 1.81 SG mud weight.
				08:00	Drilled 17 1/2" hole from 791 m to 885 m.
				09:00	Circulated for samples.
				24:00	Continued drilling 17 1/2" hole from 885 m to 1182 m.
14	1299	1.03	1.16	09:30	Drilled 17 1/2" hole from 1181 m to 1263 m.
				11:00	Pulled out of the hole to 992 m. The hole was tight from 1197 m to 992 m.
				14:30	Backreamed from 992 m to 777 m.
				18:00	Flow checked and pulled out of the hole for bit change.
				21:00	Ran back in the hole with a new bit to 1263 m.
				24:00	Drilled 17 1/2" hole from 1263 m to 1299 m.
15	1508	1.03	1.20	02:30	Drilled 17 1/2" hole from 1299 m to 1360 m.

((((ooo) Norsk Hydro	Daily report — System : BORE	Date 13/7-1989
	Well: 5514/30-1	
	Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8	
	Setting depth m,MD: 105 / 777 / 1740 / 3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				03:00	Circulated while cleaning out sand plugged shaker screens.
				08:00	Drilled 17 1/2" hole from 1360 m to 1426 m. Lost mud due to plugged shaker screens.
				09:30	Changed out the shaker screens.
				22:00	Drilled 17 1/2" hole from 1426 m to 1508 m.
				23:00	Circulated the hole clean.
				24:00	Pulled out of the hole for bit change.
16	1646	1.03	1.20	04:30	Continued pulling out og the hole.
				09:00	Made up new bit and ran in the hole to 1378 m. Washed and reamed tight spots to 1387 m and continued to run in the hole to bottom at 1508 m.
				22:30	Drilled 17 1/2" hole from 1508 m to 1637 m. Flow checked a drilling break and continued drilling to 1643 m.
				23:30	Circulated bottoms up for samples.
				24:00	Drilled 17 1/2" hole from 1643 m to 1646 m.
17	1715	1.08	1.21	12:00	Drilled 17 1/2" hole from 1646 m to 1715 m.
				22:30	Pulled out of the hole for bit change. Backreamed tight hole from 1615 m to 1417 m. Laid out the bit and the MWD tool.
				24:00	Made up new bit and bottom hole assembly and ran in the hole.
18	1754	1.08	1.21	02:30	Ran in the hole to 1688 m.
				03:00	Washed and reamed from 1688 m to 1715 m.
				07:00	Drilled 17 1/2" hole from 1715 m to 1720 m.
				08:00	Repaired mud pump no.1
				13:00	Drilled 17 1/2" hole from 1720 m to 1736 m.
				14:00	Repaired mud pump no.1
				22:30	Drilled 17 1/2" hole from 1736 m to 1754 m.
				24:00	Circulated the hole clean prior to a wiper trip.
19	1754	1.08	1.21	01:30	Made a wiper trip from 1754 m to 1450 m and ran back to bottom.
				03:30	Circulated the hole clean prior to logging.
				07:30	Pulled out of the hole for logging.
				24:00	Rigged up and started logging. No.1: DIL/LSS/GR/SP

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System : BORE

Date
13/7-1989

Well: 5514/30-1

Casing Size (in):	30	20	13 3/8	9 5/8
Setting depth m,MD:	105	777	1740	3339

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Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					No.2: LDL/CNLCAL/GR No.3: SHDT
20	1754	1.08	1.22	08:00	Continued logging. No.3: SHDT No.4: CST NO.5: CST
				11:30	Ran in the hole for wiper trip.
				12:30	Washed and reamed to 1754 m and worked the junk basket.
				14:30	Circulated the hole clean.
				16:30	Pulled out of the hole to 770 m.
				17:30	Slipped and cut the drilling line.
				20:30	Pulled out of the hole and laid down the junk sub.
				21:00	Pulled the wear bushing.
				22:00	Rigged up to run the 13 3/8" casing.
				24:00	Ran the 13 3/8" casing.
21	1754	1.08	1.22	04:00	Ran the 13 3/8" casing to the 20" shoe.
				04:30	Changed the bails and rigged up the 500 MT elevator and slips.
				06:00	Rigged up the air hose to the elevator and repaired broken shackle for the top drive counter balance.
				13:30	Ran the 13 3/8" casing with the shoe at 1740 m and float collar at 1714 m.
				15:45	Circulated the casing volume.
				16:15	Tested the cement lines to 265 bar, loaded the cement plugs and made up the cement head.
				19:45	Cemented the casing, bumped the plug and tested the casing to 265 bar.
				21:00	Opened the ports in the mud line suspension system, circulated the annulus clean with seawater, closed the ports and retested the casing to 265 bar for 10 minutes.
				23:30	Nippled down the 21 1/4" BOP and the flowline. Lifted the stack and set the casing slips.
				24:00	Made a rough cut on 13 3/8" casing.
22	1754	1.08	1.22	00:30	Continued to rough cut the 13 3/8" casing.
				04:00	Nippled down the bell nipple and racked back the 21 1/4" BOP. Made a final cut on the 13 3/8" casing and removed the 20" crossover. Installed the 13 5/8" crossover and tested the seals to 159 bar.
				12:00	Installed the 13 5/8" BOP.

((((ooo) Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				17:00	Tested the BOP stack to 265 bar and tested the casing and the wellhead against the shear ram to 265 bar.
				22:00	Tested the surface equipment and the choke manifold to 265 bar.
				24:00	Laid down the 17 1/2" bottom hole assembly.
23	1790	1.08	1.22	02:30	Continued to lay down the 17 1/2" bottom hole assembly.
				08:30	Picked up 12 1/4" bottom hole assembly and ran in the hole. Tagged cement at 1712 m.
				10:30	Drilled the cement, the float collar and the float shoe. Washed and reamed the rat hole to 1754 m.
				11:30	Drilled 12 1/4" hole from 1754 m to 1757 m.
				12:00	Circulated for leak off test.
				13:30	Pulled back into the shoe and tested the surface lines to 204 bar. Performed a leak off test equivalent to 2.0 SG mud density.
				24:00	Drilled 12 1/4" hole from 1757 m to 1790 m.
24	1841	1.08	1.22	09:30	Drilled 12 1/4" hole from 1790 m to 1810 m.
				10:30	Circulated and dropped a single shot survey.
				15:30	Pulled out of the hole, recovered the survey and changed out the bit.
				17:30	Ran in the hole with a new bit.
				24:00	Drilled 12 1/4" hole from 1810 m to 1841 m.
25	1915	1.08	1.22	09:30	Drilled 12 1/4" hole from 1841 m to 1870 m.
				14:30	Pulled out of the hole to change bit.
				15:30	Made up a new bit and ran back in the hole to the casing shoe.
				16:30	Serviced the top drive.
				17:00	Continued to run in the hole to the bottom.
				24:00	Drilled 12 1/4" hole from 1870 m to 1915 m.
26	2065	1.08	1.22	07:00	Drilled 12 1/4" hole from 1915 m to 1960 m.
				08:00	Repaired a leak in the bell nipple.
				24:00	Drilled 12 1/4" hole from 1960 m to 2065 m.

((((ooo) Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
27	2215	1.08	1.22	24:00	Drilled 12 1/4" hole from 2065 m to 2215 m.
28	2295	1.08	1.22	02:30	Drilled 12 1/4" hole from 2215 m to 2225 m.
				03:00	Circulated and dropped a survey.
				09:00	Pulled out of the hole and recovered the survey.
				12:00	Made up a new bit and ran back in the hole to the shoe.
				12:30	Serviced the top drive.
				13:30	Continued to run in the hole. Washed and reamed from 2188 m to 2225 m.
				24:00	Drilled 12 1/4" hole from 2225 m to 2295 m.
29	2458	1.08	1.24	24:00	Drilled 12 1/4" hole from 2295 m to 2458 m.
30	2476	1.08	1.24	07:00	Drilled 12 1/4" hole from 2458 m to 2476 m.
				07:30	Circulated and dropped a survey.
				13:00	Pulled out of the hole, worked through tight spots from 2254 m to 2235 m, and retrieved the survey.
				19:00	Pulled the wearbushing, ran the testplug and tested the BOP. Pulled the test plug and ran the wearbushing.
				23:30	Made up new bit and ran in the hole to 2041 m.
				24:00	Reamed from 2041 m to 2055 m.
31	2573	1.08	1.28	03:00	Washed and reamed tight spot from 2055 m to 2064 m. Worked stuck pipe free at 2433 m and continued to wash to 2476 m.
				24:00	Drilled 12 1/4" hole from 2476 m to 2573 m.
32	2603	1.08	1.28	00:30	Drilled 12 1/4" hole from 2573 m to 2575 m.
				01:30	Circulated and ran a survey on slick line.
				11:00	Continued to drill 12 1/4" hole from 2575 m to 2603 m.
				11:30	Dropped a survey.
				15:00	Pulled out of the hole and retrieved the survey.
				16:00	Pulled the wear bushing. Checked for wear and reran the wearbushing.
				20:30	Picked up new bottom hole assembly, made up new bit and ran in the hole.

((((ooo) Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				24:00	Worked through tight spots and reamed from 2350 m to 2362 m.
33	2634	1.08	1.28	01:30	Washed and reamed from 2362 m to 2418 m. Continued to run in the hole to 2588 m. Washed and reamed from 2588 m to 2603 m. Worked the junk sub at bottom.
				06:00	Drilled 12 1/4" hole from 2603 m to 2610 m.
				11:30	Pulled out of the hole.
				12:00	Cleaned out the junk sub and laid down the short drill collar and the bit sub.
				15:30	Made up a new bit and ran in the hole to the casing shoe.
				16:00	Serviced the top drive.
				17:00	Slipped and cut the drilling line.
				19:00	Continued to run in the hole.
				19:30	Washed and reamed from 2547 m to 2610 m.
				24:00	Drilled 12 1/4" hole from 2610 m to 2634 m.
34	2731	1.08	1.28	16:00	Drilled 12 1/4" hole from 2634 m to 2731 m.
				19:00	Dropped a survey.
				20:00	Pulled out of the hole and retrieved the survey.
				21:00	Pulled the wear bushing. Inspected for wear, rotated the wear bushing 45 deg, and ran it back.
				24:00	Made up a new bit and ran in the hole to the casing shoe.
35	2810	1.08	1.28	01:00	Continued to run in the hole to 2688 m. Washed from 2688 m to 2732 m.
				24:00	Drilled 12 1/4" hole from 2732 m to 2810 m.
36	2851	1.08	1.28	13:30	Continued to drill 12 1/4" hole from 2810 m to 2851 m.
				18:00	Dropped a survey. Pulled out of the hole and retrived the survey.
				19:00	Installed a new wear bushing.
				19:30	Serviced the top drive.
				23:30	Made up new bit and roller reamer, and ran in the hole to 2576 m. The brake rim hose bursted.
				24:00	Repaired the brake rim hose.
37	2918	1.08	1.28	01:00	Ran in the hole to 2774 m.
				01:30	Washed from 2774 m to 2846 m and reamed from 2846 m to 2851 m.
				24:00	Drilled 12 1/4" hole from 2851 m to

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30, 20, 13 3/8, 9 5/8 Setting depth m,MD: 105, 777, 1740, 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					2918 m.
38	2947	1.08	1.28	07:30	Continued to drill 12 1/4" hole from 2918 m to 2944 m.
				08:00	Dropped a survey.
				12:00	Pulled out of the hole and retrieved the survey.
				12:30	Pulled the wear bushing.
				17:30	Ran the test plug and tested the BOP. Retrieved the test plug.
				18:00	Ran the wear bushing.
				22:00	Made up new bit and junk basket, and ran in the hole to 2944 m.
				23:30	Worked the junk basket.
				24:00	Drilled 12 1/4" hole from 2944 m to 2947 m.
39	3020	1.08	1.28	24:00	Drilled 12 1/4" hole from 2947 m to 3020 m.
40	3050	1.08	1.28	00:30	Continued drilling 12 1/4" hole from 3020 m to 3022 m.
				01:00	Repaired mud pump no.1
				02:00	Drilled 12 1/4" hole from 3022 m to 3025 m.
				02:30	Repaired mud pump no.1.
				03:00	Drilled 12 1/4" hole from 3025 m to 3027 m.
				03:30	Repaired mud pump no.1.
				06:00	Drilled 12 1/4" hole from 3027 m to 3032 m.
				06:30	Dropped a survey.
				12:30	Pulled out of the hole and retrieved the survey. Changed bit and laid down the junk basket.
				16:30	Ran back in the hole to 2960 m.
				17:30	Washed from 2960 m to 3032 m.
				24:00	Drilled 12 1/4" hole from 3032 m to 3050 m.
41	3128	1.08	1.28	24:00	Drilled 12 1/4" hole from 3050 m to 3128 m.
42	3153	1.08	1.28	01:00	Continued to drill 12 1/4" hole from 3128 m to 3132 m.
				01:30	Repaired mud pump no.2.
				03:30	Drilled 12 1/4" hole from 3132 m to 3139 m. Lost 20 bar pump pressure.
				04:00	Checked the surface equipment for leakage.
				04:30	Dropped a survey.
				10:00	Pulled out of the hole, retrieved the

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8 Setting depth m,MD: 105 | 777 | 1740 | 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					survey and inspected for washout. Laid down 2 bad drill collars.
				11:00	Inspected the wear bushing.
				15:00	Made up a new bit and ran back in the hole.
				24:00	Drilled 12 1/4" hole from 3139 m to 3153 m.
43	3178	1.08	1.28	15:00	Continued to drill 12 1/4" hole from 3153 m to 3178 m. Lost 20 bar pump pressure.
				15:30	Checked the pressure loss and dropped a survey.
				21:30	Pulled out of the hole and retrieved the survey. Found a washout in the heavy weight drill pipe. Replaced the joints and changed the bottom hole assembly.
				22:30	Changed out the wear bushing.
				24:00	Made up a new bit and ran back in the hole.
44	3200	1.08	1.28	07:00	Continued to run in the hole. Service broke the drill collars.
				07:30	Washed to bottom and worked the junk sub.
				17:00	Drilled 12 1/4" hole from 3178 m to 3200 m. Lost pump pressure.
				21:30	Pulled out of the hole and laid down damaged jar. Cleaned the junk sub.
				24:00	Made up a new bit and ran back in the hole.
45	3217	1.08	1.28	01:00	Ran in the hole to the casing shoe.
				02:00	Slipped and cut the drilling line.
				04:00	Continued to run in the hole.
				04:30	Washed to bottom and worked the junk sub
				10:30	Drilled 12 1/4" hole from 3200 m to 3217 m. Lost torque while drilling.
				14:30	Pulled out of the hole. Found 95 m of the bottom hole assembly missing due to twist of in a drill collar box.
				19:00	Made up an overshot and ran in the hole to the top of the fish at 3124 m.
				19:30	Circulated over the fish and caught the fish.
				24:00	Pulled out of the hole. Laid down damaged drill collars and the overshot.
46	3255	1.08	1.28	00:30	Continued to pull out of the hole with the fish.
				01:30	Pulled the wear bushing, rotated it 90 deg. and ran it back.

((((ooo) ------- Norsk Hydro	Daily report — System : BORE	Date 13/7-1989
	Well: 5514/30-1	
	Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8	
	Setting depth m,MD: 105 | 777 | 1740 | 3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				07:30	Made up a new bit and ran in the hole.
				08:30	Washed from 3217 m to bottom.
				24:00	Drilled 12 1/4" hole from 3217 m to 3255 m.
47	3332	1.08	1.28	24:00	Drilled 12 1/4" hole from 3255 m to 3332 m.
48	3352	1.08	1.28	08:00	Continued to drill 12 1/4" hole from 3332 m to 3352 m.
				09:00	Repaired the mud pumps.
				11:00	Circulated the hole clean.
				11:30	Dropped a survey.
				15:30	Pulled out of the hole and recovered the survey.
				24:00	Rigged up and start logging. No.1:DIL/LSS/GR/SP.
49	3352	1.08	1.28	06:00	Continued logging with the following logs. No.2: LDL/CNL/CAL/GR.
				13:00	No.3: SHDT
				17:00	No.4: CST
				21:00	No.5: CBL/VDL
				24:00	No.6: CST
50	3352	1.08	1.28	01:00	Continued logging. No.6: CST
				01:30	Rigged down the logging equipment.
				04:00	Retrieved the wear bushing, changed the upper pipe rams to 9 5/8", and tested to 265 bar.
				04:30	Made up the 9 5/8" mudline suspension.
				05:00	Rigged up to run the 9 5/8" casing.
				21:00	Ran the 9 5/8" casing to 3310 m, where hole was tight.
				22:00	Made up the circulating head.
				24:00	Circulated and worked the casing free.
51	3352	1.08	1.28	04:00	Circulated the 9 5/8" casing down from 3310 m to 3337 m.
				04:30	Landed the 9 5/8" casing with the shoe at 3339 m.
				06:00	Rigged up and circulated the hole clean prior to cementing.
				12:30	Cemented the 9 5/8" casing with 1.44 RD lead slurry and 1.90 RD tail slurry. Displaced the plug with 122.5 m3 mud. The plug did not bump.
				21:00	Changed the upper pipe rams to 5". Lifted the BOP and set the casing slips. Made a rough cut of the 9 5/8" casing.

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					Removed the well head crossover and made a final cut of the casing. Instaled the "C"-section and tested to 272 bar.
				23:00	Nippled up the BOP.
				24:00	Pressure tested the 9 5/8" casing to 476 bar against shear ram.
52	3352	1.08	1.29	04:00	Tested the BOP stack to 476 bar.
				09:00	Laid down the 12 1/4" bottom hole assembly and the core barrel.
				09:30	Ran the wear bushing.
				20:00	Made up 8 1/2" bottom hole assembly with junk basket and ran in the hole. Tagged the cement at 3267 m.
				24:00	Washed and reamed cement from 3267 m to 3303 m. Drilled the float collar, the cement and the shoe at 3339 m. Cleaned out the rat hole to 3350 m.
53	3380	1.12	1.29	00:30	Continued to clean out the rat hole to 3352 m.
				02:30	Drilled 8 1/2" hole from 3352 m to 3355 m.
				03:30	Circulated the hole clean.
				04:00	Performed a leak off test equivalent to 1.84 SG mud weight.
				10:00	Drilled 8 1/2" hole from 3255 m to 3368 m.
				14:00	Pulled out of the hole to change bit.
				19:30	Made up a new bit and ran back in the hole. Worked the junk basket at bottom.
				24:00	Drilled 8 1/2" hole from 3368 m to 3380 m.
54	3425	1.15	1.29	07:00	Continued to drill 8 1/2" hole from 3380 m to 3398 m.
				09:00	Made a wiper trip to 3690 m and washed back to bottom.
				16:00	Continued to drill 8 1/2" hole from 3398 m to 3425 m. Lost 69 bar pump pressure.
				21:00	Pulled out of the hole and found a wash out in the heavy weight drill pipe.
				24:00	Made up a new bit, laid out the junk sub and ran in the hole.
55	3498	1.22	1.29	02:00	Continued to run in the hole to the casing shoe.
				03:00	Slipped and cut the drilling line.
				03:30	Continued to run in the hole.
				16:30	Drilled 8 1/2" hole from 3425 m to 3498 m.

((((ooo) Norsk Hydro	Daily report — System : BORE	Date 13/7-1989
	Well: 5514/30-1	
	Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8	
	Setting depth m,MD: 105 | 777 | 1740 | 3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
				17:00	Circulated for survey.
				18:30	Ran a survey on slick line. Attempted to retrieve survey. The tool was stuck and the slick line parted.
				19:30	Attempted to recover the survey tool without success.
				21:00	Pulled the drill string into the casing shoe.
				22:00	Attempted to recover the survey tool but the line parted.
				24:00	Pulled the drill string out of the hole.
56	3556	1.29	1.32	03:30	Continued to pull the drill string out of the hole and recovered the survey tool.
				09:00	Ran back into the hole with a new bit.
				24:00	Drilled 8 1/2" hole from 3498 m to 3556 m.
57	3615	1.3	1.32	10:00	Continued to drill 8 1/2" hole from 3556 m to 3601 m.
				11:00	Repaired the mud pump.
				15:30	Continued to drill 8 1/2" hole from 3601 m to 3615 m. Had a loss in pump pressure.
				22:30	Pulled out of the hole and found a washout in the heavy weight drill pipe.
				23:00	Inspected the wear bushing.
				24:00	Laid out the heavy weight drill pipe and the drill collars.
58	3625	1.3	1.32	03:00	Laid down excess drill collars and picked up new drill pipe.
				11:30	Made up a core barrel and ran in the hole while picking up drill pipe to replace the damaged joints.
				13:00	Broke circulation and washed to the bottom. Dropped the ball and recorded the circulating pressures.
				22:30	Cored from 3615 m to 3625 m.
				24:00	Broke off the core with 400 KN overpull, and pulled out of the hole.
59	3625	1.3	1.30	03:00	Continued to pull out of the hole with the core barrel and laid out the core.
				03:30	Laid out the core barrel.
				16:00	Rigged up for logging and ran the following logs. No.1: DIL/LSS/GR/SP No.2: CNL/LDL/CAL/GR No.3: CBL/VDL
				21:30	Ran in the hole for a wiper trip. Washed

((((ooo) ------- Norsk Hydro	Daily report System : BORE Well: 5514/30-1 Casing Size (in): 30 / 20 / 13 3/8 / 9 5/8 Setting depth m,MD: 105 / 777 / 1740 / 3339	Date 13/7-1989 3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					and reamed from 3600 m to 3625 m.
				22:30	Circulated and increased the mud weight to 1.35 r.d.
				24:00	Pulled out of the hole to 3404 m where the hole was tight. Worked the pipe free and reamed from 3404 m to 3405m. Continued to pull out of the hole.
60	3425	1.3		00:30	Continued to pull out of the hole to the casing shoe.
				02:00	Ran back to bottom. Washed and reamed from 3454 m to 3625 m.
				03:30	Pumped a high viscous pill and circulated the hole clean.
				08:00	Pulled out of the hole.
				17:30	Rigged up for logging and ran the following logs. No.4: SHDT No.5: VSP Checkshot survey. Rigged down the logging equipment.
				22:00	Picked up the 3 1/2" drill pipe stinger and ran in the hole to 3625 m.
				24:00	Set a balanced cement plug from 3625 m to 3425 m.
61	1485	1.3		01:00	Rigged up and reverse circulated at 3425 m.
				02:00	Set a balanced cement plug from 3425 m to 3289 m.
				03:30	Pulled back to 3289 m and reverse circulated.
				09:00	Pulled out of the hole and laid down excess drill pipe.
				12:00	Rigged up Schlumberger and ran gauge ring and junk basket to 3259 m. Ran and set a bridge plug at 3259 m. Tested the bridge plug to 160 bar.
				15:30	Ran in the hole with a 4" perforation gun and perforated the 9 5/8" casing at 1640 m with 8 shots.
				17:00	Ran in the hole with the drill pipe to 1740 m.
				18:00	Established injection rate at 139 bar.
				19:00	Set a balanced cement plug from 1740 m to 1485 m.
				20:30	Pulled back to 1450 m and attempted to squeeze cement into the perforations with 276 bar without sucsess. Circulated above the cement plug and made a second attempt to squeeze with 276 bar without success.
				24:00	Pulled out of the hole and laid down

((((ooo) Norsk Hydro	Daily report System : BORE Well: 5514/30-1	Date 13/7-1989
	Casing Size (in): 30 | 20 | 13 3/8 | 9 5/8 Setting depth m,MD: 105 | 777 | 1740 | 3339	3

Report number	Mid. depth m,MD	Est.Pore Pressure (SG)	Mud Dens. (SG)	Stop time	Short Summary
					excess drill pipe.
62	135	1.3		00:30	Continued to pull out of the hole and laid down the drill pipe.
				01:00	Pulled the wear bushing.
				02:30	Made up 9 5/8" casing cutter, ran in the hole and cut the casing at 240 m. Pulled out of the hole.
				08:00	Nippled down the BOP and the C-section wellhead.
				11:30	Pulled the 9 5/8" casing.
				14:00	Made up the 13 3/8" casing cutter, ran in the hole and cut the casing at 238.5 m. Pulled out of the hole.
				19:00	Pulled the 13 3/8" casing.
				20:00	Ran in the hole to 840 m and rigged up to cement.
				24:00	Set balanced cement plugs inside the 9 5/8" casing from 840 m to 540 m and from 540 m to 240 m. Set a balanced cement plug inside the 20" casing from 240 m to 135 m.
63	135	1.3		01:00	Pulled back to 100 m and circulated to clean the pipe.
				01:30	Cut and laid down the 20" wellhead.
				04:00	Made up 20" casing cutter, ran in the hole and cut the 20" casing at 85 m. Pulled out of the hole and laid down the cutter assembly.
				04:30	Made up the slings and attempted to pull the 20" casing without success.
				05:30	Made up the 20" casing spear and ran in the hole. Attempted to pull the 20" casing without success.
				06:00	Backed out the 20" casing in the mud line suspension hanger. Pulled out of the hole and laid down the 20" casing spear.
				07:30	Pulled and laid down the 20" casing.
				12:30	Made up the 30" casing cutter, ran in the hole and cut the 30" casing at 85 m.
				18:00	Pulled out of the hole with the cutter assembly. Rigged down the tension plate, pulled and laid down the 30" conductor.
				22:00	Laid down the drill collars and excess drill pipe from the derrick.
				24:00	Prepared to skid the rig. The rig was released to Global Marine/ Amoco at 24:00 Hrs.

3.3 Time distribution

The total time used to drill and permanent plug and abandon the well was 1512 hours. The time distribution is shown in Table B-1 and fig B-1.

The operation can be splitted into the following main groups:

-	skidding and preparation	1.1 days
-	Drilling the well to total depth	47.8 days
-	Plugging back	3.2 days
-	Formation evaluation	4.7 days
-	Lost time	6.2 days

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Table B-1

((((ooo) ------- Norsk Hydro	**T i m e d i s t r i b u t i o n** System : BORE Well : 5514/30-1 Depth: 3625 m,MD Rig: GLOMAR MORAY FIRTH 1 All phases	Date 6/7-1989 7

Operations	Hrs	%	Hrs	%	Subtotal
Rig moving					
Skidding	29.5	1.95			
Sum			29.50	1.95	29.50
Drilling					
Drilling	600.5	39.72			
Underreaming	18.0	1.19			
Opening hole	29.0	1.92			
Tripping	243.0	16.07			
Circ. and cond. hole and mud	10.0	0.66			
Formation leak off test	5.5	0.36			
Surveying	10.0	0.66			
Wellhead/BOP handling	7.0	0.46			
BOP testing/activities	65.0	4.30			
Running casing	124.8	8.25			
Primary cementing	26.8	1.77			
Slip and cut drilling line	3.0	0.20			
Other	1.0	0.07			
Sum			1143.50	75.63	1173.00
Formation evaluation					
Tripping	3.5	0.23			
Circ and cond mud/hole	4.0	0.26			
Circulating for samples	2.0	0.13			
Coring	23.0	1.52			
Logging	80.5	5.32			
Sum			113.00	7.47	1286.00
Plug and abandonment					
Tripping	15.5	1.03			
Circ and cond mud/hole	3.5	0.23			
Perforating	3.5	0.23			
Cement plug	9.0	0.60			
Mechanical plug	3.0	0.20			
Squeezing	2.5	0.17			
Cutting	21.0	1.39			
Equipment recovery	18.5	1.22			
Sum			76.50	5.06	1362.50
Downtime					
Reaming	31.0	2.05			
Wiper trip	16.5	1.09			
Fishing> due to hole equipment	35.5	2.35			
Wellhead/BOP equipment repair	2.0	0.13			
Drilling equipment repair	56.5	3.74			
Other	8.0	0.53			
Sum			149.50	9.89	1512.00
Reported time (100.00 % of well total 1512.00 hours) :					1512.00

((((ooo) ------- Norsk Hydro	**T i m e d i s t r i b u t i o n** System : BORE	Date 6/7-1989
	Well : 5514/30-1 Depth: 3625 m,MD	
	Rig: GLOMAR MORAY FIRTH 1	
	Phase : Mobilization	7

Operations	Hrs	%	Hrs	%	Subtotal
Rig moving....................					
Skidding :	27.51	00.00			
Sum			27.50	100.00	27.50
Reported time (1.82 % of well total 1512.00 hours) :					27.50

((((ooo) ------- Norsk HYDRO	Time distribution System : BORE Well : 5514/30-1 Depth: 3625 m,MD Rig: GLOMAR MORAY FIRTH 1 PHASE : DRIVING OF 30" CONDUCTOR.	Date 6/7-1989 7

Operations		Hrs	%	Hrs	%	Subtotal
Drilling......................						
Opening hole	:	3.5	5.30			
Tripping	:	17.0	25.76			
Running casing	:	37.5	56.82			
Sum				58.00	87.88	58.00
Downtime.....................						
Reaming	:	1.5	2.27			
Drilling equipment repair	:	6.5	9.85			
Sum				8.00	12.12	66.00

Reported time (4.37 % of well total 1512.00 hours) : 66.00

((((ooo) ------- Norsk Hydro	**Time distribution** System : BORE Well : 5514/30-1 Depth: 3625 m,MD Rig: GLOMAR MORAY FIRTH 1 Phase : Drilling of 26 " hole	Date 6/7-1989 7

Operations	Hrs	%	Hrs	%	Subtotal
Drilling					
Drilling	26.5	14.44			
Underreaming	18.0	9.81			
Opening hole	25.5	13.90			
Tripping	30.0	16.35			
Circ. and cond. hole and mud	3.5	1.91			
Wellhead/BOP handling	1.5	0.82			
BOP testing/activities	15.5	8.45			
Running casing	20.0	10.90			
Primary cementing	15.0	8.17			
Sum			155.50	84.74	155.50
Downtime					
Reaming	12.0	6.54			
Wiper trip	2.0	1.09			
Wellhead/BOP equipment repair	2.0	1.09			
Drilling equipment repair	5.0	2.72			
Other	7.0	3.81			
Sum			28.00	15.26	183.50
Reported time (12.14 % of well total 1512.00 hours) :					183.50

((((ooo) ------- Norsk Hydro	**T i m e d i s t r i b u t i o n** System : BORE Well : 5514/30-1 Depth: 3625 m,MD Rig: GLOMAR MORAY FIRTH 1 Phase : Drilling of 17 1/2" hole	Date 6/7-1989 7

Operations		Hrs	%	Hrs	%	Subtotal
Drilling......................						
Drilling	:	98.0	38.66			
Tripping	:	49.0	19.33			
Circ. and cond. hole and mud	:	4.5	1.78			
Formation leak off test	:	2.0	0.79			
Wellhead/BOP handling	:	0.5	0.20			
BOP testing/activities	:	24.0	9.47			
Running casing	:	31.3	12.33			
Primary cementing	:	5.3	2.07			
Slip and cut drilling line	:	1.0	0.39			
Sum				215.50	85.01	215.50
Formation evaluation..........						
Tripping	:	2.0	0.79			
Circulating for samples	:	2.0	0.79			
Logging	:	24.5	9.66			
Sum				28.50	11.24	244.00
Downtime......................						
Reaming	:	4.0	1.58			
Drilling equipment repair	:	5.5	2.17			
Sum				9.50	3.75	253.50
Reported time (16.77 % of well total 1512.00 hours) :						253.50

((((ooo) ------- Norsk Hydro	Time distribution	Date 6/7-1989
	System : BORE	
	Well : 5514/30-1 Depth: 3625 m,MD	
	Rig: GLOMAR MORAY FIRTH 1	
	Phase : Drilling of 12 1/4" hole	7

Operations		Hrs	%	Hrs	%	Subtotal
Drilling......................						
Drilling	:	407.0	57.89			
Tripping	:	123.0	17.50			
Circ. and cond. hole and mud	:	2.0	0.28			
Formation leak off test	:	2.0	0.28			
Surveying	:	9.5	1.35			
Wellhead/BOP handling	:	4.5	0.64			
BOP testing/activities	:	25.5	3.63			
Running casing	:	31.5	4.48			
Primary cementing	:	6.5	0.92			
Slip and cut drilling line	:	1.0	0.14			
Other	:	1.0	0.14			
Sum				613.50	87.27	613.50
Formation evaluation..........						
Logging	:	34.0	4.84			
Sum				34.00	4.84	647.50
Downtime......................						
Reaming	:	12.0	1.71			
Wiper trip	:	1.5	0.21			
Fishing> due to hole equipment	:	21.0	2.99			
Drilling equipment repair	:	20.0	2.84			
Other	:	1.0	0.14			
Sum				55.50	7.89	703.00
Reported time (46.49 % of well total 1512.00 hours) :						703.00

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Norsk
Hydro

T i m e   d i s t r i b u t i o n

System : BORE

Well : 5514/30-1   Depth: 3625 m,MD
Rig: GLOMAR MORAY FIRTH 1
Phase : Drilling of 8 1/2" hole

Date
6/7-1989

7

Operations	Hrs	%	Hrs	%	Subtotal
Drilling					
Drilling	69.0	34.50			
Tripping	24.0	12.00			
Formation leak off test	1.5	0.75			
Surveying	0.5	0.25			
Wellhead/BOP handling	0.5	0.25			
Running casing	4.5	2.25			
Slip and cut drilling line	1.0	0.50			
Sum			101.00	50.50	101.00
Formation evaluation					
Tripping	1.5	0.75			
Circ and cond mud/hole	4.0	2.00			
Coring	23.0	11.50			
Logging	22.0	11.00			
Sum			50.50	25.25	151.50
Downtime					
Reaming	1.5	0.75			
Wiper trip	13.0	6.50			
Fishing> due to hole equipment	14.5	7.25			
Drilling equipment repair	19.5	9.75			
Sum			48.50	24.25	200.00
Reported time (13.23 % of well total 1512.00 hours) :					200.00

((((ooo) Norsk HYDRO	Time distribution	Date 6/7-1989
	System : BORE	
	Well : 5514/30-1 Depth: 3625 m,MD	
	Rig: GLOMAR MORAY FIRTH 1	7
	PHASE : PLUG & ABANDON	

Operations		Hrs	%	Hrs	%	Subtotal
Rig moving....................						
Skidding	:	2.0	2.55			
Sum				2.00	2.55	2.00
Plug and abandonment..........						
Tripping	:	15.5	19.75			
Circ and cond mud/hole	:	3.5	4.46			
Perforating	:	3.5	4.46			
Cement plug	:	9.0	11.46			
Mechanical plug	:	3.0	3.82			
Squeezing	:	2.5	3.18			
Cutting	:	21.0	26.75			
Equipment recovery	:	18.5	23.57			
Sum				76.50	97.45	78.50
Reported time (5.19 % of well total 1512.00 hours) :						78.50

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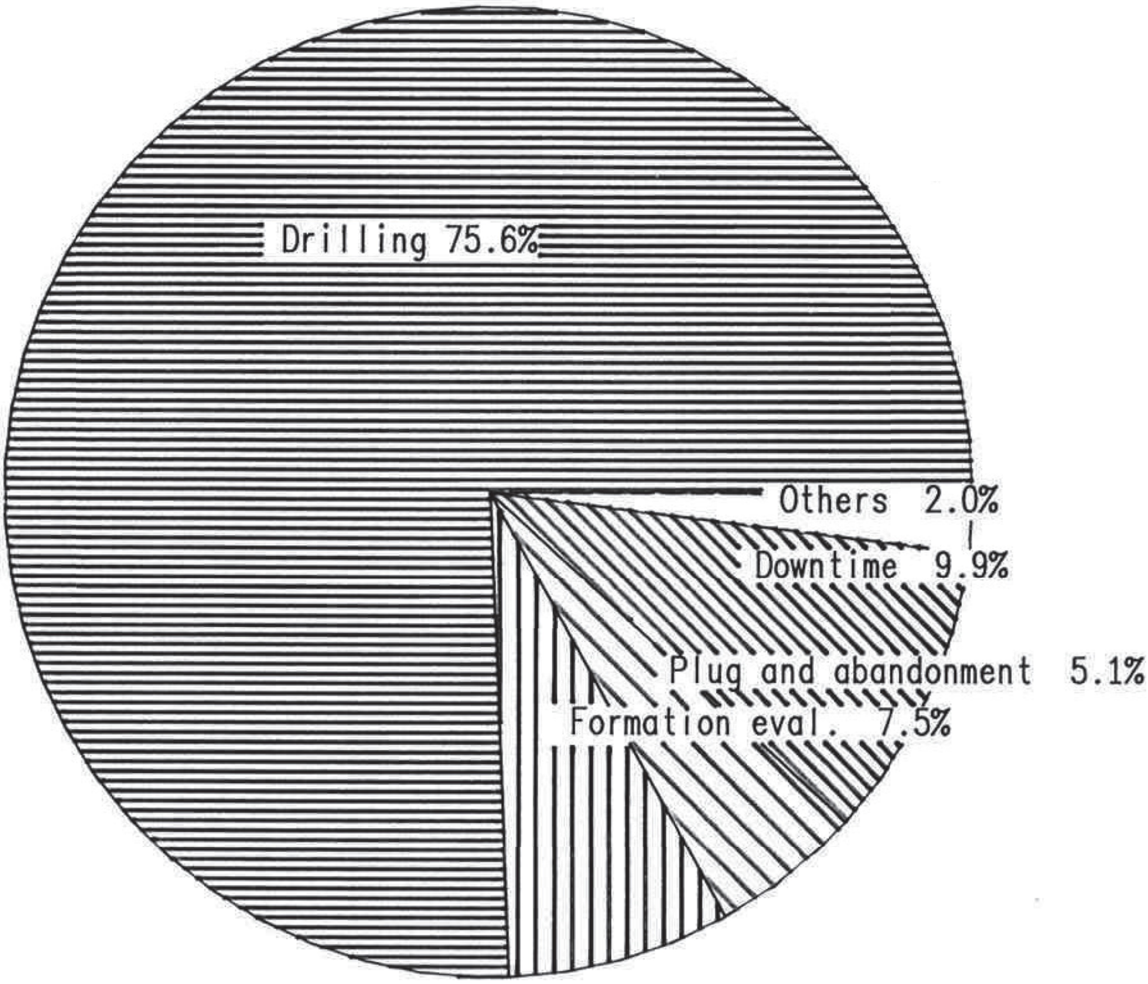


TIME REPORTED (HRS): 1512 OF TOTAL 1512

Others:

SKIDDING : 2.0 %

Norsk Hydro Drilling Department Date:19890706	TIME DISTRIBUTION		Fig.: B-1
	WELL: 5514/30-1		

NORSK HYDRO

Table B-2

((((ooo) ------- Norsk Hydro	H o l e d e v i a t i o n System : BORE Well: 5514/30-1. Depths, m: RKB 36. Water 44. Assumed vert. 80 Proposed direction (deg): 0 (referensed to grid north) Coordinates are measured from the Wellhead-centre.	Date 9/6-1989 12

Meas. Depth (m)	Incli- nation (deg)	Direc tion (deg)	Tool Type	Vert. Depth (m)	Coordinates North (m)	East (m)	Depar- ture (m)	Dogleg d/30m	Build d/30m	Turn d/30m
129.0	0.40	115.80	MWD	129.0	-0.07	0.15	0.2	0.24	0.24	*
148.0	0.30	143.90	MWD	148.0	-0.14	0.24	0.3	0.31	-0.16	44.37
230.0	0.60	113.70	MWD	230.0	-0.49	0.76	0.9	0.14	0.11	-11.05
286.0	0.70	93.60	MWD	286.0	-0.63	1.37	1.5	0.13	0.05	-10.77
342.0	0.80	88.40	MWD	342.0	-0.64	2.10	2.2	0.06	0.05	-2.79
399.0	0.50	130.20	MWD	399.0	-0.79	2.69	2.8	0.29	-0.16	22.00
455.0	0.50	186.10	MWD	455.0	-1.19	2.85	3.1	0.25	0.00	29.95
511.0	0.50	196.00	MWD	511.0	-1.67	2.76	3.2	0.05	0.00	5.30
568.0	0.60	173.10	MWD	568.0	-2.20	2.73	3.5	0.13	0.05	-12.05
625.0	0.40	141.50	MWD	625.0	-2.65	2.89	3.9	0.18	-0.11	-16.63
682.0	0.70	165.40	MWD	682.0	-3.15	3.10	4.4	0.20	0.16	12.58
739.0	1.10	178.00	MWD	739.0	-4.03	3.21	5.2	0.23	0.21	6.63
780.0	0.50	162.50	MWD	780.0	-4.60	3.27	5.6	0.46	-0.44	-11.34
842.0	0.60	194.90	MWD	842.0	-5.17	3.27	6.1	0.16	0.05	15.68
900.0	0.30	193.50	MWD	900.0	-5.61	3.16	6.4	0.16	-0.16	-0.72
956.0	0.70	116.10	MWD	956.0	-5.90	3.43	6.8	0.37	0.21	-41.46
1011.0	0.70	12.40	MWD	1011.0	-5.72	3.80	6.9	0.60	0.00	*
1068.0	1.10	32.10	MWD	1067.9	-4.92	4.17	6.4	0.26	0.21	10.37
1125.0	1.30	38.80	MWD	1124.9	-3.95	4.87	6.3	0.13	0.11	3.53
1183.0	1.20	45.20	MWD	1182.9	-3.01	5.71	6.5	0.09	-0.05	3.31
1239.0	1.40	55.70	MWD	1238.9	-2.21	6.69	7.0	0.17	0.11	5.63
1256.0	1.60	47.90	MWD	1255.9	-1.93	7.04	7.3	0.50	0.35	-13.76
1324.0	1.40	42.00	MWD	1323.9	-0.68	8.30	8.3	0.11	-0.09	-2.60
1353.0	1.20	54.60	MWD	1352.9	-0.24	8.78	8.8	0.36	-0.21	13.03
1410.0	1.20	64.80	MWD	1409.9	0.36	9.81	9.8	0.11	0.00	5.37
1465.0	1.20	69.20	MWD	1464.8	0.81	10.87	10.9	0.05	0.00	2.40
1521.0	0.60	44.80	MWD	1520.8	1.22	11.62	11.7	0.37	-0.32	-13.07
1576.0	0.80	42.70	MWD	1575.8	1.71	12.09	12.2	0.11	0.11	-1.15
1635.0	0.30	85.60	MWD	1634.8	2.03	12.52	12.7	0.31	-0.25	21.81
1692.0	0.40	57.00	MWD	1691.8	2.15	12.84	13.0	0.10	0.05	-15.05
1703.0	0.40	11.00	MWD	1702.8	2.20	12.87	13.1	0.85	0.00	*
1802.0	1.50	1.00	SING	1801.8	3.84	12.96	13.5	0.34	0.33	-3.03
2225.0	1.00	330.00	SING	2224.7	12.57	11.21	16.8	0.06	-0.04	-2.20
2476.0	2.00	350.00	SING	2475.6	18.78	9.36	21.0	0.13	0.12	2.39
2575.0	1.25	3.00	SING	2574.6	21.56	9.12	23.4	0.25	-0.23	3.94
2731.0	1.00	275.00	SING	2730.6	23.38	7.85	24.7	0.30	-0.05	-16.92
2851.0	3.25	26.00	SING	2850.5	26.53	8.30	27.8	0.93	0.56	27.75
2944.0	3.00	22.00	SING	2943.4	31.16	10.36	32.8	0.11	-0.08	-1.29
3032.0	2.00	15.00	SING	3031.3	34.77	11.62	36.7	0.36	-0.34	-2.39
3139.0	2.25	75.00	SING	3138.2	37.12	14.14	39.7	0.60	0.07	16.82
3178.0	3.00	86.00	SING	3177.2	37.39	15.89	40.6	0.69	0.58	8.46
3352.0	6.00	85.00	SING	3350.6	38.50	29.50	48.5	0.52	0.52	-0.17

4. PERMANENT ABANDONMENT OF WELL 5514/30-1

The permanent abandonment is shown in figure B-2 and was carried out in the following way:

1. A cement plug was set in open hole from 3625 m to 3425 m.

2. A balanced cement plug was set across the 9 5/8" casing shoe from 3289 m to 3425 m.

3. A bridgeplug was set inside the 9 5/8" casing at 3259 m and tested to 160 bar.

4. The 9 5/8" casing was perforated at 1640 m. A balanced cement plug were set inside the 9 5/8" casing from 1740 m to 1485 m. A negative attempt was made to squeeze cement into the 9 5/8" x 13 3/8" annulus.

5. A cement plug was set inside 9 5/8" from 840 m to 240 m.

6. The 9 5/8" casing was mechanically cut at 240 m and retrieved.

7. The 13 3/8" casing was cut at 238.5 m and retrieved.

8. A top cement plug was set inside the 20" casing from 240 m to 135 m.

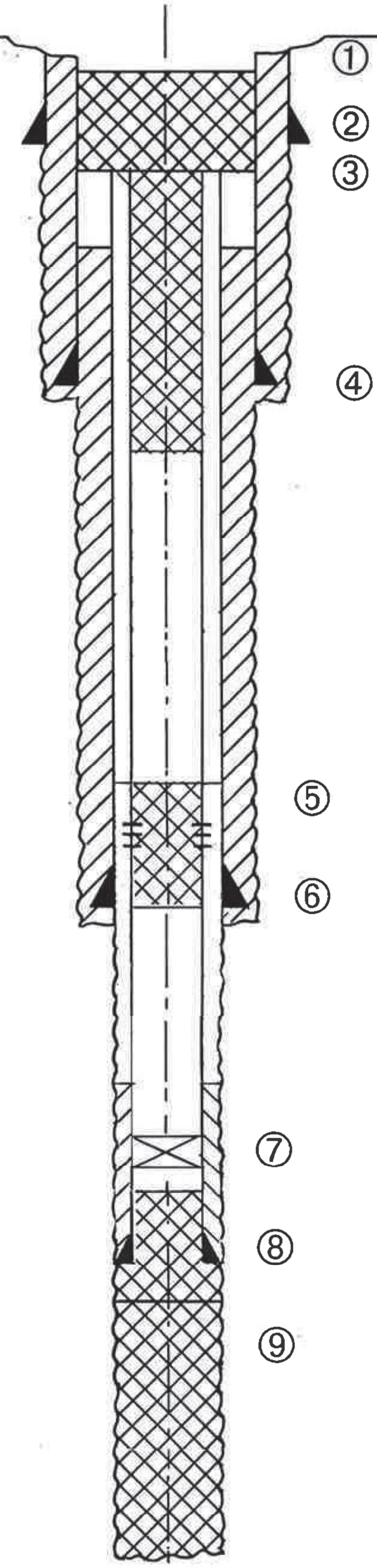
9. The 20" casing was cut at 85 m and attempted to be retrieved without success. The casing was then unscrewed in the mudline suspension system and retrieved.

10. The 30" casings were cut at 85 m and retrieved together with the last part of the 20" casing.

All depths refers to RKB

Well status prior to abandonment

Seabed at 80 m.



30" conductor at 105 m.

13 3/8" casing cemented back to 512 m

20" casing at 777 m

13 3/8" casing at 1740 m

9 5/8" casing cemented back to 3150 m

9 5/8" casing at 3339 m

Total depth at 3625 m

1. 30" and 20" casing cut at 85 m.
2. Top cement plug inside 20" casing from 135 m to 240 m.
3. 9 5/8" casing cut at 240 m and 13 3/8" casing cut at 238.5 m
4. Cement plugs from 840 m to 240 m
5. Perforation at 1640 m
6. Cement plug inside 9 5/8" casing from 1740 m to 1485 m.
7. Bridge plug at 3259 m.
8. Cement plug acros 9 5/8" casing shoe from 3289 m to 3425 m.
9. Cement plug in open hole from 3625 m to 3425 m.

HYDRO Drilling Department	Permanent Abandonment Well 5514/30-1	Gr. no.:	Fig.: B-2
		Date: Sign: BEn	Dwg. no.:

5. PORE PRESSURE, FORMATION INTEGRITY, OVERBURDEN AND FORMATION TEMPERATURE

5.1 Pore pressure

The final pore pressure profile that has been established for well 5514/30-1 is based on the sonic log, the Dc-exponent, flowline temperatures, drilling parameters and the hole condition.

The final profile is shown in fig. B-3.

All depths are in m TVD with reference to RKB.

The following is a description of the pore pressure development:

Both the sonic log and the Dxc are indicating a build up from normal pressure gradient (ie 1.03 rd) at 1820 m to a gradient of 1.09 rd. The pore pressure gradient seems to stay at this magnitude down to 2000 m for then to be normal in the sandstone below.

Further down the sonic log indicates another increase of the pressure gradient to 1.06 rd at 2600 m. The gradient staying at this level down to 3130 m is supported by the Dxc and flowline temperatures.

A more rapidly pore pressure increase for 3130 m to a max. gradient of 1.30 rd at TD (3624.5 m) is indicated by the sonic log, the Dxc and flowline temperatures. The situation being close to balance in the deepest part of the well is also supported by increasing ROP and the hole condition observed with fill/tight hole and splintered shale when not circulating.

5.2 Formation integrity

A total of three Leak Off Tests (LOT) were performed with the following results:

Csg (in)	Csg.shoe (m)	Open hole (m)	Form.int. (rd)	Test	Formation
20"	777	791	1.82	LOT	Lst/Chk
13 3/8"	1740	1757	2.0	LOT	Clyst w/Sst
9 5/8"	3339	3355	1.84	LOT	Clyst

5.3 Overburden gradient

The overburden gradient for well 5514/30-1 has been calculated from the Litho Density Log (LDL) ran in the interval from 800 to 3600 m. In the chalk/limestone above 800 m an average bulk density of 2.25 g/a was assumed. Due to this some uncertainty is related to the magnitude of the overburden gradient.

5.4 Formation temperature

The final temperature profile is based on temperature measurements recorded during electric logging which have been converted to Bottom Hole Static Temperatures (BHST) by using the Horner plot method. A temperature of 5°C at sea bottom has also been assumed.

The final profile is shown in fig. B-4.

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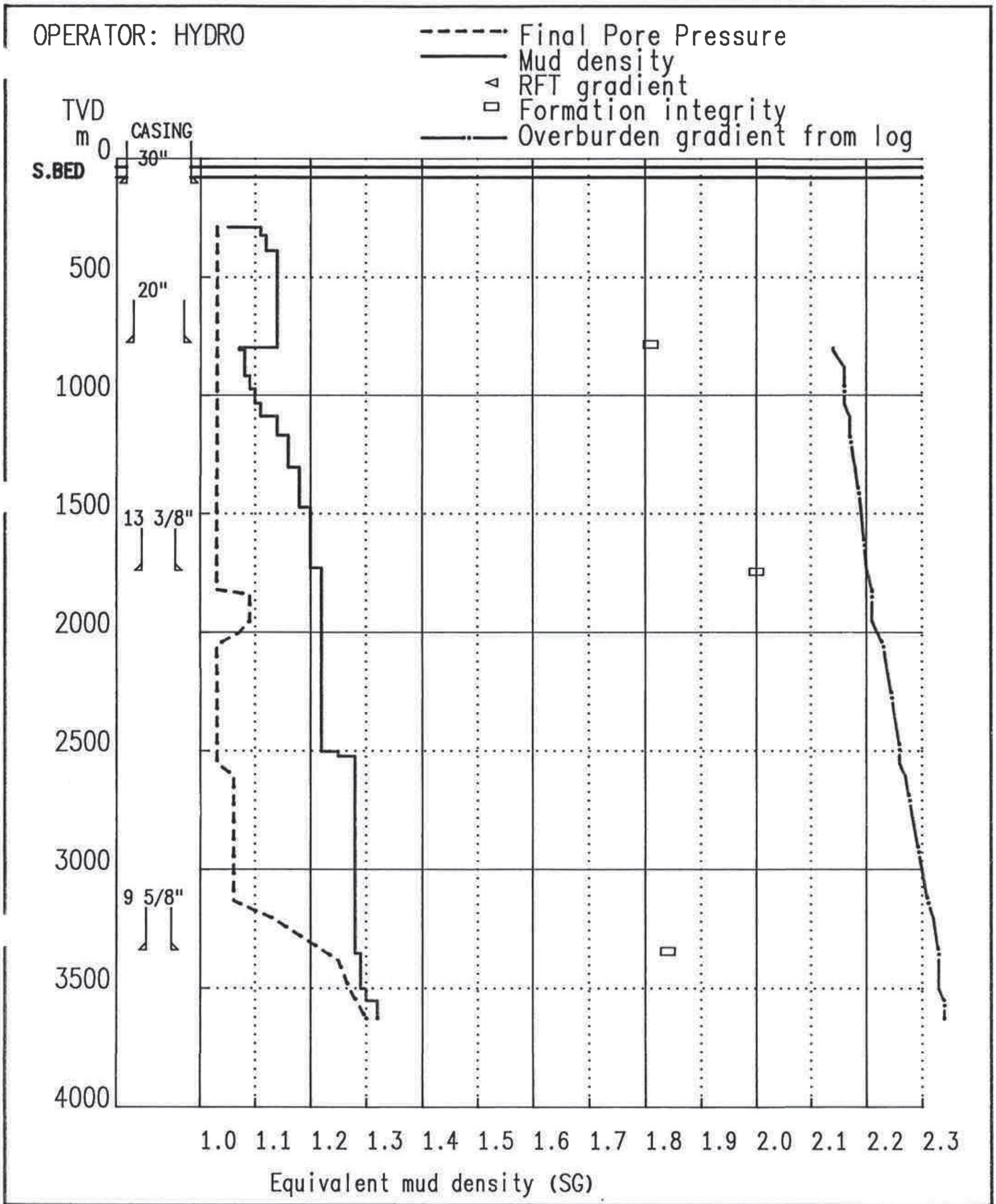
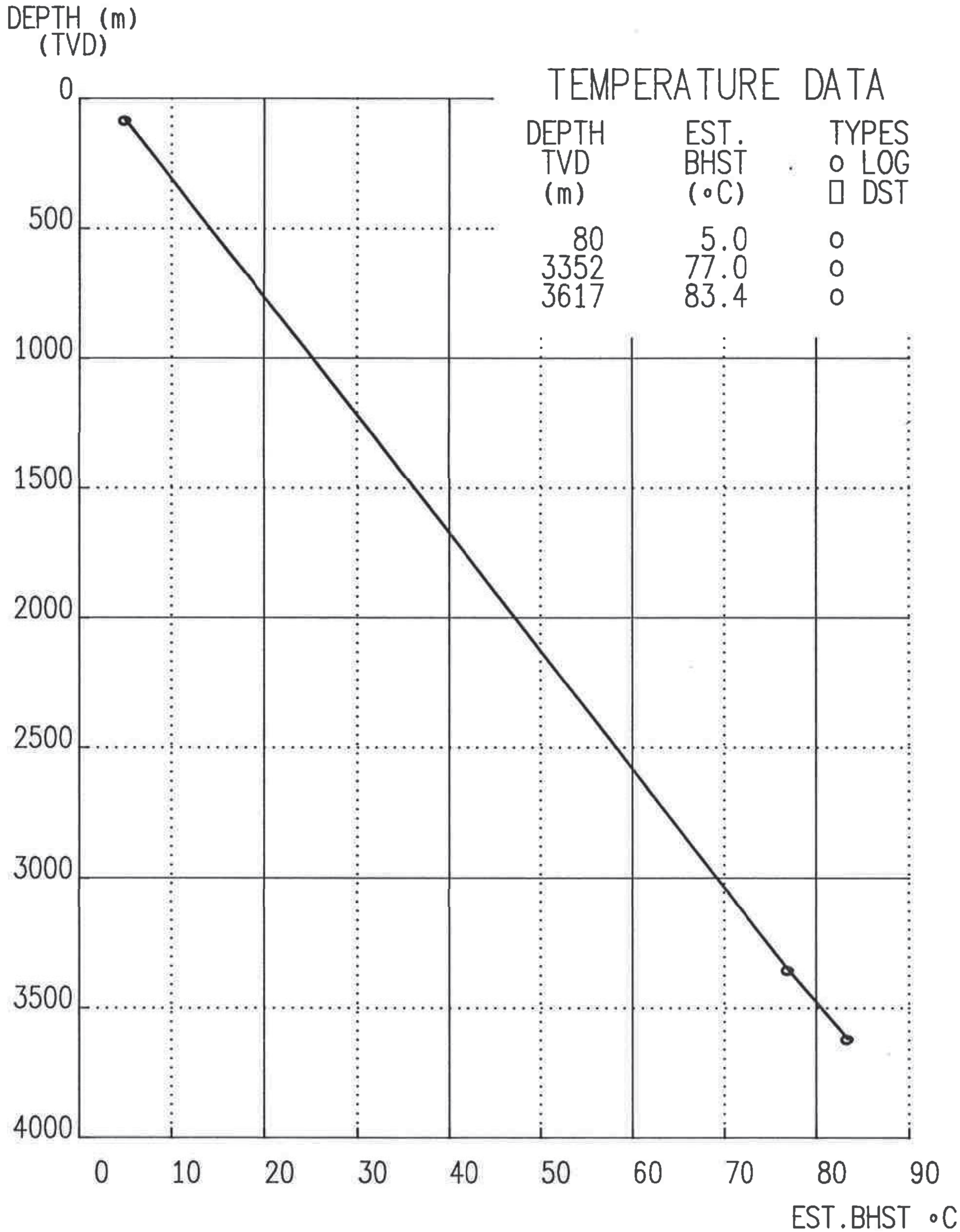


Norsk Hydro Drilling Department Date:19890714	FINAL PORE PRESSURE MUD DENSITY, RFT AND OVERBURDEN GRAD. FORMATION INTEGRITY. WELL: 5514/30-1		Fig.: B-3

NORSK HYDRO



Norsk Hydro
Drilling Department

Date:19890808

TEMPERATURE
PROFILE
WELL: 5514/30-1

Fig.:
B-4

Table B-3

((((ooo) Norsk Hydro	Pore pressure System : BORE Well: 5514/30-1 Seabed at : 80 m RKB Total depth: 3625 m,MD,RKB	Date 13/7-1989 9

Vertical Depth (m)	Pore Pressure from SonicLog (SG)	Pore Pressure from DC-exp. (SG)	RFT/FMT (SG)	Most probable Pore Pressure (SG)	Actual mud Density used (SG)
80	1.03	1.03		1.03	1.05
285	1.03	1.03		1.03	1.11
320	1.03	1.03		1.03	1.12
385	1.03	1.03		1.03	1.14
777	1.03	1.03		1.03	1.14
795	1.03	1.03		1.03	1.07
805	1.03	1.03		1.03	1.08
875	1.03	1.03		1.03	1.08
915	1.03	1.03		1.03	1.09
970	1.03	1.03		1.03	1.10
1030	1.03	1.03		1.03	1.11
1085	1.03	1.03		1.03	1.14
1165	1.03	1.03		1.03	1.16
1300	1.03	1.03		1.03	1.18
1470	1.03	1.03		1.03	1.20
1725	1.03	1.03		1.03	1.22
1820	1.03	1.03		1.03	1.22
1840	1.09	1.09		1.09	1.22
1950	1.08	1.09		1.09	1.22
2000	1.07			1.07	1.22
2050	1.03			1.03	1.22
2476	1.03			1.03	1.22
2500	1.03			1.03	1.25
2520	1.03			1.03	1.28
2550	1.03			1.03	1.28
2600	1.08			1.06	1.28
3129	1.07			1.06	1.28
3199	1.13			1.13	1.28
3349				1.23	1.29
3378	1.25			1.25	1.29
3498	1.27			1.27	1.30
3548					1.32
3622	1.30			1.30	1.32

Table E-4

		Date
((((ooo) Norsk Hydro	**F o r m a t i o n i n t e g r i t y** System : BORE	13/7-1989
	Well: 5514/30-1	
	Seabed at : 80 m RKB	10
	Total depth: 3625 m,MD,RKB	

Casing Shoe Depth (m,MD)	Open Hole Depth (m,MD)	Form Int Strenght (SG)
777	777	1.81
1740	1757	2.00
3339	3339	1.84

6. MATERIALS REPORT

1. Main consumption casing and wellhead

2. Main consumption cement and additives

3. Cement report

4. Bit record

5. Bottom hole assembly

6. Mud report

0022q
sn,BEn/agi

Table B-5

((((ooo) Norsk Hydro	Main consumptions System : BORE Well: 5514/30-1 Wellhead: Data from table 8.	Date 30/6-1989 6

CASING

Size (in)	Grade	Weight (kg/m)	Threads Type	Length (m)
30	X-52	309.00	RL-4	105
20	X-56	195.60	LS	777
13 3/8	N-80	105.20	BUTTRES	1576
13 3/8	P-110	101.90	BUTTRES	164
9 5/8	P-110	79.60	NK 3SB	642
9 5/8	P-110	68.70	NK 3SB	2703

Table B-6

((((ooo) Norsk Hydro	Main consumptions System : BORE Well: 5514/30-1 Cement contractor: HALLIBURTON Data from table 9.	Date 30/6-1989 6

Casing size (in)	Additive name	Total used (1)
20		
Spacer	SEAWATER	8000
Lead-	Cement	28254
	Seawater	101798
	ECONOLITE	3560
Tail-	Cement	4762
	Seawater	7001
	CACL2	668
Flush		
13 3/8		
Spacer	SEAWATER	7000
Lead-	Cement	24127
	Seawater	52288
	ECONOLITE	760
	HR-4L-DK	1520
Tail-	Cement	8889
	Seawater	12880
	HR-4L-DK	210
Flush		
9 5/8		
Spacer		
Lead-	Cement	21587
	Seawater	86999
	HDP 100 A	1374
	FDP 365	367
	CFR 3L	680
Tail-	Cement	4444
	Seawater	5800
	HDP 100 A	700
	CFR-3L	379
Flush		

Table B-7

((((ooo) Norsk Hydro	Cement reports System : BORE Well: 5514/30-1 Cement contractor: HALLIBURTON Data from table 9.	Date 30/6-1989 11

Casing Size (in)	Slurry Volume (m3)	Slurry Density (SG)	Thickening Time (hrs)	BHST (deg.C)	Cement/ Additive name	Compo- sition (1/100kg)	Total used (1)
Lead-20	126.0	1.44	6.00	33	Cement		28254
					Seawater	114.38	101798
					ECONOLITE	4.00	3560
Tail-20	11.0	1.90	3.00	33	Cement		4762
					Seawater	46.67	7001
					CACL2	4.45	668
Lead-13 3/8	78.0	1.68	3.60	56	Cement		24127
					Seawater	68.80	52288
					ECONOLITE	1.00	760
					HR-4L-DK	2.00	1520
Tail-13 3/8	22.0	1.89	3.75	56	Cement		8889
					Seawater	46.00	12880
					HR-4L-DK	0.75	210
Lead- 9 5/8	109.0	1.44	6.33	73	Cement		21587
					Seawater	127.94	86999
					HDP 100 A	2.02	1374
					FDP 365	0.54	367
					CFR 3L	1.00	680
Tail- 9 5/8	11.0	1.90	5.00	73	Cement		4444
					Seawater	41.43	5800
					HDP 100 A	5.00	700
					CFR-3L	2.71	379

(((
(ooo)
Norsk Hydro

C e m e n t   r e p o r t s

System : BORE

Date 5/7-1989

Well: 5514/30-1
Cement contractor: HALLIBURTON
Data from table 16

11

Type of Job	Depth Bot. m,MD	Slurry Volume (m3)	Slurry Density (SG)	Compress. Strenght (Bar/hrs)	Thickening Time (hrs)	Cement/ Additive name	Compo-sition 1/100kg	Total used (1)
PLUG	3625	8.40	1.90		3.40	Cement Seawater HR-4L-DK	 44.70 1.70	3429 4828 184
PLUG	3425	8.60	1.90		3.40	Cement Seawater HR-4L-DK	 43.96 1.97	3524 4880 219
PLUG	1740	9.70	1.90		3.00	Cement Seawater	 43.32	3968 5415
PLUG	840	12.00	1.90		4.00	Cement Seawater	 40.72	5302 6800

((((ooo) Norsk Hydro	Bit record	Date 6/7-1989	Date 6/7-1989
	System : BORE		
	Well: 5514/30-1		
	Data from table 4.		5

BIT NUMBER	Size (in)	Manu fact urer	Trade Name	Serial number	IADC Code	Nozzles diameter (../32")				BHA no.	Depth out m,MD	Bit meter (m)	Drill time (hrs)	Rot. hours (hrs)	ROP (m/h)	Rotation min/max (rpm)	Total bit revol.	Weight min/max (KN)	Flow min/max (m3/h)	Wear T	B	G	Other	Remarks
1 P	17 1/2	SMIT	SDGH	XH8170	135	28	28	28	16	1	105	25	3.00	3.00	8.3	70/70		182/182	272/272	3	4	0		
2 HO	26	SECU	CUSTOM			14	14	14		1	105	25	3.00	3.00	8.3	70/70		182/182	272/272	1	1	20		
3	17 1/2	SMIT	SVH	XE4411	215	24	24	24	16	2	787	682	26.50	16.40	41.6	20/175	132798	45/317	264/264	2	7	0		
1PRR1	17 1/2	SMIT	SDGH	XH8170	135	28	28	28	16	3	788	683	25.50	21.00	32.5	100/150		45/317	278/278					
4 HO	24	SECU	B24	A1410		40	40	40		3	787	682	25.50	21.00	32.5	100/150	163800	45/317	278/278	2	6	0		
1PRR2	17 1/2	SMIT	SDGH	XH8170	135	22	22	22	16	4	788	683												
5 UR	26	SMIT	SER.17000	1036		16	16	16		4	783	678	18.00	10.20	66.5	80/100	52754	0/5	20/20					
6	17 1/2	SMIT	SVH	XH1907	215	24	24	24	16	5	1263	501	32.90	25.20	19.9	50/130	193771	250/500	2/4.1	7	4	4		
7	17 1/2	SECU	M44NG4	410581	215	24	24	24	16	5	1508	245	22.50	19.00	12.9	130/170	160579	100/300	2/4.1	7	2	0		
8	17 1/2	HUGH	X22K	8541	515	24	24	24		5	1715	207	25.50	23.20	8.9	150/150	187529	88/363	/234	8	8			
9	17 1/2	SMIT	2JS	XD 0752	515	20	16	16		6	1754	39	17.50	16.30	2.4	80/160	144580	0/350	210/246	4	7	3		
10	17 1/2	SECU	M44N	412750	215	24	24	24		7	1754	0						0/0	240/240	1	1	0		WASHING
11	12 1/4	HUGH	XDV	022TK	215	16	16	14		8	1810	56	21.00	19.40	2.9	110/145	161900	178/222	180/180	8	5	0		
12	12 1/4	CRIS	S200	121						9	1870	60	16.00	13.80	4.3	160/180	133986	90/222	238/238				100 %	
13	12 1/4	REED	HP51A	H13255	517	16	16	16		10	2225	355	57.50	52.10	6.8	80/100	284468	178/267	198/198	7	5	2		
14	12 1/4	HUGH	ATM22	77622	517	16	16	16		10	2476	251	41.50	39.30	6.4	90/90	190305	133/236	198/198	8	6	3		
15	12 1/4	HUGH	ATJ33	A54BK	537	16	16	16		10	2603	127	30.00	27.80	4.6	40/100	148367	133/236	198/198	8	4	0		
16	12 1/4	DB	TT603	7980338						11	2610	7	4.50	4.50	1.6	60/150	35166	90/204	198/198				10 %	TFA:1.5
17	12 1/4	SMIT	F27DL	KH1300	527	16	16	16		12	2731	121	20.50	19.20	6.3	70/85	82223	90/220	198/198	6	2	3		8 BT
18	12 1/4	SMIT	F3L	KH5116	537	16	16	16		12	2851	120	34.60	34.60	3.5	80/80	154182	90/318	198/198	8	4	10		
19	12 1/4	SMIT	F27D	222450	527	16	16	16		13	2944	93	30.00	29.30	3.2	70/90	137930	90/310	159/159	5	2	3		
20	12 1/4	SMIT	F3	XJ2710	537	13	13	13		14	3032	88	30.00	28.00	3.1	70/90	153427	90/310	136/136	4	2	3		
21	12 1/4	SMIT	F3	XJ2713	537	13	13	13		15	3139	107	34.00	30.90	3.5	70/90	159732	40/318	136/136	3	2	6		
22	12 1/4	HUGH	J33	A55BM	537	14	14	14		15	3178	39	24.00	22.20	1.8	88/100	126000	320/320	136/136	2	2	6		
23	12 1/4	DB	TBT16	7890122						16	3200	22	9.50	8.20	2.7	130/190	75428	68/227	176/176				15%	TFA:75-1.2
24	12 1/4	EC	S226	123561						17	3217	17	5.50	3.80	4.5	180/210	57750	16/16	625/625				15 %	
25	12 1/4	HUGH	ATM22	A79HK	517	14	14	12		18	3352	135	47.50	45.60	3.0	80/80	211700	320/320	136/136	2	4	0		
26	8 1/2	SMIT	SDGH	XJ4329	135	12	12	12		19	3368	16	8.00	8.00	2.0	100/100		133/133	106/106	3	2	3		
27	8 1/2	EC	S225	123393						20	3425	57	18.50	16.70	3.4	120/120	119100	130/150	140/140				20%	
28	8 1/2	J K	MK1	103818						21	3498	73	12.00	11.70	6.2	150/150	113200	155/155	142/142				20%	
29	8 1/2	J K	MK1	104187						22	3615	117	29.50	25.70	4.6	160/160	239800	180/200	142/142				35%	
30C	8 1/2	CRIS	C 315	CP1961						23	3625	10	9.50	9.10	1.1	100/115	51900	66/80	65/65				5%	
31	8 1/2	SMIT	SDGH	XJ4920	135	12	12	12		24	3625	0								1	1	0		WIPER TRIP

Table B-8

Table B-9

((((ooo) ------- Norsk Hydro	B o t t o m h o l e a s s e m b l y System : BORE Well: 5514/30-1 Data from table 7 and table 10 ("Depth interval")	Date 9/6-1989 8

BHA no.:1 Item no./Name/OD,in/Length,m Depth interval md: 80-105

1	Bit	17 1/2	0.43	5	DC Steel	9 1/2	9.38
2	Hole Opener	26	2.54	6	X-over	9 1/2	0.78
3	Bit Sub	9 1/2	1.12	7	X-over	6 1/2	0.71
4	Nonmag collar	9 1/2	9.13	8	HWDP	6 1/2	137.99

BHA no.:2 Item no./Name/OD,in/Length,m Depth interval md: 105-787

1	Bit	17 1/2	0.43	6	X-over	9 1/2	0.78
2	Bit Sub	9 1/2	1.12	7	DC Steel	8	17.91
3	MWD	9 1/2	12.57	8	Jar	8	9.69
4	Nonmag collar	9 1/2	9.13	9	DC Steel	8	27.07
5	DC Steel	9 1/2	102.53	10	X-over	2 3/4	0.77

BHA no.:3 Item no./Name/OD,in/Length,m Depth interval md: 105-787

1	Bit	17 1/2	0.43	7	X-over	9 1/2	0.73
2	Steel stab	17 1/2	2.27	8	DC Steel	8	17.91
3	Hole Opener	24	1.95	9	Jar	8	9.69
4	Bit Sub	9 1/2	1.12	10	DC Steel	8	27.02
5	DC Steel	9 1/2	9.73	11	X-over	7 3/4	0.77
6	DC Steel	9 1/2	102.53				

BHA no.:4 Item no./Name/OD,in/Length,m Depth interval md: 105-785

1	Bit	17 1/2	0.48	7	DC Steel	8	17.91
2	Hole Opener	24	1.95	8	Jar	8	6.69
3	Under Reamer	26	3.35	9	DC Steel	8	27.02
4	Bit Sub	9 7/16	1.12	10	X-over	7 3/4	0.77
5	DC Steel	9 1/2	28.09	11	HWDP	6 1/2	137.99
6	X-over	9 1/2	0.78				

BHA no.:5 Item no./Name/OD,in/Length,m Depth interval md: 762-1715

1	Bit	17 1/2	0.41	8	X-over	9 1/2	0.78
2	Bit Sub	9 7/16	1.12	9	DC Steel	8	17.91
3	Bit Sub	9 1/2	0.65	10	Jar	8	9.79
4	MWD	9 1/2	11.92	11	DC Steel	8	27.03
5	DC Steel	9 1/2	9.13	12	X-over	7 3/4	0.77
6	Steel stab	17 1/2	2.27	13	HWDP	6 1/2	137.99
7	DC Steel	9 1/2	149.11				

BHA no.:6 Item no./Name/OD,in/Length,m Depth interval md: 1715-1754

((((ooo) ------- Norsk Hydro	**B o t t o m h o l e a s s e m b l y** System : BORE Well: 5514/30-1 Data from table 7 and table 10 ("Depth interval")	Date 9/6-1989 8

1	Bit	17 1/2	0.41	8	X-over	9 1/2	0.78
2	Bit Sub	9 3/16	1.12	9	DC Steel	7 3/8	17.91
3	Nonmag collar	9 1/2	9.13	10	Jar	8	9.79
4	DC Steel	9 1/2	3.59	11	DC Steel	8	27.02
5	DC Steel	9 1/2	9.29	12	X-over	7 3/4	0.77
6	Steel stab	17 1/2	2.27	13	HWDP	6 1/2	157.99
7	DC Steel	9 1/2	139.84				

BHA no.:7 Item no./Name/OD,in/Length,m Depth interval md: 1754-1754

1	Bit	17 1/2	0.41	8	Steel stab	17 1/2	2.27
2	X-over	9 1/2	0.78	9	DC Steel	9 1/2	139.84
3	Junksub	9 1/2	0.8	10	DC Steel	8	17.91
4	X-over	9 1/2	1.17	11	Jar	8	9.74
5	Bit Sub	9 1/2	1.12	12	DC Steel	8	27.02
6	Nonmag collar	9 1/2	9.13	13	X-over	8	0.77
7	DC Steel	9 1/2	3.59	14	HWDP	5	137.99

BHA no.:8 Item no./Name/OD,in/Length,m Depth interval md: 1754-1810

1	Bit	12 1/4	0.3	7	DC Steel	8	196.45
2	Bit Sub	8	0.88	8	Jar	8	8.79
3	Junksub	8	0.8	9	DC Steel	8	35.88
4	DC Steel	8	2.77	10	X-over	8	0.47
5	Nonmag collar	8	8.72	11	HWDP	5	137.99
6	Steel stab	12 1/4	1.21				

BHA no.:9 Item no./Name/OD,in/Length,m Depth interval md: 1810-1870

1	Bit	12 1/4	0.72	6	DC Steel	8	133.83
2	Bit Sub	8	0.88	7	Jar	8	8.79
3	DC Steel	8	2.77	8	DC Steel	8	27.18
4	Nonmag collar	8	8.72	9	X-over	7 3/4	0.77
5	Steel stab	12 1/4	1.21	10	HWDP	5	137.99

BHA no.:10 Item no./Name/OD,in/Length,m Depth interval md: 1870-2603

1	Bit	12 1/4	0.32	6	DC Steel	8	214.42
2	Bit Sub	8	0.88	7	Jar	8	8.97
3	Shock Abs./Sub	8	4.23	8	DC Steel	8	17.91
4	Nonmag collar	8	8.72	9	X-over	8	0.77
5	Steel stab	12 1/4	1.21	10	HWDP	5	137.99

BHA no.:11 Item no./Name/OD,in/Length,m Depth interval md: 2603-2610

1	Bit	12 1/4	0.41	7	DC Steel	8	133.83

((((ooo) Norsk Hydro	**Bottom hole assembly** System : BORE Well: 5514/30-1 Data from table 7 and table 10 ("Depth interval")	Date 9/6-1989 8

2 Junksub	9 1/2	0.81		8 Jar	8	8.97
3 Bit Sub	8	0.88		9 DC Steel	8	27.17
4 DC Steel	8	2.77		10 X-over	7 3/4	0.91
5 Nonmag collar	8	8.72		11 HWDP	5	137.99
6 Steel stab	12 1/4	1.5				

BHA no.:12 Item no./Name/OD,in/Length,m Depth interval md: 2610-2851

1 Bit	12 1/4	0.32	6 DC Steel	8	205.14
2 Bit Sub	8	0.88	7 Jar	8	8.97
3 Shock Abs./Sub	8	4.23	8 DC Steel	8	17.91
4 Nonmag collar	8	8.72	9 X-over	7 3/4	0.77
5 Roller Reamer	12 1/4	1.28	10 HWDP	5	137.99

BHA no.:13 Item no./Name/OD,in/Length,m Depth interval md: 2851-2944

1 Bit	12 1/4	0.32	6 DC Steel	8	214.42
2 Bit Sub	8	0.88	7 Jar	8	8.97
3 Shock Abs./Sub	8	4.23	8 DC Steel	8	17.91
4 Nonmag collar	8	8.72	9 X-over	7 3/4	0.77
5 Roller Reamer	12 1/4	2.47	10 HWDP	5	137.99

BHA no.:14 Item no./Name/OD,in/Length,m Depth interval md: 2944-3032

1 Bit	12 1/4	0.32	7 DC Steel	8	214.42
2 Junksub	9 5/8	0.8	8 Jar	8	8.97
3 Bit Sub	8	0.88	9 DC Steel	8	17.91
4 Shock Abs./Sub	8	4.23	10 X-over	7 3/4	0.77
5 Nonmag collar	8	8.72	11 HWDP	5	137.99
6 Roller Reamer	12 1/4	1.28			

BHA no.:15 Item no./Name/OD,in/Length,m Depth interval md: 3032-3178

1 Bit	12 1/4	0.32	6 DC Steel	8	214.42
2 Bit Sub	8	0.88	7 Jar	8	8.97
3 Shock Abs./Sub	8	4.23	8 DC Steel	8	17.91
4 Nonmag collar	8	8.72	9 X-over	7 3/4	0.77
5 Roller Reamer	12 1/4	2.47	10 HWDP	5	139.99

BHA no.:16 Item no./Name/OD,in/Length,m Depth interval md: 3178-3200

1 Bit	12 1/4	0.43	6 DC Steel	8	115.59
2 Junksub	9 5/8	0.83	7 Jar	8	9.78
3 Bit Sub	8	0.88	8 DC Steel	8	17.81
4 Nonmag collar	8	8.72	9 X-over	7 3/4	0.77
5 Steel stab	12 1/4	1.45	10 HWDP	5	137.99

((((ooo) Norsk Hydro	Bottom hole assembly System : BORE Well: 5514/30-1 Data from table 7 and table 10 ("Depth interval")	Date 9/6-1989 8

BHA no.:17 Item no./Name/OD,in/Length,m Depth interval md: 3200-3217

1	Bit	12 1/4	0.48	6	DC Steel	8	142.36
2	Junksub	9 5/8	0.83	7	Jar	7 3/8	9.7
3	Bit Sub	8	0.88	8	DC Steel	8	17.7
4	Nonmag collar	8	8.73	9	X-over	7 3/4	0.77
5	Steel stab	12 1/4	1.45	10	HWDP	5	137.99

BHA no.:18 Item no./Name/OD,in/Length,m Depth interval md: 3217-3352

1	Bit	12 1/4	0.3	6	Jar	7 7/8	9.7
2	Bit Sub	8	0.88	7	DC Steel	8	17.7
3	Nonmag collar	8	8.72	8	X-over	7 3/4	0.77
4	Steel stab	12 1/4	1.45	9	HWDP	5	137.99
5	DC Steel	8	232.28				

BHA no.:19 Item no./Name/OD,in/Length,m Depth interval md: 3352-3368

1	Bit	8 1/2	0.26	8	X-over	6 7/16	0.73
2	Junksub	7 5/8	0.82	9	DC Steel	6 1/2	241.27
3	Bit Sub	6 1/2	0.92	10	X-over	6 3/4	0.53
4	X-over	6 3/4	0.82	11	Jar	6 3/8	9.25
5	Nonmag collar	6 1/2	8.74	12	X-over	6 1/2	0.77
6	DC Steel	6 1/2	2.37	13	DC Steel	6 1/2	27.24
7	Steel stab	8 1/2	1.74	14	HWDP	5	137.99

BHA no.:20 Item no./Name/OD,in/Length,m Depth interval md: 3368-3425

1	Bit	8 1/2	0.35	8	X-over	6 3/8	0.73
2	Junksub	7 5/8	0.82	9	DC Steel	6 1/2	152.42
3	Bit Sub	6 1/2	0.92	10	X-over	6 3/8	0.53
4	X-over	6 7/8	0.82	11	Jar	6 3/8	9.25
5	Nonmag collar	6 1/2	8.74	12	Jar	6 1/2	0.77
6	DC Steel	6 1/2	2.37	13	DC Steel	6 1/2	27.24
7	Steel stab	8 1/2	1.74	14	HWDP	5	137.99

BHA no.:21 Item no./Name/OD,in/Length,m Depth interval md: 3425-3498

1	Bit	8 1/2	0.19	7	X-over	6 7/16	0.73
2	Bit Sub	6 1/2	0.92	8	DC Steel	6 1/2	152.43
3	X-over	6 7/8	0.82	9	Jar	6 3/8	9.52
4	Nonmag collar	6 1/2	8.74	10	X-over	6 1/2	0.77
5	DC Steel	6 1/2	2.37	11	DC Steel	6 1/2	27.24
6	Steel stab	8 1/2	1.72	12	DC Steel	5	110.27

((((ooo) ------- Norsk Hydro	Bottom hole assembly System : BORE Well: 5514/30-1 Data from table 7 and table 10 ("Depth interval")	Date 9/6-1989 8

BHA no.:22 Item no./Name/OD,in/Length,m Depth interval md: 3498-3615

1	Bit	8 1/2	0.23	5	DC Steel	6 1/2	241.27
2	Bit Sub	8 1/2	0.92	6	Jar	6 3/4	9.36
3	Nonmag collar	6 9/16	9.7	7	DC Steel	6 1/2	27.24
4	Steel stab	8 1/2	1.58	8	HWDP	5	110.27

BHA no.:23 Item no./Name/OD,in/Length,m Depth interval md: 3615-3625

1	Core bit	8 1/2	0.3	4	Jar	6 3/4	9.36
2	Core barrel	6 1/2	18.57	5	DC Steel	6 1/2	27.24
3	DC Steel	6 1/2	90.21				

BHA no.:24 Item no./Name/OD,in/Length,m Depth interval md: 3625-3625

1	Bit	8 1/2	0.3	4	Jar	6 3/4	9.36
2	Roller Reamer	8 1/2	1.5	5	DC Steel	6 1/2	27.24
3	DC Steel	6 1/2	90.21				

6.1 Mud report

26" hole section:

A 17 1/2" pilot hole was drilled to 787 m using a prehydrated bentonite - seawater system conditioned with PAC-polymer and Calcium Carbonate designed to give good wallbuilding properties and hole stability in the expected unconsolidated sand.

An obstruction in the 30" conductor was milled prior to opening the hole to 24". When pulling out, thigh hole was experienced with max. overpull of 70 ton, and lots of cuttings were observed when backreaming. This was assumed to be sloughing shale based on high MBT (47 kg/m^3) and the type of cuttings observed at surface.

Decision was made to add approx. 60 kg/m^3 of KCl to the mud to prevent hydration and dispersion of the clays whilst underreaming the hole to 26". The mudweight was also increased to 1.25 r.d.

Laboratory analyses, however showed that the formation consisted of mostly chalk and only 11% reactive clay. The 20" casing was run and cemented at 777 m without problems.

17 1/2" hole section:

The 20" shoe was drilled out with seawater and the hole displaced to KCl-Polymer mud. After drilling 3 m into new formation, a leakoff test was performed to an equivalent mud-
weight of 1.81 r.d. The 17 1/2" hole was then drilled to 1754 m.

Several intervals with tight hole was experienced when tripping. Mud weight was raised from 1.16 r.d. to 1.20 r.d. at 1299 m and futher to 1.22 r.d. at approx. 1740 m and KCl content was increased to 80 kg/m^3 to stabilize the hole.

Periodicly loss of mud over the shakers were observed due to blinding of screens when drilling sand.

The hole was logged and 13 3/8" casing was run and cemented without problems at 1740 m.

12 1/4" hole section:

The KCl-mud from the previous section was pretreted with bicarbonate for drilling the cement.

The 12 1/4" hole was drilled to section t.d. at 3352 m increasing the mudweight to 1.28 r.d. at approx. 2570 m, and starting to lightly disperse the mud with chrome free lignosulfonate at 2900m.
Calcium Carbonate in small amount was added to stabilize the sandsections and the KCl was allowed to drift out of the system.

Thight spots were encountered frequently and had to be washed and reamed. At 2433 m the pipe got stuck but was worked free. A twisted off bottom hole assembly was caught on first attempt and pulled out of the hole.

The hole was logged prior to run 9 5/8" casing. Due to thight hole, the casing had to be circulated down the last 28 m.

8 1/2" hole section:

This section was drilled to 3615 m, and a core was cut from 3615 m to 3625 m using the mud from the previous section.

As temperature increased, additions of chrome free lignosulfonate and Miltemp were made to maintain rheology and HTHP fluid loss within specifications.

During logging, it was experienced tight hole on the first 2 logs. A wiper trip was performed and the mudweight was increased to 1.35 r.d. It was found 15 m fill at bottom.

The hole was plugged and abandoned without problems.

0022q
sn,BEn/agi

Norsk Hydro

D a i l y   m u d   p r o p e r t i e s

System : BORE

Date
6/7-1989

Well: 5514/30-1
Mud Contractor: PROMUD DANMARK APS
Data: "Mid depth" from table 3, otherwise from table 14.

Date	Mid. depth m,MD	Mud Dens. (SG)	PV cp	YP Pa	GEL 0 Pa	GEL 10 Pa	pH	100 psi (cc)	HP/HT (cc)	Cl- inn/out mg/l	Alkalinity Pf	Alkalinity Pm	Alkalinity Mf	Ca++ inn/out mg/l	Oil %	Sol %	H2O %	V.G. meter at 115 gr. F 600 rpm	300 rpm	200 rpm	100 rpm	6 rpm	3 rpm	Mud Type
890407	105	1.05	0	0																				SPUD
890408	105	1.05	7	9	1	2	10.2	10.0		3000/	0.30	1.20	1.00	40/				33	26	17	12	2	1	SPUD
890409	634	1.14	18	16	10	15	9.0	13.0		6000/	0.80	1.00	0.80	80/		9		68	50	45	40	20	10	SPUD
890410	787	1.14	10	11	4	9	9.0	10.0		5800/	1.00	1.00	0.80	100/		7		42	32	25	15	9	6	SPUD
890411	787	1.16	10	12	4	9	9.0	8.2		6000/	0.10	1.00	0.60	68/		9		45	35	20	15	5	3	SPUD
890412	788	1.16	13	13	4	10	9.0	8.0		6000/	0.10	1.00	0.60	100/		1		53	40	25	18	13	5	SPUD
890413	788	1.16	10	17	5	14	9.0	10.5				0.80	0.20	360/		12		66	50	37	27	18	7	KCL
890416	791	1.16	9	13	1	2	10.5	6.0		41000/41000	1.50	2.30	2.80	400/				45	36	24	15	2	1	KCL
890417	1182	1.16	15	14	2	6	10.0	5.8		38000/38000	0.70	1.50	1.30	360/		12		58	43	32	24	15	3	KCL
890418	1299	1.16	16	12	2	4	9.5	5.8		40000/40000	0.20	1.30	0.60	360/		14		56	40	31	23	12	4	KCL
890419	1508	1.20	16	13	1	3	10.0	6.0		33000/33000	0.10	0.50	0.50	400/		10		58	42	30	20	4	2	KCL
890420	1646	1.20	15	12	1	3	10.0	5.5		34000/34000	0.10	0.60	0.60	/600		11		55	40	29	18	5	2	KCL
890421	1715	1.21	15	13	1	3	9.5	5.2		34000/34000	0.10	0.50	0.40	680/		10		56	41	27	16	5	2	KCL
890422	1754	1.21	18	12	1	3	10.0	5.0		35000/35000	0.10	0.40	0.40	640/		10		60	43	29	18	4	2	KCL
890423	1754	1.21	17	13	1	3	10.0	50.0				0.50	0.40	600/		10		60	43	31	19	6	3	KCL
890424	1754	1.22	23	11	1	3	9.5	5.2		33000/33000	0.40	0.40	0.40	600/		10		68	45	35	22	5	3	KCL
890425	1754	1.22	19	10	1	3	9.5	5.0		31000/31000	0.10	0.40	0.30	600/		10		58	39	28	16	5	2	KCL
890426	1754	1.22	18	11	1	3	9.5	5.1		31000/31000	0.10	0.40	0.40	60/		10		58	40	28	17	6	2	KCL
890427	1790	1.22	20	10	1	3	11.5	5.0		27000/27000	0.60	2.70	1.20	400/		13		60	40	28	17	6	2	KCL
890428	1841	1.22	27	11	2	4	10.0	4.8	18.0	28000/28000	0.20	2.40	0.80	200/		13		67	45	31	18	6	2	KCL
890429	1915	1.22	23	9	2	4	10.0	4.8	18.0	28000/28000	0.20	2.60	0.80	200/		12		65	42	29	18	6	2	KCL
890430	2065	1.22	23	9	2	4	10.0	4.9	18.0	25000/25000	0.10	2.00	0.60	220/		12		65	42	29	16	6	2	KCL
890501	2215	1.22	27	9	2	4	10.0	4.5	18.0	22000/22000	0.10	2.00	0.50	250/		12		72	45	32	19	6	2	KCL
890502	2295	1.22	24	9	2	4	10.0	4.7	18.0	23000/23000	0.10	1.70	0.50	380/		13		67	43	28	17	6	2	KCL
890503	2458	1.24	30	11	2	5	10.0	4.5	18.0	22000/23000		1.60	0.30	320/		14		82	52	34	25	7	2	KCL
890504	2476	1.24	27	9	2	5	10.0	5.2	18.0	22000/23000	0.10	1.60	0.40	320/		14		72	45	30	21	7	2	KCL
890505	2573	1.28	27	10	3	7	10.0	5.0	18.0	22000/22000	0.10	1.20	0.30	320/320		16		75	48	37	25	8	5	KCL
890506	2603	1.28	27	15	7	12	10.0	5.0	18.0	20000/22000		1.20	0.20	350/350		16		85	58	47	35	15	6	KCL
890507	2634	1.28	25	12	3	7	10.0	5.0	18.0	20000/20000	0.10	1.40	0.50	200/200		16		75	50	39	29	17	7	POLYMER
890508	2731	1.28	25	13	5	11	10.0	5.0	18.1	20000/20000	0.10	1.40	0.60	250/250		16		76	51	38	30	20	8	POLYMER
890509	2810	1.28	23	13	8	15	10.0	5.6	18.1	20000/20000	0.40	1.40	0.40	200/200		16		73	50	40	34	20	15	POLYMER
890510	2851	1.28	22	13	8	16	10.0	5.8	18.1	18000/18000	0.10	1.60	0.40	200/200		16		72	50	41	33	20	14	POLYMER
890511	2918	1.28	19	15	7	12	10.5	5.8	18.0	16000/16000	0.10	1.10	0.50	140/140		13		67	48	40	31	16	14	POLYMER
890512	2947	1.28	18	13	8	11	9.5	5.8	18.0	15000/15000	0.10	0.80	0.50	140/140		14		62	44	39	30	19	16	POLYMER
890513	3020	1.28	16	11	7	12	10.0	6.0	18.0	15000/15000	0.10	0.80	0.50	140/140		13		55	39	34	20	18	14	POLYMER
890514	3050	1.28	17	12	8	12	10.0	6.0	18.0	15000/15000	0.10	0.70	0.50	120/120		13		58	41	35	27	19	15	POLYMER
890515	3128	1.28	16	13	8	13	10.0	6.0	18.0	16000/16000	0.10	0.70	0.50	120/120		13		58	42	37	28	20	16	POLYMER
890516	3153	1.28	15	12	8	12	10.0	6.0	18.0	16000/16000	0.10	0.70	0.50	120/120		13		55	40	35	31	21	16	POLYMER
890517	3178	1.28	15	13	7	12	10.0	6.0	18.0	16000/16000	0.10	0.70	0.50	120/120		13		56	41	34	29	20	15	POLYMER
890518	3200	1.28	16	12	7	12	10.0	5.8	18.0	16000/16000	0.10	0.70	0.50	120/120		13		56	40	35	28	20	14	POLYMER
890519	3217	1.28	16	12	8	12	10.0	6.0	18.0	16000/16000	0.10	0.70	0.50	120/120		13		57	41	36	30	21	16	POLYMER
890520	3255	1.28	16	12	7	11	10.0	6.0	18.0	15000/15000	0.10	0.70	0.50	120/120		13		56	40	33	26	14	14	POLYMER
890521	3332	1.28	15	8	5	10	10.0	6.0	18.0	15000/15000	0.10	0.70	0.50	120/120		14		45	30	25	20	14	12	POLYMER
890522	3352	1.28	13	8	5	10	10.0	6.2	18.0	14000/14000	0.10	0.80	0.60	160/160		13		42	29	23	18	11	9	POLYMER

Table B-10

((((ooo) Norsk Hydro

Daily mud properties

Date 6/7-1989

System : BORE

Well: 5514/30-1
Mud Contractor: PROMUD DANMARK APS
Data: "Mid depth" from table 3, otherwise from table 14.

Date	Mid. depth m,MD	Mud Dens. (SG)	PV cp	YP Pa	GEL 0 Pa	GEL 10 Pa	pH	100 psi (cc)	HP/HT (cc)	Cl- inn/out mg/l	Alkalinity Pf	Alkalinity Pm	Alkalinity Mf	Ca++ inn/out mg/l	Oil %	Sol %	H2O %	V.G. meter at 115 gr. F 600 rpm	300 rpm	200 rpm	100 rpm	6 rpm	3 rpm	Mud Type
890523	3352	1.28	15	9	7	12	10.0	6.0		14000/14000	0.10	0.70	0.60	160/160		13		48	33	27	21	18	14	POLYMER
890524	3352	1.28	17	10	8	12	10.0	6.0		14000/14000	0.10	0.70	0.60	160/160		13		54	37	31	25	20	16	POLYMER
890525	3352	1.28	15	9	7	12	10.0	6.0		14000/14000	0.10	0.70	0.60	160/160		13		48	33	29	23	18	14	POLYMER
890526	3352	1.29	12	5	2	4	11.5	18.0		14000/14000	2.00	5.00	3.00	360/360		14		34	22	18	13	7	3	POLYMER
890527	3380	1.29	20	8	2	3	10.5	5.6	18.0	14000/14000	1.00	3.00	2.00	160/160		10		57	37	25	14	3	2	POLYMER
890528	3425	1.29	21	10	2	4	10.5	5.5	20.0	14000/14000	0.80	2.60	2.10	100/100		11		62	41	30	17	3	2	POLYMER
890529	3498	1.29	22	11	2	5	10.0	4.0	19.0	14000/14000	0.50	2.60	2.00	120/120		11		66	44	30	20	7	4	POLYMER
890530	3556	1.32	27	10	2	5	10.0	4.8	20.0	12000/12000	0.30	1.20	0.80	100/100		14		74	47	38	25	5	3	POLYMER
890531	3615	1.32	30	12	2	3	10.0	4.8	20.0	12000/12000	0.30	1.40	1.10	160/160		14		84	54	41	25	6	3	POLYMER
890601	3625	1.32	30	8	2	5	10.0	5.0	20.0	12000/12000	0.10	0.90	0.70	200/200		14		77	47	36	22	6	3	POLYMER
890602	3625	1.30	33	9	2	5	10.0	5.1	20.0	12000/12000	0.10	1.00	0.80	200/200		15		84	51	40	26	6	3	POLYMER

Table B-11

((((ooo) ------- Norsk Hydro	Mud consumption System : BORE Well: 5514/30-1 Mud company: PROMUD DANMARK APS	Date 9/6-1989 13

		Actual used
Drilling of 26 " hole		
BARITE	Kg	17000
BENTONITE	Kg	25650
CACO3	Kg	12125
CAUSTIC SODA	Kg	575
KCL	Kg	25000
PROPOL REG	Kg	350
PROPOL SL	Kg	3125
SODA ASH	Kg	575
Drilling of 17 1/2" hole		
BARITE	Kg	143000
CAUSTIC SODA	Kg	825
KCL	Kg	53000
PROPOL REG	Kg	7525
PROPOL SL	Kg	5075
SODA ASH	Kg	300
XCD-POLYMER	Kg	100
PRODEFOAM	1	300
Drilling of 12 1/4" hole		
BARITE	Kg	99000
BENTONITE	Kg	3700
CACO3	Kg	13800
CAUSTIC SODA	Kg	3250
NAHCO3	Kg	750
PROPOL REG	Kg	3500
PROPOL SL	Kg	4600
PROTHIN	Kg	2530
SODA ASH	Kg	125
PRODEFOAM	1	430
Drilling of 8 1/2" hole		
BARITE	Kg	23000
BENTONITE	Kg	1050
CAUSTIC SODA	Kg	250
MILTEMP	Kg	1525
NAHCO3	Kg	1125
PROPOL REG	Kg	1150
PROPOL SL	Kg	1125
PROTHIN	Kg	2525
PRODEFOAM	1	180

7. Total cost report

Depth :	3.624 m
Rig rate :	DKK 262.000
Exchange :	USD 1 = DKK 7.20
Start date:	05.04.89 at 00.01 hr
Final date:	06.06.89 at 24.00 hr
Total days:	63.0

Estimated costs in DKK 1.000:

Rig positioning & survey:	900
Rig costs incl. rig mob/demob.:	22.810
Drilling tools, H2S & Oil spill equip.:	6.270
Wellhead & mudline suspension:	1.500
Casing & casing services:	5.860
Cement & cementing services:	2.230
Mud & mud services:	3.820
Wire line logging:	3.050
Supply & stand by vessels:	3.780
Helicopter:	1.450
Misch. transport & freight:	315
Warehouse & office:	3.340
Onshore & offshore supervision:	6.300
Estimated total well cost:	61.625

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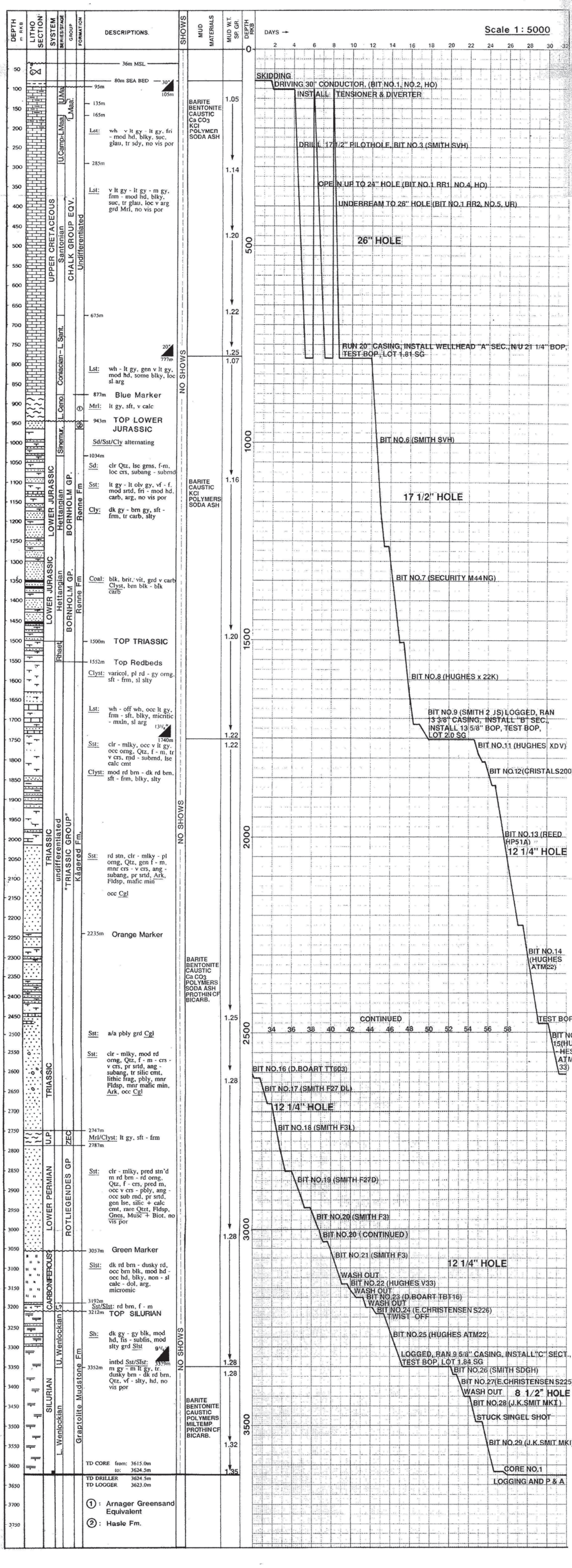
GEUS
Report File no
Enclosure
1807 (2/2)

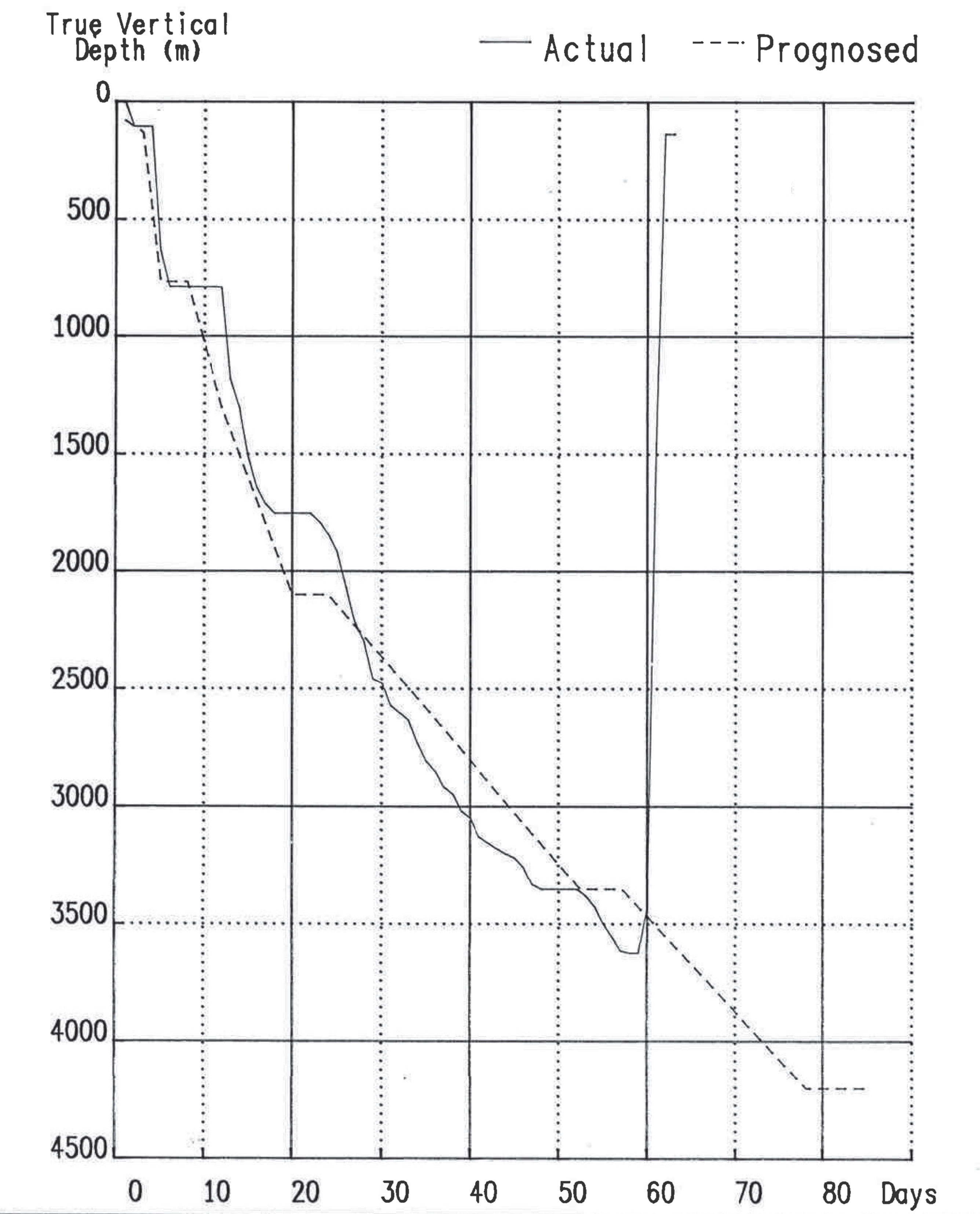
Norsk Hydro

MODTAGET DGU
08 DEC. 1989
UNDERGRUND
ARKIV

DRILLING PROGRESS, WELL 5514/30-1

OPERATOR : NORSK HYDRO	SPUD IN : 06.04.89 AT 17:00 HRS	WATER DEPTH : 44m
COORDINATES : 55° 00' 54.09"N	WELL COMPL. : 06.06.89 AT 24:00 HRS	RKB to MSL : 36m
: 14° 18' 43.14"E	RIG : GLOMAR MORAY FIRTH I	RKB to SEABED : 80m





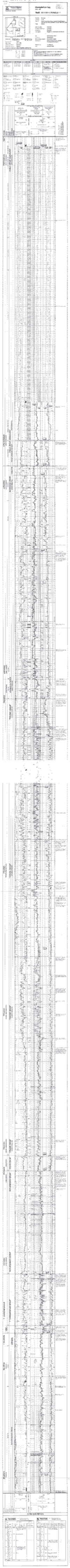
Norsk Hydro
Drilling Department

Date:19890609

PROGNOSED AND ACTUAL DRILLING CURVES

WELL: 5514/30-1

Fig.: B-5


Completion log

Appendix C Stina 1 well log description

GEUS

Report file no.

1785

STINA-1

Stina-1, Final well report. Vol. 2 (2) (Geology)

Copenhagen

01-09-1989

AMOCO DENMARK EXPLORATION COMPANY

5414/7-1 (STINA-1)

GEOLOGICAL WELL REPORT

Compiled by:

J. L. Roberts

September 1989

TABLE OF CONTENTS

JR/mct281

Pertinent Data

PERTINENT DATA SHEET

COUNTRY: Denmark

API NUMBER: 972050024100

WELL NAME: 5414/7-1 (Stina 1)

GEOLOGICAL PROVINCE: Ronne Graben

LOCATION: Lat: 54° 47' 19.92"N
Long: 14° 37' 43.38" E

ELEVATION: KB=36 Meters WD = 31 Meters

DATE SPUDDED: 11 June 1989

DATE REACHED T.D.: 7 July 1989

RIG RELEASE DATE: 13 July 1989

ESTIMATED FINAL COST: $4,660,329.00 Gross ($4,369,058.40 Net)

AUTHORIZED T.D.: 2736m MDRKB (2700m TVDSS)

DRILLER'S T.D.: 2518m MDRKB (2482m TVDSS)

LOG T.D.: 2510m MDRKB

P.B.T.D.: 98m MDRKB

STATUS: Plugged and Abandoned

OPERATOR: Amoco

PARTNER INTEREST:			
	Amoco	75%	(Paid 93.75% during exploration phase)
	F. L. Smidth	5%	(Paid 6.25% during exploration phase)
	Dopas	20%	(Carried during exploration)

DRILLING CONTRACTOR: Global Marine

RIG TYPE: Jack Up

RIG NAME: Glomar Moray Firth

CASING:

Size (Inches)	Depth (Meters, RKB)
30	137
20	355
13-3/8	1080

WIRELINE LOGS: See Table 1

		M,MD	M,S
FORMATION TOPS:	Quaternary	67	31
	M. Jurassic	127?	91
	L. Jurassic	304	268
	U. Triassic	555	519
	L. Triassic Bunter	1084	1048
	U. Perm. Zechstein	1635	1599
	L. Perm. Rotliegendes	1858	1822
	Silurian	2115	2079
	TD	2518	2482

CONVENTIONAL CORES: N/A

DRILLSTEM TESTS OPERATIONS SUMMARY: N/A

JR/mct281

TABLE 1: WIRELINE SURVEY SUMMARY
5414/7-1 (STINA-1)

LOG	DATE	SCALE 1:500	SCALE 1:200	TOP LOGGED INTERVAL(M)	BOTTOM LOGGED INTERVAL (M)	REMARKS
ISF-BHC-GR	16 June 89	X	X	137	363	GR to surface
BGT-BHC-GR	16 June 89	X	X	137	363	GR to surface
ISF-BHC-GR	21 June 89	X	X	355	1087	
LDL-CNL-GR-CAL	22 June 89	X	X	355	1087	
SHDT-GR	22 June 89		X	355	1087	
Computerized Cyberdip	22 June 89		X	355	1087	Processed SHDT Data
DLL-MSFL-BHC-GR	7 July 89	X	X	1080	2510	
LDL-CNL-NGL	7 July 89	X	X	1080	2510	
NGT Ratios	7 July 89	X	X	1080	2510	
SHDT-GR	8 July 89		X	1079	2510	
Check Shot Survey	8 July 89			355	2500	
CST-GR	8 July 89			1155	2498	

TABLE 2: AMOCO GROUP DANISH SECOND LICENCING ROUND

AMOCO (OPERATOR)	25%	Paid 93.75% during exploration phase.
F.L. SMIDTH	5%	Paid 6.25% during exploration phase.
DOPAS	20%	Carried during exploration.

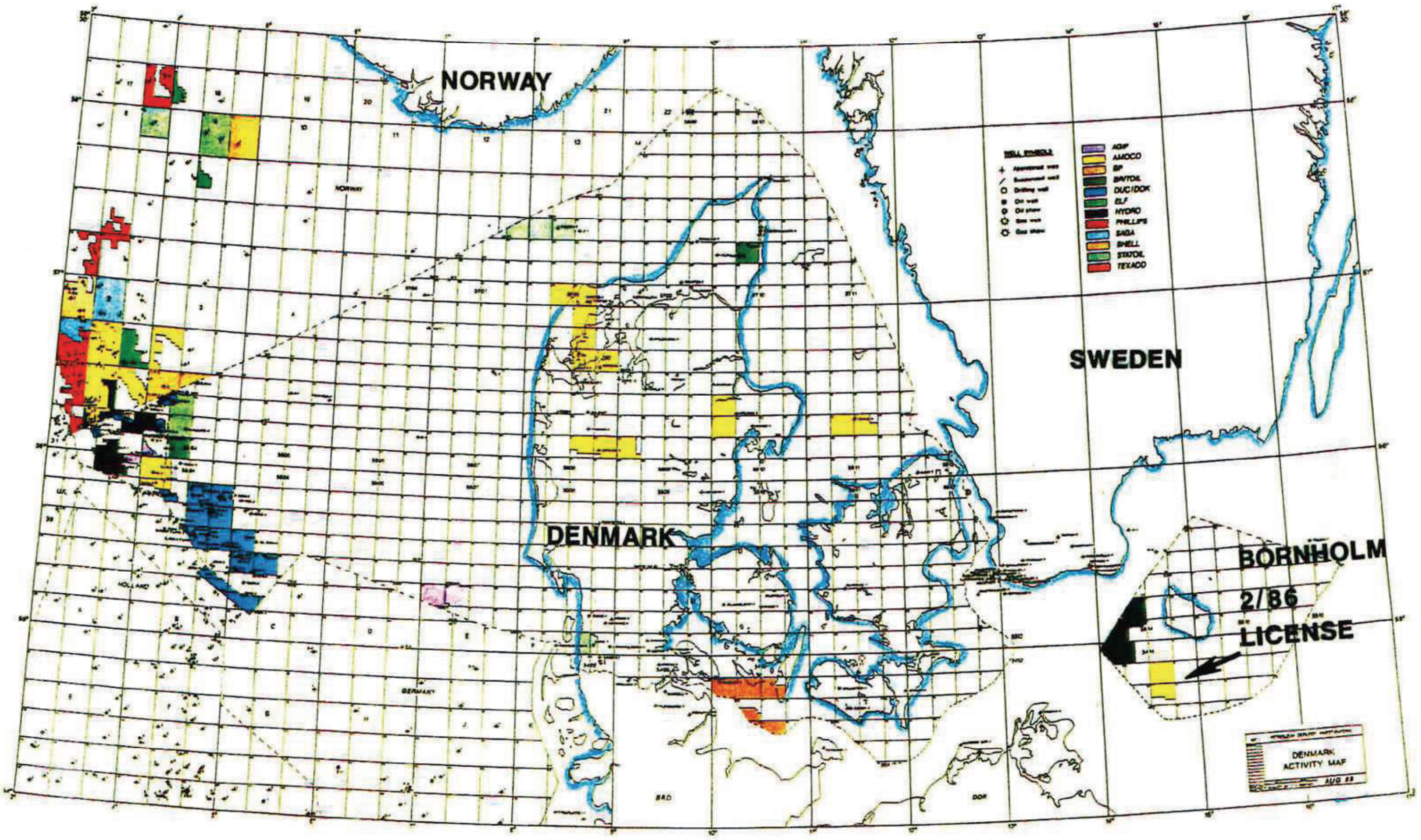

NORWAY
SWEDEN
DENMARK
BORNHOLM
2/86
LICENSE
DENMARK
ACTIVITY MAP
AGIP
AMOCO
BP
BRITOIL
DUC/DOK
ELF
HYDRO
PHILLIPS
SAGA
SHELL
STATOIL
TEXACO

FIGURE 1

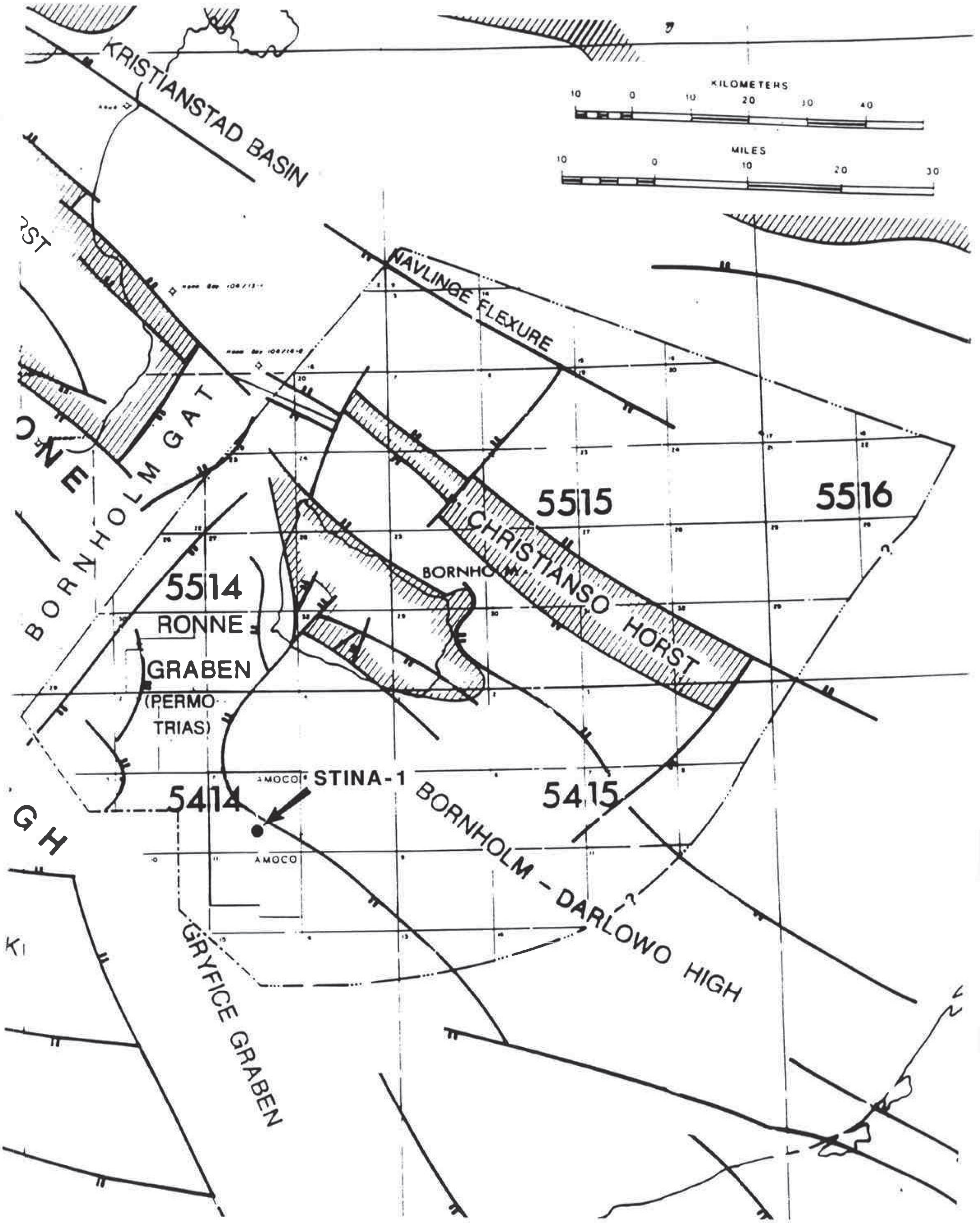


Figure 2: Bornholm Structural Elements and Location of Stina-1 Well

Geological Report

GEOLOGICAL REPORT

Introduction

The 5414/7-1 (Stina 1) well is located approximately 35 kilometers southwest of Bornholm Island, Denmark, in the Baltic Sea, at latitude 54°47'19.92"N and longitude 14°37'43.38"E (Figures 1 and 2). Amoco Denmark Exploration Company spudded the well on June 11, 1989, at shot point 394 of seismic line AM88B-05. The well reached a total depth of 2518 meters MDRKB on July 7, 1989, and was plugged and abandoned as a dry hole. The rig was released on July 13, 1989. Amoco's interest in the well was 93.75% during exploration. F. L. Smidth held the remaining 6.25%.

Wireline logs were run in the 26 inch, 17½ inch, and 12¼ inch holes (Table 1). No conventional cores were taken. Fifty of 60 sidewall cores shot were recovered. Field descriptions of sidewall cores are found in Appendix 2. RFT and drillstem tests were not conducted.

Background

The Amoco Group, Table 2, was awarded the offshore Bornholm Licence 2/86 on June 24, 1986, for a period of six years as part of the Danish Second Round of Licencing. The licence consists of block 5414/7 and part of block 5414/11 (Figures 1 and 2).

The Amoco Group's obligation on the licence was the acquisition of 450 kilometers of proprietary seismic by June 24, 1989. A decision to drill or drop the 2/86 licence block also has to be made by June 24, 1989.

Since the decision was made to drill a well on the Bornholm 2/86 licence, the remaining well obligation on the 3/84 Jutland Licence was transferred to the Bornholm licence.

The seismic option was reduced to 150 kilometers in January 1988 by the Danish Energy Agency in lieu of the Amoco Group participating in a non-exclusive shallow corehole program off the west coast of Bornholm Island. The corehole program was not sufficiently subscribed and so was not initiated. As a result, the Amoco Group withdrew support for this program.

The acquisition of 150 kilometers of proprietary seismic was completed in mid-September 1988. The Danish Energy Agency agreed to drop the remaining 300 kilometer seismic obligation if a well was drilled on Licence 2/86.

A 3000 kilometer airborne geochemical airtrace and aeromagnetic study was completed in June, 1988, over the entire Bornholm Enclave by Barringer Research, Inc., of Toronto, Canada. The purpose of the airtrace survey was to detect the presence of liquid hydrocarbons leaking to the surface from the undrilled basins around Bornholm Island. A number of hydrocarbon anomalies were detected to the northeast and west of Bornholm Island. The strongest anomaly was detected on the southwest portion of Licence 2/86. The detection of traces of liquid hydrocarbons in the air suggested that there may have been source rocks generating oil in the Bornholm area. The aeromagnetic data confirmed the configuration of basement structure as mapped from gravity data.

Regional Geological Setting

The Caledonian orogeny occurred at the end of Silurian time and involved uplift and erosion of the Paleozoic section on Bornholm Island. The west-trending Caledonian front lies to the south of Bornholm and extends from the Central Graben in the North Sea to northern Poland where it joins the Tornquist Zone. Wrenching movement along the Caledonian front is estimated to be 1600 kilometers. The Fennoscandian Border Zone formed during Caledonian time and consists of northwest trending en echelon faults which extend from Sweden to Bornholm Island. Motion along this fault system has been estimated to be 1500 kilometers of sinistral strike-slip movement.

At the end of Carboniferous time, the Variscan orogeny affected the area south of Bornholm, and the Ronne Graben was developed. It connected the Danish Subbasin in northern Denmark to the Gryfice Graben offshore northern Poland. The seaway caused by this connection permitted the deposition of Permian age sediments in the Ronne Graben. The presence of Permian Zechstein and Rotliegend sections in the recently drilled Petrobaltic K5-1 supports this hypothesis. The seaway remained until Triassic time when continental Triassic sedimentary sequences were deposited.

During Lower Jurassic time, the regional sea level rise allowed for deltaic sedimentation to extend from southern Sweden to the Bornholm area. By Middle Jurassic time, the continuing transgression was locally affected by contemporaneous uplift, tilting, and downthrowing of individual fault blocks. Local tectonics as well as minor periods of regression caused lateral variations in sediment thickness and vertical facies changes.

These included lacustrine, deltaic, and marine sediments as seen in outcrops on Bornholm Island. In comparison, it is postulated that within the Ronne Graben sediments were deposited under mostly a shallow marine influence.

During the Tertiary Alpine orogeny, regional compressive forces caused reactivation of Mesozoic age faults within the Fennoscandian Border Zone, the Tornquist Zone, the Polish Trough, and the Danish Subbasin. This compressive event is manifest by numerous inversion anticlinal features located within the Ronne Graben. The inversion anticlinal features and tilted Paleozoic fault blocks were the key structural targets for hydrocarbon exploration on the 2/86 Licence.

Reservoir Objectives

The 5414/7-1 well was designed to test the prospectivity of Lower Jurassic and Lower Triassic Sandstones, with Permian Rotliegend Sandstones as a possible third objective.

Pre-Drill Prognosis

The 5414/7-1 well was drilled to test a faulted anticline formed by wrench fault related forces which compressed and inverted the prospective sections against the northeast graben bounding basement high.

Mapping on the near base Jurassic seismic event defined the uppermost objective to posses four-way dip structural closure of 21 square kilometers

(5250 acres) areally and 100 meters of vertical relief. The structure at the near base Triassic objective exhibited three-way dip closure with fault controlled closure to the north. This structure showed areal closure of approximately 62 square kilometers (15,500 acres) at the base Triassic level and vertical relief of approximately 400 meters.

Post-Drilling Results

A comparison of prognosed and actual stratigraphy is graphically illustrated in Figure 3. The Lower Jurassic objective section was found to be 251 meters thick and 69 meters low to prognosis. The porosity of the sands was generally good, but there were no shows.

The original formation tops were revised when the Upper Triassic claystone came in 165 meters high to prognosis. The Lower Triassic objective section (Bunter Sandstone) was found to be 374 meters thick and 4 meters high to the revised prognosis. Porosity of the Bunter sands was very good in the upper and middle portions and decreased to fair with depth. There were no shows.

The Permian Rotliegendes section was found to be approximately 278 meters thick and approximately 6 meters low to the revised prognosis ("approximate" due to the highly transitional nature of the contact between the Zechstein and Rotliegendes Units). This section was expected to consist of well sorted, loosely cemented, porous sands. It was found, however, to consist of thin interbeds of claystone, siltstone, and sandstone with no significant shows.

Carboniferous-aged sediments were not present, and the total depth of 2518 meters MDRKB was reached after drilling 403 meters of Silurian claystone.

Detailed descriptions of the drill cuttings are available in Appendix 1 and are summarized graphically on the Wellsite Lithology Log (Enclosure 4).

JR/JLT277B

STINA-1 WELL STRATIGRAPHY

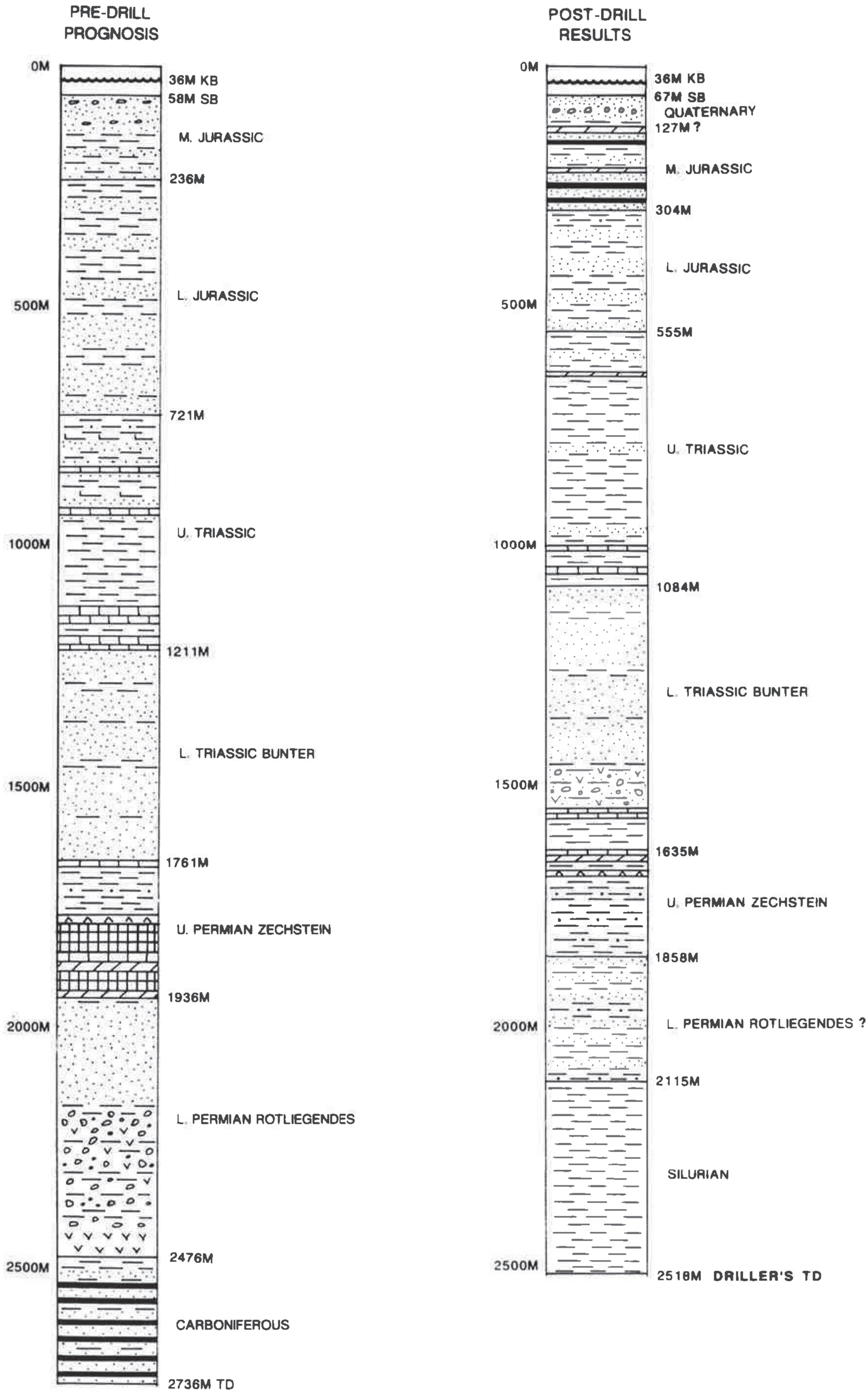


Figure 3: Stratigraphy

Formation tops are based on cuttings and log information. Tops listed are meters below RKB.

Log Analysis

DENMARK 5414/7-1 (STINA-1)

LOG ANALYSIS & TRIP REPORT

97-205-T8901-00

by

Robert L. Terry

July 19, 1989

Houston General Office - Exploration Technical Services

Formation Evaluation Department

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

SUMMARY

The 5414/7-1 well offshore from Bornholm Island in the Baltic Sea (Figure 1) was logged during the period of July 7-8, 1989. This was the final logging run for this well and covered the interval from 1080 to 2510.7 meters. This section of the well was drilled with a salt saturated mud in anticipation of encountering salt formations in the Zechstein interval. When this did not prove to be the case, the chloride concentration was allowed to decrease to approximately 100,000 ppm. No PHPA mud was used on this well. The borehole was in fair condition with several zones exhibiting significant washout. Borehole deviation was generally less than 5 degrees, but starting at 1985 meters the hole angle began to build steadily until it reached a maximum of 24.5 degrees in the area of 2450 meters. This deviation is a result of the structural dip encountered in the Silurian shales. These shales were found (from the Dipmeter) to have a structural dip of 30 degrees to the West-Southwest. The drilling rates increased dramatically when these shales were penetrated.

The logging operations went smoothly and a detailed level-by-level analysis was performed using the Dual Water model in the PETCOM software system to produce a wellsite CPI (Computer Processed Interpretation). The CPI log is attached in the pocket at the back of this report.

The formations penetrated in the logged interval from 1080-2503 meters were the Bunter (1080-1636), the Zechstein (1636-1842), the Rotliegendes (1842-2112) and the Silurian (2112-2503). These formations are illustrated in the stratigraphic section that appears as Figure 2.

CONCLUSIONS

1) The Bunter sands in this well exhibited excellent reservoir potential (22% average porosity), but were uniformly wet. The apparent hydrocarbon shows from 1080 to 1100 meters were due to hole rugosity. Other trace shows throughout this zone can also be attributed to rugosity effects on the porosity tools and side bed effects on the resistivity devices. These generally resulted in the water saturation computation varying from 90-100%. See Table 1 for a detailed analysis by formation.

2) The Zechstein interval did not contain the anticipated salt sections. It was generally shaly with few clean porous zones. In fact, only 1.25 meters of reservoir rock was noted on the CPI log.

3) The Rotliegendes formation contained some reservoir rock (27.5 meters at 13.8% average porosity). Unfortunately, this zone was also wet, with only 1.75 meters of calculated pay which was primarily due to hole rugosity effects on the porosity devices (not real hydrocarbon shows). The hydrocarbon indication calculated in the interval from 2016-2021 meters was checked with a sidewall core sample and found to be a wet conglomerate. This pay calculation was due to an overestimation of the porosity (insufficient shale calculation...too clean for the conglomerate).

4) The lack of hydrocarbons in this well is probably related to the total absence of the Carboniferous interval (normally a source bed) below the Rotliegendes. Silurian shales lie immediately below the reservoir rocks in this well and indications from the service company personnel on site indicated similar results on the Norsk Hydro well to the North of our location.

RECOMMENDATIONS

1) No attempt should be made to test the Bunter formation and the well should be plugged and abandoned. The formation had excellent reservoir potential and given an adequate source, should be extremely productive. Further exploration using this formation as a reservoir is warranted.

2) The Zechstein formation in this area does not have adequate reservoir potential and no play should be developed based upon this zone.

3) The Rotliegendes was wet and did not have good reservoir potential. It does not appear to be a good prospect for future plays.

4) The lack of the Carboniferous coals as a source of gas resulted in this well being a dry hole. Further exploration (seismic?) to define the extent of this missing section could result in a play development elsewhere for gas in the Bunter sands.

WELLSITE OPERATIONS

The unexpected penetration of Silurian shales with their correspondingly high drilling rates resulted in the well being ready to log prior to the log analyst's arrival. The first logging run (Dual Laterolog/Micro Spherically Focused Log/Borehole Compensated Sonic) was monitored by the Amoco wellsite geologist. Subsequent logging runs were monitored by the wellsite log analyst.

Since this well was classified as a tight hole, all films, prints and data tapes were collected from the wireline service company (Schlumberger) at the completion of the job. One print of the raw Dipmeter log was provided to the Amoco drilling engineer at the wellsite to use the four arm caliper measurement in cement calculations. All other log data was removed from the wellsite. Data acquisition went very smoothly thanks in part to the presence of two Schlumberger engineers, which made it possible to have a fresh engineer at all times. The log data was transferred from the CSU (Cyber Service Unit) to the Amoco log analyst's PC, rather than the Schlumberger PC. This was done for three reasons. First, the Toshiba 5100 provided by Amoco could receive the data twice as fast as the Schlumberger PC (9600 vs. 4800 baud). Secondly, the Schlumberger PC was only equipped with floppy disk drives (no hard disk) which meant that if the data file was too large for the floppy disk, the copy operation would fail. Third, the Amoco machine had a more recent version of the Schlumberger CSU transfer program than Schlumberger's own PC (version 2.6 vs. version 2.5).

The logging services performed on this well and the pertinent borehole environmental data are as follows:

Log Heading Data and Logging Services

Date Logged	7 thru 8 July 1989
Run Number	2
Total Depth Logger	2,510.7 Meters
Bit Size	12.25 Inches
Mud Density	11.2 lbs/gallon Salt Sat.
Mud Resistivity	0.071 ohm/meters @ 78 F
Filtrate Resistivity	0.054 ohm/meters @ 75 F
Bottomhole Temperature	142 F

The following logs were run and interpreted:

DLL (1080-2506).........Dual Laterolog

MSFL (1080-2506)........Micro Spherically Focused Log

CNL (1080-2509.5).......Compensated Neutron Log

LDL (1080-2509.5).......Litho Density Log

BHC (1080-2506).........Borehole Compensated Sonic

NGL (1080-2509.5).......Natural Gamma Ray Log

SHDT (1080-2504)........Stratigraphic High Resolution Dipmeter

CST (see list)..........Chronological Sidewall Sampler

Check Shot Survey (entire borehole)

A detailed time breakdown follows for the logging operations on this well:

5414/7-1 OPERATION TIME REPORT

Date	Time	Operation
7/07	1245	Rig up Schlumberger
	1325	Start DLL-MSFL-BHC-GR
	1900	Finish DLL-MSFL-BHC-GR (data transferred to disk after logging)
	1945	Start LDL-CNL-NGL
7/08	0230	Finish LDL-CNL-NGL (data transferred to disk after logging)
	0330	Start SHDT
	0900	Finish SHDT
	0945	Start Check Shot survey
	1630	Finish Check Shot survey
	1700	Start CST (60 shots)
	2100	Finish CST
	2200	Rig down Schlumberger

The total logging time for this job was 33.25 hours. There was no lost time due to tool failure, mechanical problems or other causes.

The intention on this well was to take 60 sidewall cores. In fact, only 50 cores were recovered from the 60 shots attempted, resulting in a recovery rate of 83%. The bullets used were the old style combination bullets with 10 gram powder loads. It would be advisable in the future to use a rotary sidewall coring tool instead of the percussion bullet tools. This would improve core recovery and also allow for accurate petrophysical measurements of permeability and porosity. The results of the sidewall coring operation are as follows:

Sidewall Core Report

Depth	Formation	Lithology	Recovery	Fluorescence
2498	Silurian	Claystone	0.75"	None
2482.5	Silurian	Siltstone	0.50"	None
2467.5	Silurian	Claystone	1.00"	None
2451.3	Silurian	Siltstone	0.75"	None
2432.5	Silurian		No Recovery	
2419.5	Silurian	Claystone	0.50"	None
2404	Silurian	Claystone	0.75"	None
2390	Silurian	Claystone	0.75"	None
2369.5	Silurian	Claystone	0.75"	None
2353	Silurian	Siltstone	0.50"	None
2341.3	Silurian	Claystone	1.00"	None
2327.5	Silurian	Claystone	0.25"	None
2312.8	Silurian	Claystone	0.75"	None
2295	Silurian	Claystone	1.50"	None
2275.5	Silurian	Shale	0.50"	None
2258	Silurian	Claystone	1.00"	None
2242.5	Silurian	Claystone	0.75"	None
2227	Silurian	Clay	1.00"	None
2210	Silurian	Claystone	1.00"	None
2195	Silurian	Claystone	1.25"	None
2180	Silurian	Siltstone	1.00"	None
2169.5	Silurian	Shale	1.00"	None
2156.3	Silurian	Shale	0.75"	None
2135.3	Silurian		No Recovery	
2118	Silurian	Claystone	0.50"	None
2108.3	Rotliegend	Conglomerate	1.00"	None
2104.8	Rotliegend		No Recovery	
2100	Rotliegend	Claystone	1.25"	None
2094	Rotliegend	Claystone	1.50"	None
2091	Rotliegend		No Recovery	
2074	Rotliegend	Conglomerate	0.75"	None
2018.5	Rotliegend	Conglomerate	0.75"	None
1991	Rotliegend	Sand	0.50"	None
1983	Rotliegend	Sand	0.50"	None

Depth	Formation	Lithology	Recovery	Fluorescence
1976	Rotliegend	Sand	1.00"	None
1973	Rotliegend	Sand & Clay	1.50"	None
1962	Rotliegend	Sand	0.75"	None
1939.8	Rotliegend	Sand & Clay	0.75"	None
1927	Rotliegend	Sand	1.00"	None
1915.5	Rotliegend	Conglomerate	0.75"	None
1899	Rotliegend	Sand	0.75"	None
1898	Rotliegend	Sand	1.00"	None
1889.8	Rotliegend	Sand	0.75"	None
1867	Rotliegend		No Recovery	
1863.5	Rotliegend	Clay	0.50"	None
1687	Zechstein	Clay	0.25"	None
1640.5	Zechstein	Anhy. & Clay	0.75"	None
1637	Zechstein		No Recovery	
1547.3	Bunter	Limestone	0.25"	None
1520.5	Bunter		No Recovery	
1491.5	Bunter	Sand	0.75"	None
1465	Bunter	Sand	0.75"	None
1421	Bunter	Clay/Sand	0.75"	None
1364	Bunter		No Recovery	
1352.5	Bunter	Sand	0.50"	None
1320.5	Bunter	Sand	0.25"	None
1304	Bunter		No Recovery	
1279.3	Bunter	Sand	0.50"	None
1256.5	Bunter	Sand	1.00"	None
1155.5	Bunter		No Recovery	

A detailed description of each of the sidewall cores as performed by the wellsite geologist is included as Table 2. The sidewall cores provided excellent control on the log analysis in the conglomerate intervals, clearly indicating that the zones were wet.

ANALYSIS TECHNIQUE & INTERPRETATION

All of the logs for the well were environmentally corrected according to the published Schlumberger chart book corrections. No Tornado Chart corrections were applied to the resistivity suite (laterologs) because the rugose hole resulted in poor MSFL data. The environmentally corrected deep laterolog measurement was used as the best approximation to Rt (true formation resistivity).

The 1,423 meters of open hole encountered in this well made it necessary to break the analysis into four separate zones. Each zone corresponds to a separate geological formation and is defined by tool responses which are relatively uniform within the zone itself and different from those of the adjacent zones. The neutron, density, sonic and gamma ray clay response for each zone were defined using neutron/density and sonic/density crossplots and histograms of the selected clay points on the plots (Figures 3-6).

Pickett Plots of Rt (true formation resistivity) versus neutron/density crossplot porosity were used to determine the free water (connate water) resistivity for each zone (Figures 7-10). An RWA/Porosity crossplot was used to determine the bound water (shale associated water) resistivity in each zone (Figures 7-10).

The measurements used for the determination of clay volume in Zone 1 (2112-2503 meters) were the gamma ray and the sonic/density crossplot (see Table 3). The measurements used for the determination of clay volume in Zone 2 (1842-2112 meters) were the gamma ray and the neutron/density crossplot (see Table 4). The measurements used for the determination of clay volume in Zone 3 (1636-1842 meters) were the gamma ray and the neutron/density crossplot (see Table 5). The measurements used for the determination of clay volume in Zone 4 (1080-1636 meters) were the gamma ray and the neutron/density crossplot (see Table 6). In all of the zone analyses the rugose hole sections were discriminated out using the caliper.

All of the parameters used in the calculation of each zone in this well appear in Tables 7-10. Due to the poor borehole condition in this well, the invaded zone water saturation (Sxo) was <u>not</u> calculated from the Rxo tool readings. The sonic was used extensively for bad hole porosity control.

A CPI (computer processed interpretation) for this well is attached to this report. In addition, a detailed reservoir summary report using porosity and water saturation cutoffs as supplied by the ELAFE geologist is included as Table 1.

<u>Technique</u>

A Dual Water Model was used to compute effective and total porosities, water saturations and a volumetric breakdown of the main constituents of the rock (wet clay, dry clay, silt and matrix volumes). The matrix density for the formation was entered and the program calculated the neutron and density porosities using a sandstone/limestone/dolomite model. The neutron and density porosities were then corrected for clay and hydrocarbon effects. An iterative technique was used to do the hydrocarbon corrections based upon the input hydrocarbon density. If at the end of the iteration the hydrocarbon and clay corrected porosities for the neutron and density were not equal, then the program automatically adjusted input parameters to resolve the discrepancy. The adjustments were performed in the following order:

1) The input matrix density was adjusted. This option was allowed for this analysis.

2) The input clay volume was adjusted. This option was not allowed for this well.

3) If the previous adjustments did not resolve the discrepancy, the neutron or density input values were considered in error and one or the other was reduced until the discrepancy was resolved.

Between each of the aforementioned adjustments a complete set of hydrocarbon iterations was performed.

The following equations were used in the Dual Water Model analysis:

Matrix corrected neutron porosity:

PNC = PHIN + (PNS - PHIN)(2.71 - RHOMA)/.06

where: PHIN = Input limestone neutron porosity
PNS = Neutron sandstone porosity

Matrix corrected neutron wet clay porosity:

PNWCC = PNWC + (PNSWC - PNWC)(2.71 - RHOMA)/.06

where: PNWC = Input limestone neutron porosity for wet clay
PNSWC = Neutron sandstone porosity for wet clay

Density calculations:

PDC = (RHOMA - RHOB)/(RHOMA - RHOMF)

PDDC = (RHOMA - RHODC)/(RHOMA - RHOMF)

PDWC = (RHOMA - RHOWC)/(RHOMA - RHOMF)

where: RHOB = Input curve density
RHODC = Dry clay density
RHOWC = Wet clay density

Neutron porosity for dry clay:

PNDCC = 1 - (1 - PDDC)(1 - PNWCC)/(1 - PDWC)

where: PNWCC = Wet clay neutron porosity

Density and neutron clay corrections:

PDCR = PDC - VCL * PDWC

PNCR = PNC - VCL * PNWCC

where: VCL = Volume of clay

Wet clay point computation of total porosity and dry clay volume:

PTOTWC = (PDWC - PDDC)/(1 - PDDC)

VDCWCP = 1 - PTOTWC

Neutron Excavation Factor:

PHIX = PHIE + VCL * PNWCC

SWH = (PHIE(1 - SHR + SHR * PNH) + VCL * PNWCC)/PHIX

$$PNEX = (RHOMA/2.66)^2(2*SWH*PHIX^2 + .04*PHIX)(1 - SWH)$$

where: SHR = Residual hydrocarbon saturation

Hydrocarbon corrected neutron and density porosity:

PNHC = (PNC + PNEX - VCL*PNWCC*B*SHR)/(1 - B*SHR)

PDHC = (RHOMA-RHOC+VCL*PDWC*A*SHR)/(RHOMA-RHOMF+A*SHR)

where: B = Neutron residual hydrocarbon factor
A = Density residual hydrocarbon factor

Total porosity:

PHIT = (PDHC * PNDCC - PNHC * PDDC)/(PNDCC - PDDC)

Dry clay volume and bound water saturation:

VDC = VCL * VDCWCP

SWB = (VDC * PTOTWC)/(VDCWCP * PHIT)

Effective porosity:

PHIE = PHIT(1 - SWB)

Water and hydrocarbon saturation:

$$SWT = \left[\frac{Rt*PHIT^{m}}{a} \left(\frac{1}{RwF} + \frac{SWB}{SWT} \left(\frac{1}{RwB} - \frac{1}{RwF} \right) \right) \right]^{-1/n}$$

$$SXOT = \left[\frac{RXO*PHIT^{m}}{a} \left(\frac{1}{RmfF} + \frac{SWB}{SXOT} \left(\frac{1}{RmfB} - \frac{1}{RmfF} \right) \right) \right]^{-1/n}$$

SW = (SWT - SWB)/(1 - SWB)

SXO = (SXOT - SWB)/(1 - SWB)

SHR = 1 - SXO

Volumetric calculations:

BVW = PHIE * SW

BVWSXO = PHIE * SXO

VWCLAY = VCD + SWB * PHIT

VMATRIX = PHIE(1 - PHIMAX)/PHIMAX

VSILT = 1 - PHIT -VDC -VMATRIX

LOGISTICS MAP BALTIC OPERATIONS

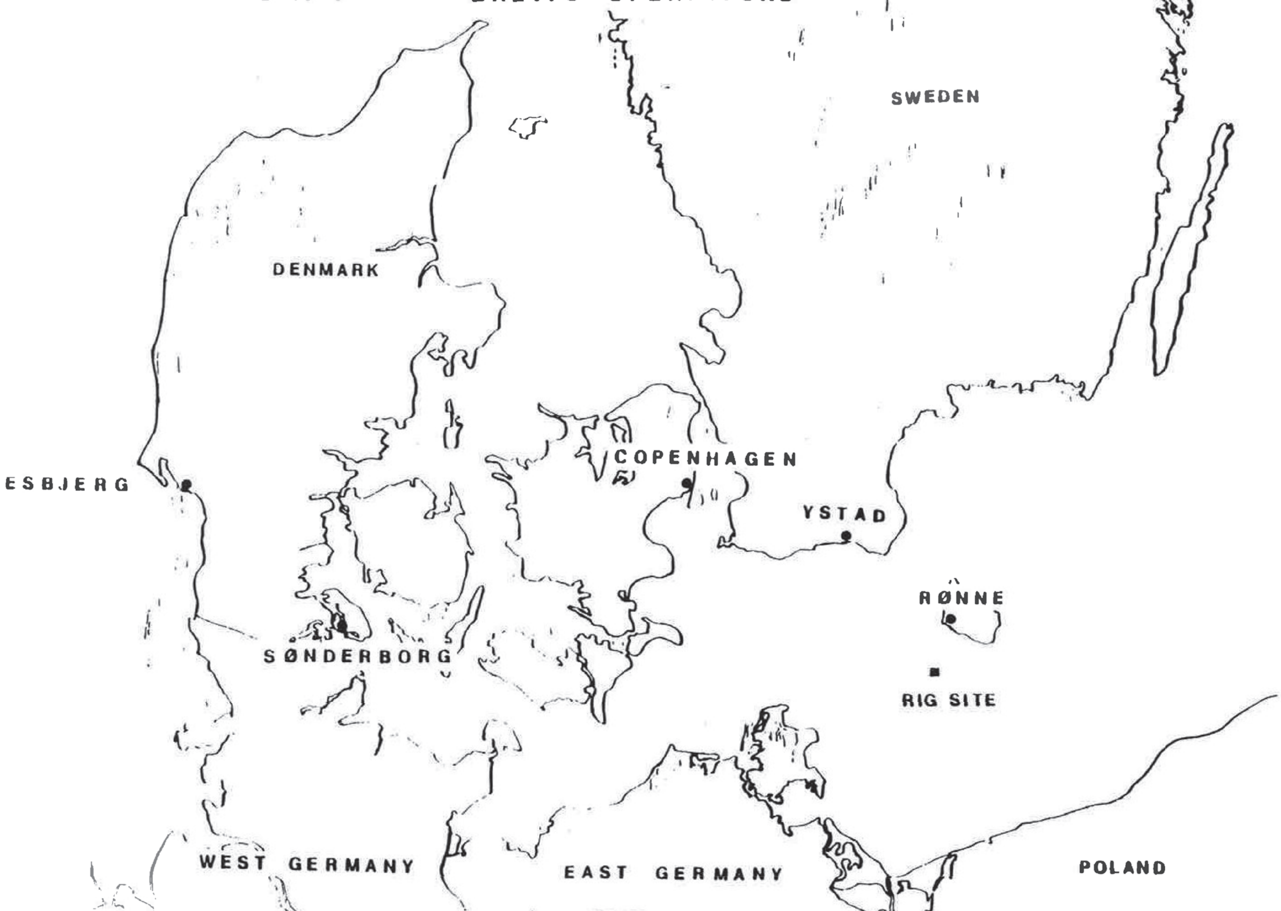


FIGURE 1

STINA-1 WELL STRATIGRAPHY

Formation tops based on cuttings and log information.
Tops listed are meters below RKB.

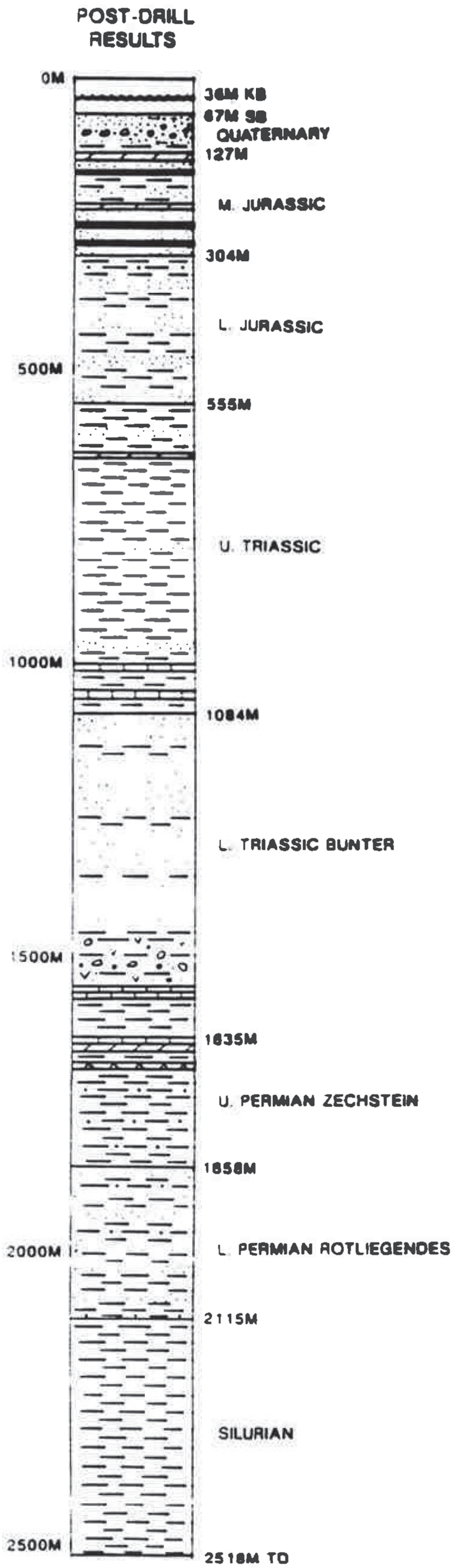
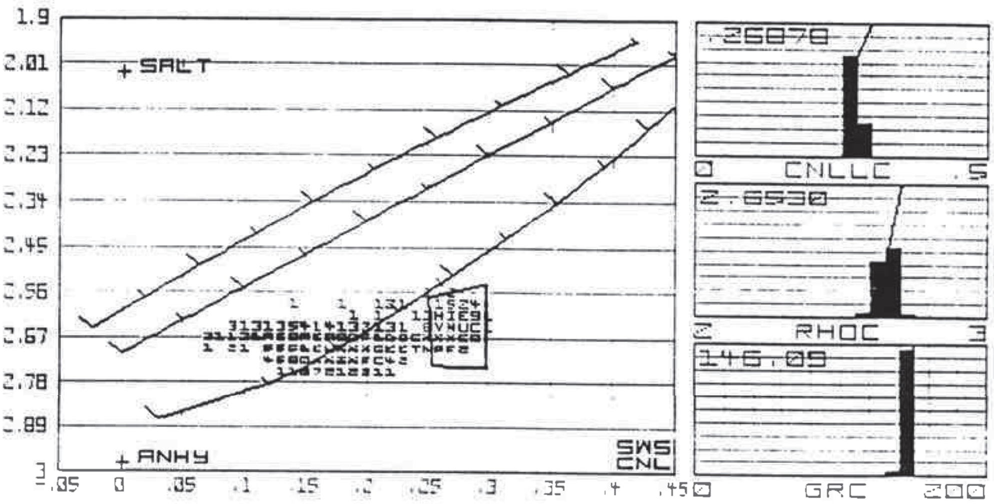


FIGURE 2

NEUTRON/DENSITY & SONIC/DENSITY CROSSPLOTS

ZONE 1

ZONE : From 2112.00 to 2503.00 M
X: CNLLC DEC Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150



ZONE : From 2112.00 to 2503.00 M
X: DTAFF MS/F Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150

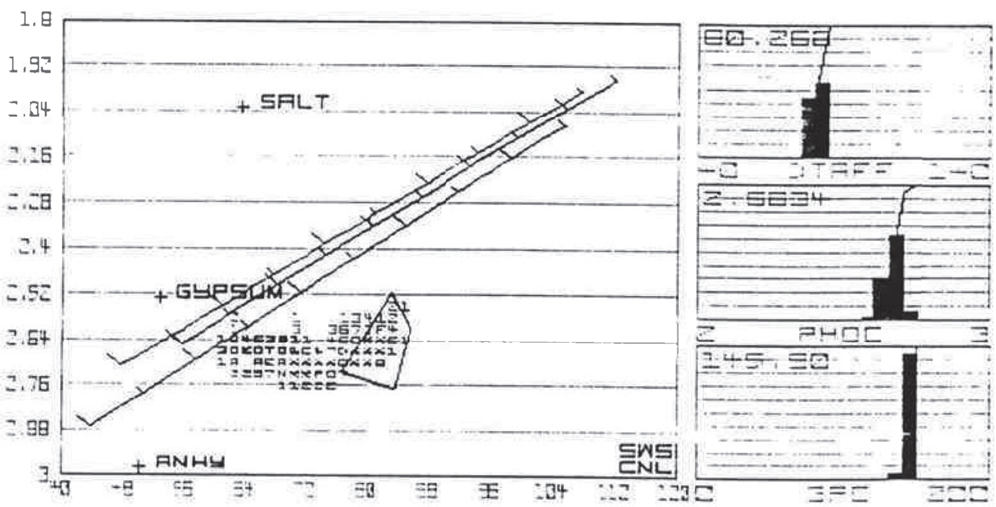
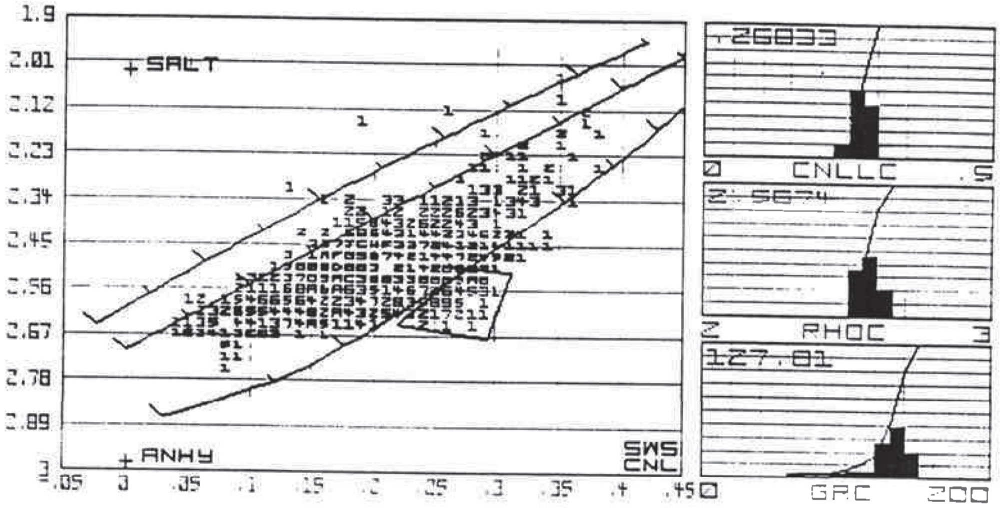


FIGURE 3

NEUTRON/DENSITY & SONIC/DENSITY CROSSPLOTS

ZONE 2

ZONE : From 1842.00 to 2112.00 M
X: CNLLC DEC Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150



ZONE : From 1842.00 to 2112.00 M
X: DTAFF MS/F Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150

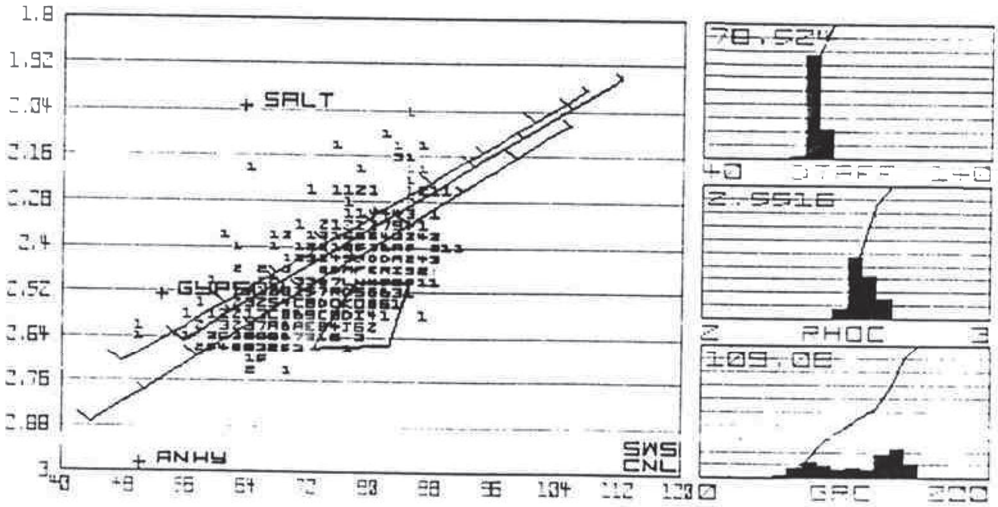
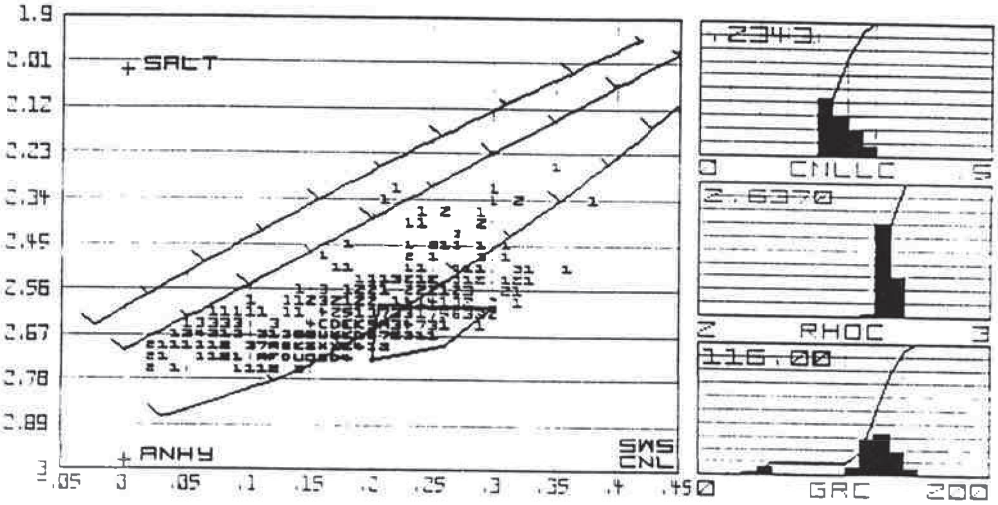


FIGURE 4

NEUTRON/DENSITY & SONIC/DENSITY CROSSPLOTS

ZONE 3

ZONE : From 1636.00 to 1842.00 M
X: CNLLC DEC Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150



ZONE : From 1636.00 to 1842.00 M
X: DTAFF MS/F Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150

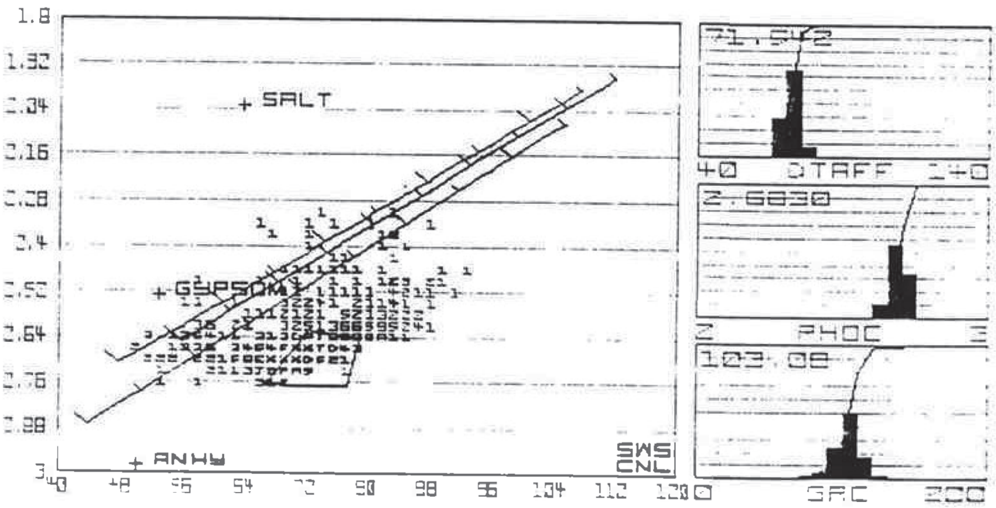
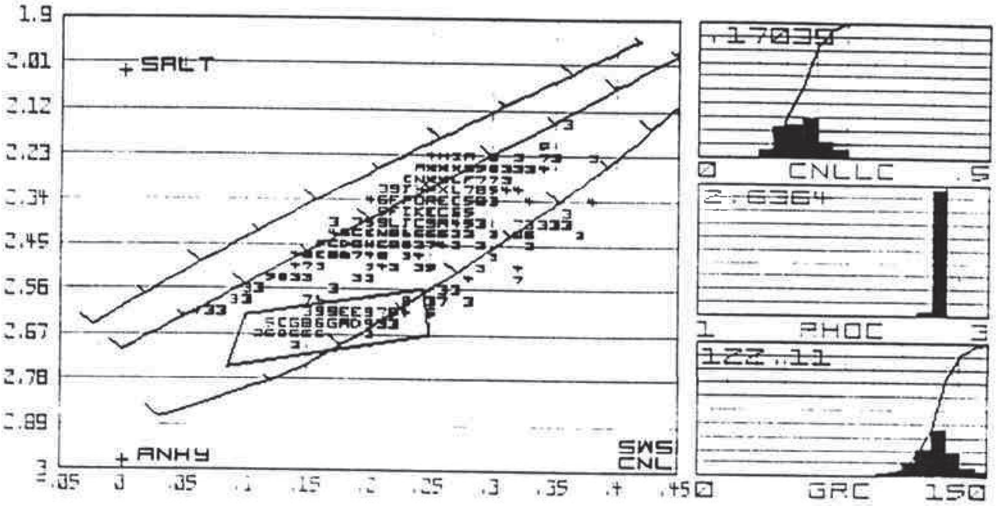


FIGURE 5

NEUTRON/DENSITY & SONIC/DENSITY CROSSPLOTS

ZONE 4

ZONE : From 1080.00 to 1636.00 M
X: CNLLC DEC Y: RHOC GM/CC Z: PEF
Z scale: 1 1.66662.33333 3.66664.33335



ZONE : From 1080.00 to 1636.00 M
X: DTAFF MS/F Y: RHOC GM/CC Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150

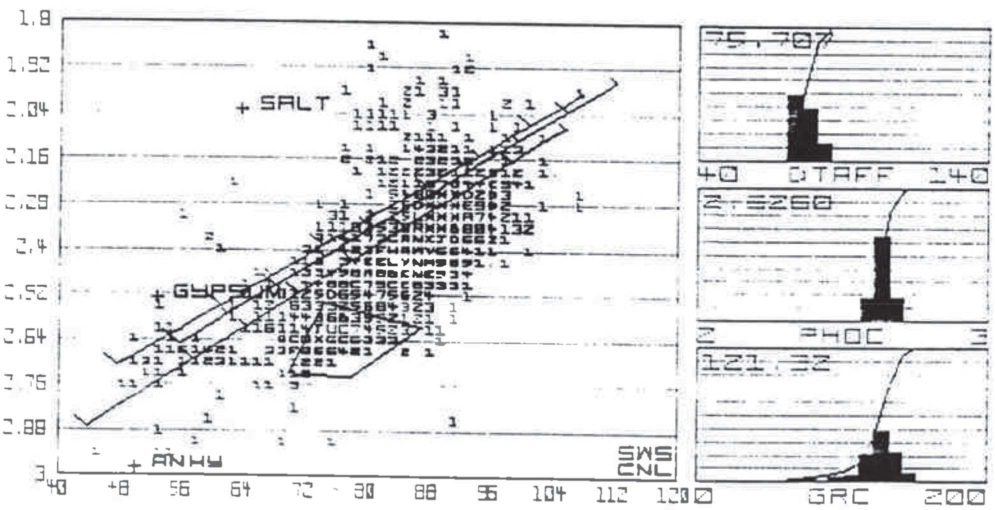
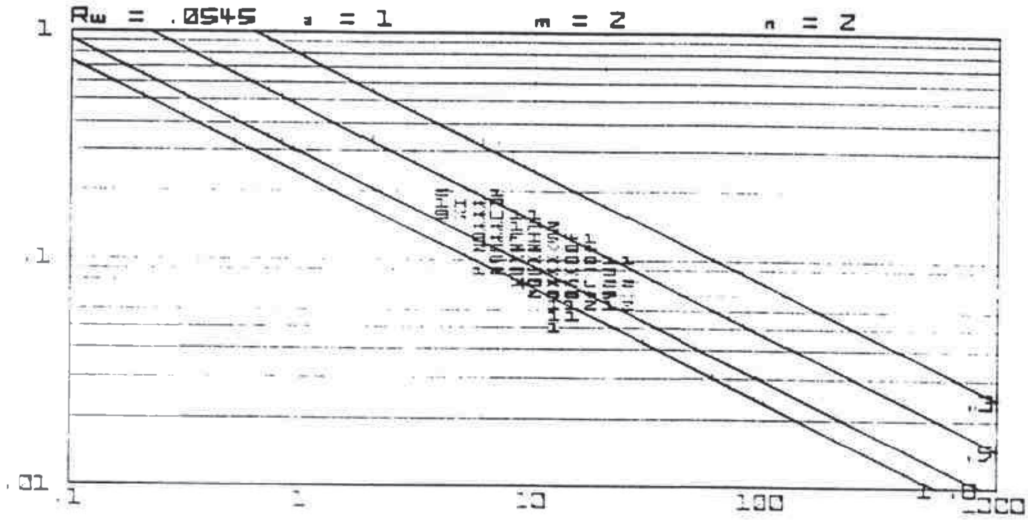


FIGURE 6

FREE WATER PICKETT PLOT & BOUND WATER PLOT

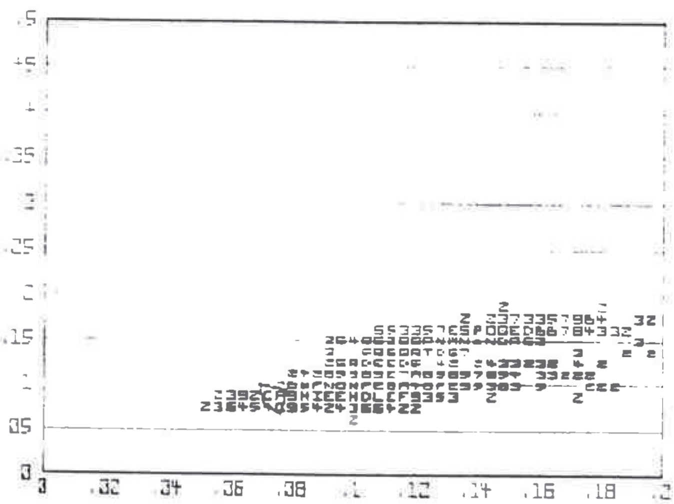
ZONE 1

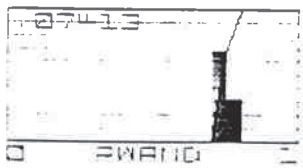
ZONE : From 2112.00 to 2503.00 M
X: LLDC OHM-M Y: PND DECIMAL Z: GRC API UNIT
Z scale: 0 25 50 75 100 125 150



Free Water

ZONE : From 2112.00 to 2503.00 M
X: RWAND OHM-M Y: PND DECIMAL Z: VCL DECIMAL
Z scale: 0 .16667 .33333 .5 .66667 .833331





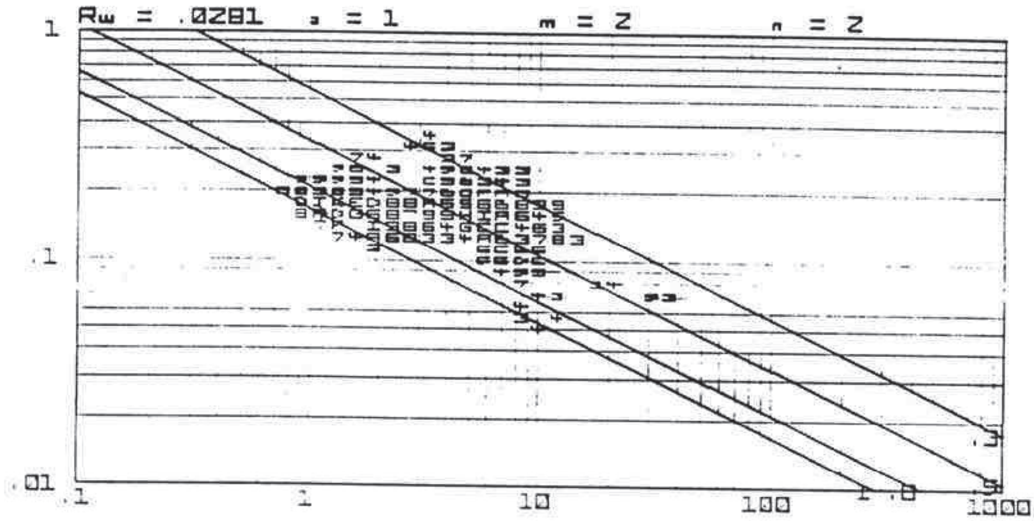
Bound Water

FIGURE 7

FREE WATER PICKETT PLOT & BOUND WATER PLOT

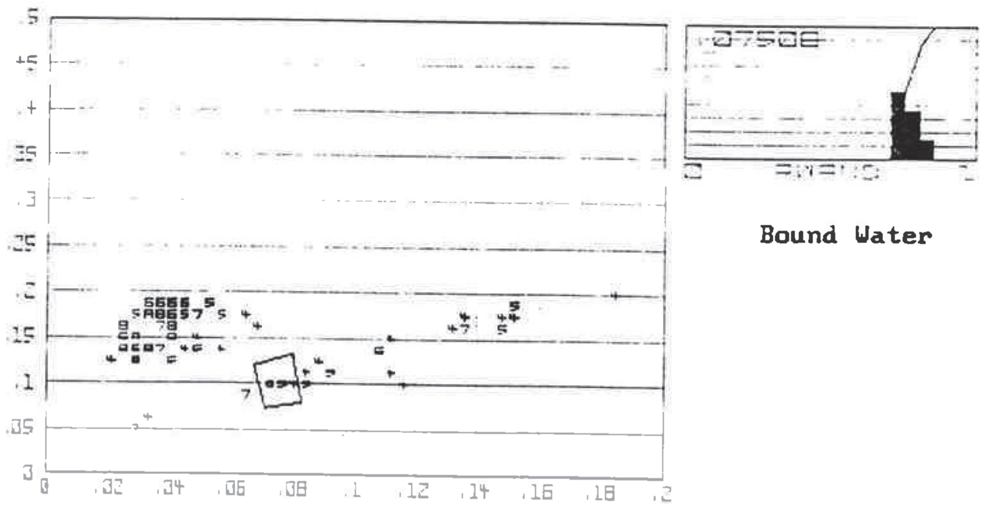
ZONE 2

ZONE : From 1842.00 to 2112.00 M
X: LLDC OHM-M Y: PND DECIMAL Z: VCL DECIMAL
Z scale: 0 .16667.33333.5 .66667.833331



Free Water

ZONE : From 1842.00 to 2112.00 M
X: RWAND OHM-M Y: PND DECIMAL Z: VCL DECIMAL
Z scale: 0 .16667.33333.5 .66667.833331

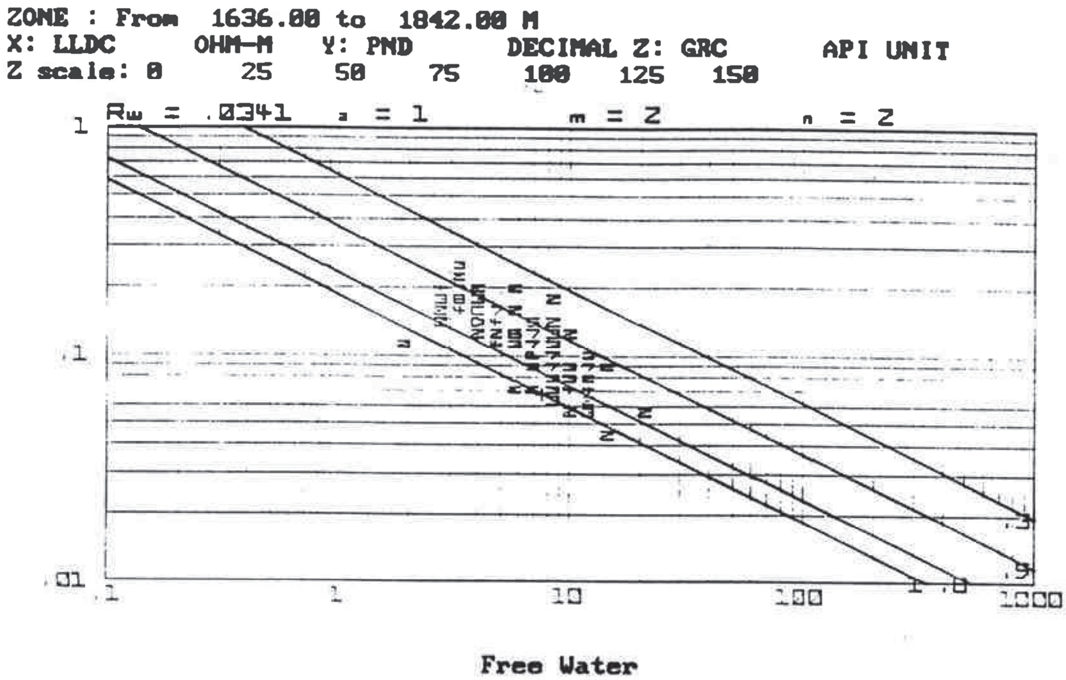


Bound Water

FIGURE 8

FREE WATER PICKETT PLOT & BOUND WATER PLOT

ZONE 3



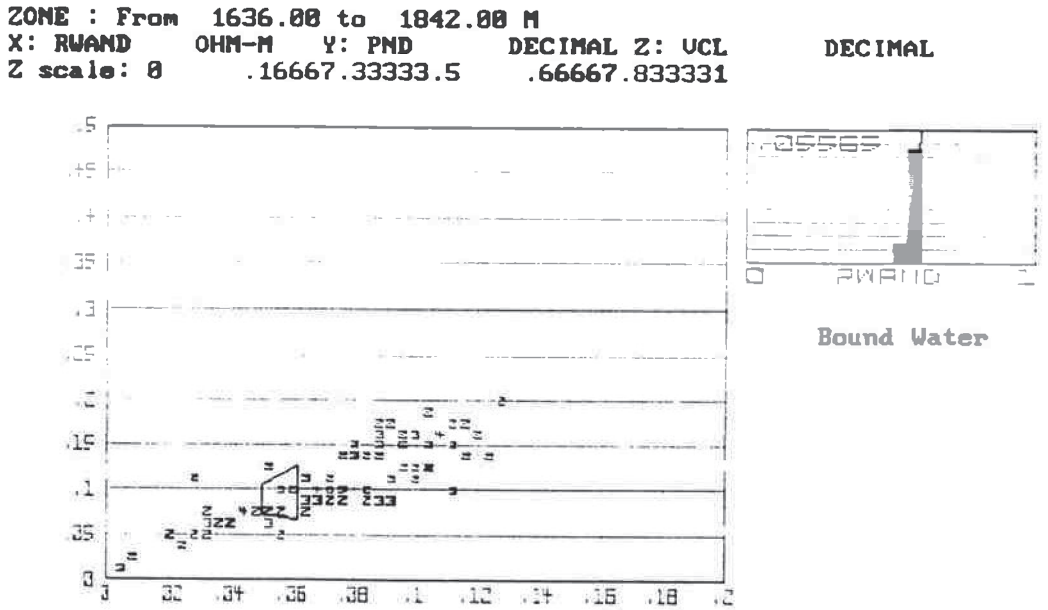
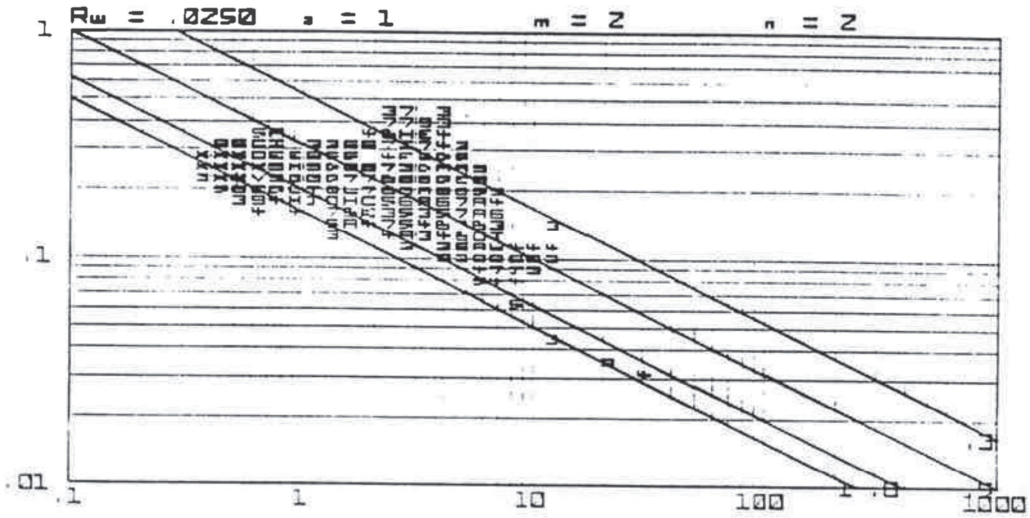


FIGURE 9

FREE WATER PICKETT PLOT & BOUND WATER PLOT

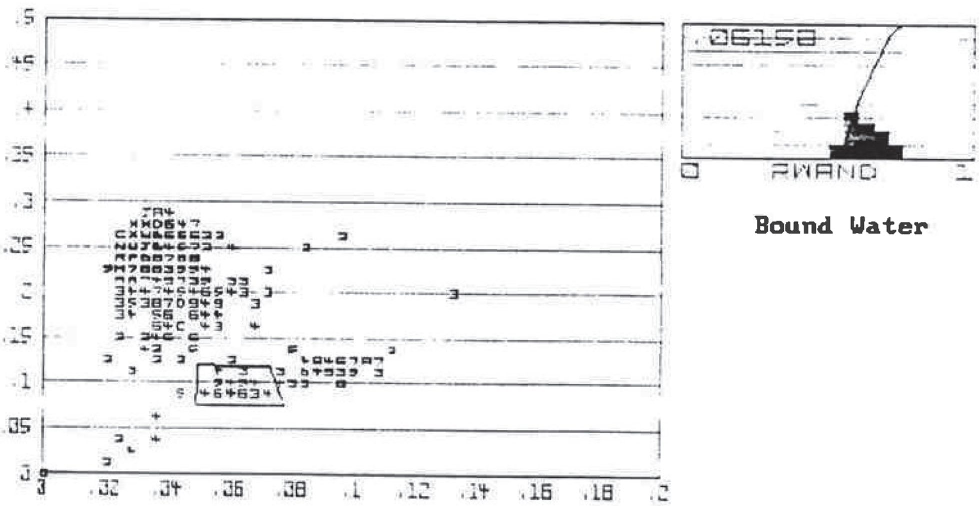
ZONE 4

ZONE : From 1080.00 to 1636.00 M
X: LLDC OHM-M Y: PND DECIMAL Z: VCL DECIMAL
Z scale: 0 .16667 .33333 .5 .66667 .833331



Free Water

ZONE : From 1080.00 to 1636.00 M
X: RWAND OHM-M Y: PND DECIMAL Z: VCL DECIMAL
Z scale: 0 .16667 .33333 .5 .66667 .833331



Bound Water

FIGURE 10

COMPANY : AMOCO DENMARK EXPLORATION COMPANY

WELL : 5414/7-1 (STINA-1)

FIELD : WILDCAT

COUNTY : OFFSHORE

STATE : BALTIC SEA

COUNTRY : DENMARK

20-JUL-89 @ 14:43:08

CUTOFFS USED TO COMPUTE SUMMATION AVERAGES

NET PAY AVERAGES

CLAY VOLUME	<=	.350
MINIMUM POROSITY	>=	.100
MAXIMUM POROSITY	<=	(NOT USED)
WATER SATURATION	<=	.400

RESERVOIR ROCK AVERAGES

CLAY VOLUME	<=	.350
MINIMUM POROSITY	>=	.100
MAXIMUM POROSITY	<=	(NOT USED)

DISCRIMINATORS USED

8 <= CALI <= 14

ZONE : From 1080.00 to 2503.00 M

ZONE NAME	ZONE TOP	ZONE BASE	GROSS INTERVAL	NET PAY	AVG PHI	AVG Sw	AVG VCL	NET RES ROCK	AVG PHI	AVG VCL
BUNTER	1080.00	1636.00	556.25 M	.50 M	.332	.170	.111	109.75 M	.222	.273
ZECHSTEIN	1636.00	1842.00	206.25 M	.25 M	.140	.127	.324	1.25 M	.118	.073
ROTLIEGENDES	1842.00	2109.00	267.25 M	1.75 M	.183	.352	.181	27.50 M	.138	.277
SILURIAN	2109.00	2503.00	394.25 M	.00 M	.000	1.000	1.000	.25 M	.138	.000

TABLE 1

Table 2 not included in original

```
541477-1
 8-JUL-89 @ 00:48:16
ZONE : From  2112.00 to  2503.00


          CLAY VOLUME DETERMINATION


CROSS PLOT curves and parameters given as:
Density curve      = RHOC      clay    =    2.65
Neutron curve      = CNLLC     clay    =     .27
Sonic curve        = DTAFF     clay    =   80.00

LINES option chosen
    Density (at the point where Neutron is zero) =     2.65
    Density (at the point where Neutron is 0.20) =     2.28
    Sonic   (at the point where Density is 2.20) =    90.00
    Sonic   (at the point where Density is 2.70) =    48.00
```

TABLE 3

5414/7-1 (STINA-1)
21-JUL-89 @ 13:33:03
ZONE : From 1842.00 to 2112.00

CLAY VOLUME DETERMINATION

```
Gamma Ray curve    = GRC     clean   =  23.00 clay    =  127.00
Discriminator1     = CALI    minimum =   8.00 maximum =   14.00

CROSS PLOT curves and parameters given as:
Density curve      = RHOC    clay    =   2.57
Neutron curve      = CNLLC   clay    =    .27

LINES option chosen
    Density [at the point where Neutron is zero] =    2.65
    Density [at the point where Neutron is 0.20] =    2.28
```

TABLE 4

541477-1
8-JUL-89 @ 00:14:17
ZONE : From 1636.00 to 1842.00

CLAY VOLUME DETERMINATION

GAMMA RAY curved
Gamma Ray curve = GRC clean = 30.00 clay = 116.00
Discriminator1 = CALI minimum = 14.00 maximum = 30.00

CROSS PLOT curves and parameters given as:
Density curve = RHOC clay = 2.64
Neutron curve = CNLLC clay = .23

LINES option chosen
Density (at the point where Neutron is zero) = 2.65
Density (at the point where Neutron is 0.20) = 2.28

TABLE 5

```
541477-1
7-JUL-89 @ 23:49:10
ZONE : From  1080.00 to  1636.00


          CLAY VOLUME DETERMINATION

GAMMA RAY curved
Gamma Ray curve     = GRC       clean    =   35.00 clay     =  125.00
Discriminator1      = CAL1      minimum  =   14.00 maximum  =   30.00

CROSS PLOT curves and parameters given as:
Density curve       = RHOC      clay     =    2.61
Neutron curve       = CNLLC     clay     =     .24

LINES option chosen
    Density (at the point where Neutron is zero) =      2.65
    Density (at the point where Neutron is 0.20) =      2.28
```

TABLE 6

5414/7-1 (STINA-1)
17-JUL-89 @ 08:00:57
ZONE : From 2112.00 to 2503.00

CONSTANTS used by DUAL WATER ANALYSIS

Input curve names are:

CNLLC	for	NEUTRON
RHOC	for	DENSITY
DTAFF	for	SONIC
VCL	for	VOLUME CLAY
CLF	for	CLAY FLAG
LLDC	for	RT
T	for	TEMPERATURE

Neutron type was CNL
Rho matrix was variable
Hydrocarbon density was fixed to the input value
Vclay was fixed to the input value
Porosity model was standard
m was variable with vclay
Discriminator for limit logic was CALI
Discriminator minimum limit = 14.000
Discriminator maximum limit = 30.000

User specified parameters

RwF	= .055	RwF Temp	= 143	RmfF	= .054
RmfF Temp	= 75	RwB	= .074	RwB Temp	= 143
RmfB	= .074	RmfB Temp	= 143	MF Density	=
P NaCl	=	HC Density	= .3	HC Den Min.	=
Neu HC Factor	=	Den HC Factor	=	Phi*Shr Limit	=
Matrix Den.	= 2.65	Wet Clay Den	= 2.653	Dry Clay Den	= 2.8
Neu Wet Clay	= .268	Phi Max	= .1	Delta Phi Max	=
Delta GD +	= .1	Delta GD -	= .03	a	= 1
m	= 2	n	= 2	Vo Clay Limit	= .35
EXP (Sxo-Sw)	= .2	IF (SW-Sxo)	= 3	Den Salt	=
Neu Salt	=	Den Coal	=	Neu Coal	=
TP Water	=	TP Clay	=	TP Hydrocarbon	=
TP Limestone	=	TP Sandstone	=	TP Dolomite	=
Min Value m	=	Max Value m	=		
Discrim. Min.	= 14	Discrim. Max.	= 30		

Bad hole logic Sonic parameters

DT Matrix	= 55.6	DT Fluid	= 181	DT Clay	= 80
CP	= 1				

MF Density	was calculated to be	1.101
P NaCl	was calculated to be	.150

++

TABLE 7

5414/7-1 (STINA-1)
18-JUL-89 @ 08:16:21
ZONE : From 1842.00 to 2112.00

CONSTANTS used by DUAL WATER ANALYSIS

Input curve names are:

CNLLC	for NEUTRON
RHOC	for DENSITY
DTAFF	for SONIC
VCL	for VOLUME CLAY
CLF	for CLAY FLAG
LLDC	for RT
T	for TEMPERATURE

Neutron type was CNL
Rho matrix was variable
Hydrocarbon density was fixed to the input value
Vclay was fixed to the input value
Porosity model was standard
m was variable with vclay
Discriminator for limit logic was CALI
Discriminator minimum limit = 14.000
Discriminator maximum limit = 30.000

User specified parameters

RwF	= .028	RwF Temp	= 134	RmfF	= .054
RmfF Temp	= 75	RwB	= .075	RwB Temp	= 134
RmfB	= .075	RmfB Temp	= 134	MF Density	=
P NaCl	=	HC Density	= .3	HC Den Min.	=
Neu HC Factor	=	Den HC Factor	=	Phi*Shr Limit	=
Matrix Den.	= 2.68	Wet Clay Den	= 2.567	Dry Clay Den	= 2.8
Neu Wet Clay	= .268	Phi Max	= .22	Delta Phi Max	=
Delta GD +	= .1	Delta GD -	= .03	a	= 1
m	= 2	n	= 2	Vo Clay Limit	= .35
EXP (Sxo-Sw)	= .2	IF (SW-Sxo)	= 3	Den Salt	=
Neu Salt	=	Den Coal	=	Neu Coal	=
TP Water	=	TP Clay	=	TP Hydrocarbon	=
TP Limestone	=	TP Sandstone	=	TP Dolomite	=
Min Value m	=	Max Value m	=		
Discrim. Min.	= 14	Discrim. Max.	= 30		

Bad hole logic Sonic parameters

DT Matrix	= 55.6	DT Fluid	= 181	DT Clay	= 78
CP	= 1				

MF Density	was calculated to be	1.102
P NaCl	was calculated to be	.150

++

TABLE 8

5414/7-1 (STINA-1)
17-JUL-89 @ 07:57:30
ZONE : From 1636.00 to 1842.00

CONSTANTS used by DUAL WATER ANALYSIS

Input curve names are:

CNLLC	for	NEUTRON
RHOC	for	DENSITY
DTAFF	for	SONIC
VCL	for	VOLUME CLAY
CLF	for	CLAY FLAG
LLDC	for	RT
T	for	TEMPERATURE

Neutron type was CNL
Rho matrix was variable
Hydrocarbon density was fixed to the input value
Vclay was fixed to the input value
Porosity model was standard
m was variable with vclay
Discriminator for limit logic was CALI
Discriminator minimum limit = 14.000
Discriminator maximum limit = 30.000

User specified parameters

RwF	= .034	RwF Temp	= 131	RmfF	= .054
RmfF Temp	= 75	RwB	= .056	RwB Temp	= 131
RmfB	= .056	RmfB Temp	= 131	MF Density	=
P NaCl	=	HC Density	= .3	HC Den Min.	=
Neu HC Factor	=	Den HC Factor	=	Phi*Shr Limit	=
Matrix Den.	= 2.65	Wet Clay Den	= 2.637	Dry Clay Den	= 2.8
Neu Wet Clay	= .234	Phi Max	= .17	Delta Phi Max	=
Delta GD +	= .1	Delta GD -	= .03	a	= 1
m	= 2	n	= 2	Vo Clay Limit	= .35
EXP (Sxo-Sw)	= .2	IF (SW-Sxo)	= 3	Den Salt	=
Neu Salt	=	Den Coal	=	Neu Coal	=
TP Water	=	TP Clay	=	TP Hydrocarbon	=
TP Limestone	=	TP Sandstone	=	TP Dolomite	=
Min Value m	=	Max Value m	=		
Discrim. Min.	= 14	Discrim. Max.	= 30		

Bad hole logic Sonic parameters

DT Matrix	= 55.6	DT Fluid	= 181	DT Clay	= 71.5
CP	= 1				

MF Density	was calculated to be	1.102
P NaCl	was calculated to be	.150

++

TABLE 9

5414/7-1 (STINA-1)
18-JUL-89 @ 08:21:24
ZONE : From 1080.00 to 1636.00

CONSTANTS used by DUAL WATER ANALYSIS

Input curve names are:
CNLLC for NEUTRON
RHOC for DENSITY
DTAFF for SONIC
VCL for VOLUME CLAY
CLF for CLAY FLAG
LLDC for RT
T for TEMPERATURE
Neutron type was CNL
Rho matrix was variable
Hydrocarbon density was fixed to the input value
Vclay was fixed to the input value
Porosity model was standard
m was variable with vclay
Discriminator for limit logic was CALI
Discriminator minimum limit = 14.000
Discriminator maximum limit = 30.000

User specified parameters

RwF	= .025	RwF Temp	= 128	RmfF	= .054
RmfF Temp	= 75	RwB	= .061	RwB Temp	= 128
RmfB	= .061	RmfB Temp	= 128	MF Density	=
P NaCl	=	HC Density	= .3	HC Den Min.	=
Neu HC Factor	=	Den HC Factor	=	Phi*Shr Limit	=
Matrix Den.	= 2.68	Wet Clay Den	= 2.636	Dry Clay Den	= 2.8
Neu Wet Clay	= .17	Phi Max	= .3	Delta Phi Max	=
Delta GD +	= .1	Delta GD -	= .03	a	= 1
m	= 2	n	= 2	Vo Clay Limit	= .35
EXP (Sxo-Sw)	= .2	IF (SW-Sxo)	= 3	Den Salt	=
Neu Salt	=	Den Coal	=	Neu Coal	=
TP Water	=	TP Clay	=	TP Hydrocarbon	=
TP Limestone	=	TP Sandstone	=	TP Dolomite	=
Min Value m	=	Max Value m	=		
Discrim. Min.	= 14	Discrim. Max.	= 30		
Bad hole logic Sonic parameters					
DT Matrix	= 55.6	DT Fluid	= 181	DT Clay	= 75.7
CP	= 1				

MF Density was calculated to be 1.102
P NaCl was calculated to be .150

++

TABLE 10

Appendices

67-70M:
SAND (100%); clear-transl or orng-rd, m occ f grained, subrnd-subang, well srtd, sph, tr calc cemt, sl calc, v glauc, good vis por.

70-79M:
SAND (100%); clr-mlky, transl occ orng-bn, f-m and v crs, subang-ang, sph v pr srt, tr calc cmt, calc mtx, mod glau, scattered lithic fragments, sl conglm, good vis por.

79-88M:
SAND (100%); clr-mlky occ orng-bn, m to v crse, subrnd-subang, sph, pr srtd, scattered fragment of clyst and lithic fragments scattered shale debris, conglomeratic fragments of igneous material, pos glacial boulder(?).

88-97M:
SAND/CGLM (100%); A/A with pyrite and lith fragm of granite and clyst. f-crse, v pr srtd.

97-106M:
CONGLOMERATE/SAND (100%); fragments of granite, metamorphics, quartzite and sandstone, and various lithic fragments of shale/siltstone, derived from glacial boulders? No shows.

106-115M:
BOULDERS CONGLOMERATE (100%); fragments of metamorphics, dolomite, granite, pyrite, quartz, clear to orange, violet, chert, varicoloured.
SAND interbeds.
No shows.

115-120M:
CLAY (40%); lt-m gy, sft, hydratable, slty.
CNGLM (60%); lithic fragments of limestone, metamorphics, sandstone, chert, pyrite, varicolored.
No shows.

120-124M:
DOLOMITE (30%); buff, hd, brit, plty wih ang to blocky break, microxln.
DOL (50%); lt brn, hd, sucrosic, micxln to xln.
CNGM (20%); qtz, metamorphic fragments a/a.
No shows.

124-133M:
SAND (70%); clr-lt buff, loose, fri, f-m, subang-subrnd, mod well srt, occ well cemt, sph.
DOLOMITE (20%); buff, hd, plty, mxln.
(10%) qtz & cngm frag's.
No shows.

134-140M:
SD (80%); clr-mlky, occ lt gy grains, loose, m-crse - v crse, pr srtd, subrounded-rounded, sph, good vis por. tr dol.
CLAY (20%); lt-m gy, sft, swel, slty,
COAL (Tr); vitr, brit, splint, ghost wood fibrous texture.
No shows.

140-148M: (spot sample)
SAND (70%); A/A. (unconsolidated)
CLAY (10%); A/A tr nod pyrite, plant remains.
FE DOLOMITE (20%); buff, v hd, ang brk, hackly break, finely fractured occ calc vns, mxln, microsucr.
No shows.

148-150M:
SAND (70%); clr-mlky, m-crse, pr srt, sbrnd, sph, loose, rare dol cmt, good vis por.
FERROAN DOL (10%); (ironstone?) buff, v hd, blky-ang brk microxln-microsucr.
COAL (10%); pyritized veins within coal.
CLAY (10%); lt gy sft, swel, abnt pyr nod.
No shows.

150-155M:
SAND (80%); A/A
CLAY (10%); A/A
COAL (10%); A/A
FE-DOL (Tr)
No shows.

155-160M:
SAND (85%); A/A
CLAY (10%); A/A
COAL (5%); A/A, heavily pryritized.

(6AM M.R. depth: 161M, 6/14/89)

160-165M:
SAND (85%); clear, fine to coarse, generally medium, sph to subsph, subrnd-rnd, unconsolidated quartz grains. Sl tr calc.
CLAY (10%); A/A, tr pyr nod.
COAL (5%); A/A, w/assoc pyrite.
No shows.

165-170M:
SAND (40%); A/A.
FE-DOL (30%); buff-v lt brn occ lt grn-brn, hd-frm, blky, ang brk, occ arg, microxln-microsucr.
COAL (Tr)
CLAY (30%); lt-med gy, frm-sft, swel, occ blky, slty, non calc, tr pyr nod.
No shows.

170-175M:
CLAY (40%); lt gy, sft, swel, slty, non-calc, w/pyr nod.
COAL (20%); vit-res lust, fibr, frm-brit.
SAND (30%); clr, m-crse, pr srt, sph, subrnd loose, gd vis por.
DOL (10%); yel-brn, buff, occ grn brn, hd, ang brk, microxln, sl ferroan.
No shows. Tr min fluor on coal.

175-180M:
CLAY (40%); w/pyrite A/A.
SAND (40%); A/A.
COAL (10%); A/A.
DOL (10%); A/A.
No shows.

180-185M:
CLAY (60%); lt-m gy, sft, swel, slty, abt pyrite nod.
SAND (70%); m-crse, sph, mod srt, subrnd, gd vis por.
COAL (10%); fibrous, frm-hd, brit, vit-res lust, blk-dk brn.
DOL (10%); buff-v lt brn, hd, blky-ang brit, microxln, occ arg, tr calcite sl Fe.
No shows.

185-190M:
SAND (60%); A/A
LIMESTONE (30%); lt-m gy, hd, blky, microxln-micritic.
CLAY (10%); A/A.
No shows.

190-195M:
CLAY (70%); lt-m gy, sft, non calc, swel, abnt pyr.
SAND (10%); A/A
LST (20%); Tr.
COAL: fibrous, lignitic.
No shows.

195-200M:
CLAY (70%); lt-m gy, sft, swell, non calc, abt pyr.
COAL (10%); fibrous, vit-res lustre, firm, occ brit.
SAND (10%); 10% Dol, tr lst.
No shows.

200-205M:
SAND (50%); clr, vf-f-m, uncons, subrnd, mod srtd, sph, tr dol cmt, good vis por.
CLAY (50%); lt-m gy, sft, swel, sol, carb, slty, sl DOL tr COAL.
No shows.

205-210M:
CLAY (90%); lt-gy, sft, sol, hydratable, v slty, carb.
COAL (10%); fibrous, res lustre, frm, tr plant remains.
No shows.

210-215M:
SAND (60%); clr-mlky, loose, f-m occ crs, mod srtd, subrund, sph-subsph, tr calc cmt, tr calcite, good vis por.
CLAY (20%); A/A with abnt nod pyr and pyr plant remains.
COAL (10%); A/A with tr plant remains.
DOL (10%); buff, lt brn, hd-frm, blky-ang, microxln, ferroan.
No shows.

215-220M:
SAND (70%); clr-transl-mlky, f-m occ crs, subrnd, sph, mod srtd, tr calc cmt, uncons, good vis por.
CLAY (20%); lt gry, sft, sol, swell, slty, tr pyr.
COAL (10); blk-dk brn, frm, brit, fibrous, vit-res.
No shows.

220-225M:
SAND (40%); A/A. Tr. mica.
COAL (70%); A/A. Large cvgs.
CLAY (40%); A/A, with pyr nodules.
No shows.

225-230M:
COAL (50%); blk-occ v-dk brn, frm-brit, occ subconchoidal, splint, fibrous, vit-res lustre pyr.
SAND (50%); clr-trnsl, m-crse, mod srtd, subrnd, sph, good vis por, tr calcite, tr mica.
No shows.

230-235M:
COAL (40%); A/A.
SAND (60%); A/A. Tr nod pyr. Tr Fe-Dol.

235-240M:
SAND (80%); clr-mlky, rr lt yel org, grains pitted, m-crs-v crse. Subrnd-subang, sph-subsph, mod-well srtd, loose, tr calc cmt, v gd vis por mica.
COAL (20%); A/A.
PYRITE (TR.) Nodular, pitted.

240-245M:
SAND (100%); clear transparent-translucent, fine to med grained, predominantly fine, well sorted, subrnd, sph-subsph, unconsolidated quartz grains, tr-1% coal fragments with minor nodular pyrite, gd vis porosity.
No shows.

245-250M:
SAND (70%); A/A, predominately fine grained with tr-1% muscovite, gd vis porosity.
No shows.
COAL (30%); Black, firm, slightly subfissile to subchoncoidal, resinous luster, tr nod pyrite. Coal exhibits greenish min fluor.
No shows.

250-255M:
SAND (100%); A/A, generally fine grained, unconsolidated, good vis Ø. Trace-1% coal A/A w/associated pyrite.
No shows.

255-260M:
SAND (100%); A/A with tr-1% coal fragments, A/A, gd vis Ø.
No shows.

260-265M:
SAND (100%); clear, gen translucent, fine-med grained, well sorted, predominantly subrounded, subsph, unconsolidated, good to very good apparent visual Ø. Tr-1% coal - some yellowish min fluor.
No shows.

265-270M:
SAND (90%); A/A, v good vis Ø. No shows.
COAL (10%); A/A, somewhat fissile.
SANDSTONE (Tr); white, opaque, v fine grained, hard, mod well sorted, mod well cemented with quartzose cement, non-calcareous, poor vis Ø. No shows.

270-275M:
SAND (70%); clear, fine-med, minor vf-grain component, subang-subrnd, subsph, tr muscovite. Good vis Ø. No shows.
COAL (30%); A/A, yellowish-green min fluor.

275-280M:
Minor Change in Fm. Constituents:
SAND (50%); A/A, v good vis Ø.
CLAY (20%); dk grey, blocky, semi-hydratable, sl calcareous, earthy texture, abundant pyrite, blocky-ang.
FERROAN DOLOMITE (20%); lt grey to olive grey. Hard, blky-ang fracture micro to cryptoxstalline, nil vis Ø. Good yellow-brn min flour.
ARKOSIC(?) SANDSTONE (10%); red to reddish brown, vf-f grained, mod sorting, subang, calcareous cement, poor vis Ø.
No shows.

280-285M:
SAND (70%); A/A, rare orangish yellow, opaque, med grains, tr. muscovite, v good vis Ø.
DOLOMITE (10%); A/A.
COAL (20%); A/A, sl min fluor yellowish-green, tr-1% pyrite.
ARKOSIC SANDSTONE (TR) A/A.

285-290M:
SAND (60%); A/A, v good vis Ø, tr muscovite. No shows.
COAL (30%); A/A
DOL (10%); buff-olive, hd, ang-blky, occ varicolored.

290-295M:
SAND (60%); A/A, v good vis Ø.
COAL (40%); blk, firm to soft, subfissile-fissle, occ fibrous-elongate, vit-resinous luster, tr-1% pyrite nod.
DOLOMITE (TR) A/A. Tr-1%.
No shows.

295-300M:
SAND (60%); clear, transparent to translucent, f-c grained, gen medium grained, mod-poor sorting, subrnd-subang, subsph, v good Ø, no shows.
COAL (30%); A/A, fissile to subfissile.
CLAY (10%); grey, soft, hydratable, v silty, nod pyrite (tr-1%)
(Calcimetry Results at 300M: 0%)

300-305M:
SAND (60%); A/A, tr amorphous quartzose spar, pink and yellow.
SANDSTONE (20%); Grey, translucent-opaque, vf-f grained, mod hard, blky, mod sorted, calcarous cement, (at 306M rop fropped significantly), sl tr rock fragments as part of framework grains, v poor vis Ø, no shows.
COAL (20%); A/A

305-310M:
SANDSTONE (80%); A/A, grey and lt brown in color, occ fractures in elongate sections, v poor vis Ø, no shows.
COAL (10%); A/A, with abnt assoc pyrite.
DOL (10%); A/A, some min fluor (yellowish-green).
SAND (TR); A/A

310-315M:
SANDSTONE (100%); A/A, predominantly med-grey, strong calcite cement continues, slightly argillaceous to silty, v poor to nil vis Ø, Tr-1% coal. No shows.

315-320M:
SANDSTONE (90%); A/A, continues argillaceous pyritic nodules and carbonaceous (Tr-1% coal), v poor vis Ø, no shows.
CLAY (10%); med grey, soft, semi-hydratable (generally washes out of sample). No shows.

320-325M:
CLAY (90%); lt-m gy, frm-sft, swel, hydratable, slty, non calc, sl carb.
SANDSTONE (10%); A/A. No shows.

325-330M:
SST (60%); lt-m gy, occ dk gy, hd, v f gdg to sltst, subrnd, sph-sl elg, v well cmt, gen silic cmt, v por vis por, arg mtx.
CLAY (40%); A/A. Tr pyr, tr dol (Fe), sl carb.

330-335M:
CLAY (30%); Med gy, frm-sft, swel, non calc.
SLST (70%); Med gy, hd, v arg, occ gdg to v f sst, silic cmt, poor vis por. No shows.

335-340M:
CLAY (70%); A/A. Tr pyrite tr Fe Dol.
SLST (30%); A/A.
No shows.

340-345M:
CLAY (50%); med grey, sft-hydratable, v slty, carb, non calc.
SLTST (50%); med gy, hd-frm, blky, mic, arg, gdg to v f sst
COAL (TR)
No shows.

345-350M:
CLAY (80%); med gy, frm-sft, swel, slty, carb mat, non calc, tr pyr, tr coal.
SLST (20%); med gy, frm-hd, blky, arg.
No shows.

350-355M:
CLAY (70%); w/pyrite A/A.
SLST (30%); A/A.
COAL (TR)
No shows.

355-360M:
CLAY (90%); med gy, sft, swel, abnt pyr nod, slty, non calc.
SLST (10%); A/A. No shows.

360-365M:
CLAY (90%); lt-med gy, sft, plastic.
SLST (10%); m gy, hd, blky, arg.

365-370M:
CLAY (100%); A/A. Tr coal pos cvgs. Cement contamination.

370-375M:
CLAY (100%); A/A. Slty, some cement contamination and polymer contamination.

375-380M:
CLAY (100%); lt-m gy, v contaminated with mud additive and cement. No shows.
10M samples while drilling over 25M/hr.

380-390M:
CLAY (100%); lt-med gy, sft, sol, highly dispersed, swelling, occ scattered silt. Non calcareous. Tr scat clr sand grains, tr carb mat, tr coal, loosing mud over shakers.

390-395M:
CLAY (100%); lt-med gy, speckled, sft, swelling, highly dispersed, hydratable, tr coal frags, non calc. No shows.

395-400M:
(Control Drill to 50M/hr.)
CLAY (100%); A/A with tr-1% coal fragments. Coal is black, mod firm, subfissile, and highly disseminated throughout sample in v f-f sand size fragments.

400-410M:
CLAY (100%); lt-med grey, very soft, dispersive and hydratable, trace coal. No shows.

410-420M:
CLAY (100%); A/A. Tr-1% coal fragments, (non calcareous). No shows. (PHPA mud appears to be coagulating clay well, although the clay appears to be dispersive by nature. Carbide log indicates hole to be ~400 stokes overgauge).

420-430M:
CLAY (100%); lt-med grey, very soft, dispersive and hydratable, appears massive with a lack of any bedding features, non calcareous. Tr-1% silt. No shows.

430-440M:
CLAY (100%); A/A, slightly carbonaceous, tr-1% silt. No shows.

440-450M:
SAND (80%); clear, transparent, f-med. Generally fine grained, well sorted, subrnd, subspherical unconsolidated, non calcareous quartz grains, v good vis Ø, no shows.
COAL (10%); blk, firm, blky fragments, tr pyrite
CLAY (10%); A/A

450-460M:
SAND (70%); A/A, v good vis Ø, no shows.
CLAY (30%); A/A w/trace-1% coal, sl tr nodular pyrite.

460-470M:
SAND (20%); A/A, v good vis Ø (unconsolidated), generally fine grained, no shows.
CLAY (70%); A/A, lt-med grey, soft, amorphous
COAL (10%); blk, firm, blocky fracture, some elongate fragments slightly pyritized in part.

470-480M:
CLAY (80%); A/A, non calcareous.
COAL (20%); blk, mod hard, blocky fracture, slightly planar-fissile, only sl pyritic in part. No shows.
(Appears to be interbedded coal seams within a rather homogenous claystone. Coal illustrates some woody debris. Minor sand units as well (440-460M).

480-490M:
CLAY (100%); A/A, sl tr silt, carbonaceous, no shows.

490-500M:
CLAY (80%); lt-med gy, speckled, sft, plastic, hydratable, swelling, non calcareous, tr scat qtz grns.
LIGNITE (20%); v dk brn, frm, earthy, fibrous. No shows.

500-510M:
CLAY (100%); A/A with good trace-1% lignite. Lignite is black to dark brown, generally soft, earthy. No shows.

510-520M:
CLAY (100%); A/A, generally light grey, non calcareous, sl trace lignite. No shows.

520-530M:
CLAY (100%); A/A, slightly carbonaceous with slight trace of silt. No shows.

530-540M:
CLAY (100%); lt grey, very soft, dispersive, hydratable, with a trace of brown fibrous plant remains. Non calcareous, no shows.

540-550M:
CLAY (100%); lt gy, rr med-gy, sft, hydratable, dispersed, non calc, sl tr silt. No shows.

550-560M: ** TOP TRIASSIC:555M **
CLYST (50%); brick red-mod red brn, occ lt grn gy, tr yel brn, frm-sft, blky-hydratable, hydrofissile, v sl dol.
CLAY (50%); lt brn-lt brn-gy tr med gy, sft, hydratable, non calc. No shows.

560-570M:
CLAYSTONE (40%); brick red-reddish brown and equally light greenish-grey in color, soft, blky, generally amorphous, hydratable, mod calcareous. The greenish colored claystone is predominately mod calcareous whereas the reddish claystone is sl calcareous/dolomitic.
CLAY (60%); lt brown-grey brown, A/A. No shows.

570-580M:
CLAYSTONE (50%); Brick red-reddish brn/lt grey grey, A/A.
CLAY (50%); lt brown to lt-med grey, A/A, remains non calcareous. No shows.
(ROP maintaining a range of 20-25M/hr.-hence sampling interval is 5M, from 580M md RKB).

580-585M: 5M SAMPLES
CLAYSTONE (50%); Predominately lt greenish-grey, with only 15-20% of sample having a reddish hue, mod calcareous, soft, blky, hydratable.
CLAY (50%); lt grey-med grey brn, v soft, amorphous, non calcareous, no shows.

585-590M:
CLAYSTONE (100%); predominantly reddish brown (70%), generally A/A, remains soft, dispersive and hydratable, no shows.

595-600M:
SAND (80%); clr, occ yel orgn grns, f-m, subrnd-rnd, well srtd, sph, unconsol, tr calc cmt, tr arg mtx, good vis por, spotty mineral fluor assoc with ls and dolomite, no shows.
CLYST (70%); lt gry-brn, occ dk rd-brn, frm, earthy, blky, occ subfiss, mod calc, tr LST.
(Drill break to ~62M/hr at ~600M MD; at 602M reversed to 46M/hr.).

600-605M:
SAND (80%); clear, occ yellow, orange, opaque grains, f-m, subang-subrnd, mod well sorted, slightly argillaceous, tr-1% limestone: white, microstalline, poor vis Ø, firm.
Sand has good vis Ø, no shows.
CLAY (20%); A/A.

605-610M:
SAND (30%); clear, org, yellow, to opaque yell-white, m-vc, subrnd, subsph, mod sorted quartz grains, tr limestone (A/A), tr anhydrite(?).
CLAYST (70%); brn, reddish brn, lt green-grey, firm to soft, blky, hydratable, slightly silty, mod calcareous.

610-615M:
SAND (70%); clear, occ org, yell, and opaque, f-c, generally med, mod well sorted, subrnd, tr limestone, white, firm. Good vis Ø, no shows.
DOL (10%); Olive green, grey, hard, blky, microxstalline, no Ø vis.
CLAYST (20%); A/A, generally brown, green.

615-620M:
CLYST (70%); lt grn-gy, occ streaked with mod grn and lt yel brn, occ brick red and red brn, frm-sft, blky, mod calc with occ ANHY streaks.
SAND (30%); clr-occ yel orng, qtz, m crse, subang, occ subrnd, sph sl subsph, mod-pr srtd, uncons, gd vis por, tr calc.
DOL; (TR) No shows.

620-625M:
CLYST (80%); lt gy brn, occ brick red, frm, blky, occ hydratable, v calc gdg to MARL.
SAND (20%); clr-org-yel, m-crs, pr srtd, subrnd, sph, uncons, gd vis por.
LST (TR); No shows.

625-630M:
MARL (90%); lt gy grn-brick red, frm, blky, swel, hydratable, no shows.
SAND (10%); clr-org-yel, m-crse, mod pr srt, sph, subrnd, gd vis por.

630-635M:
MARL (90%); lt brn-red-lt grn-gy, frm-sft, blky, swel hydratable. Tr DOL
No shows.
SAND (10%); clr-orng, orng-yel, m-v crse, w rnd-subrnd, pr srtd, sph, uncons, mostly occurring as scat qtz grns.

635-640M:
CLYST (90%); mod-rd-brn, tr grn gy, frm-sft, blky, hydr, swel, tr sand, mod calc.
LST (10%); wh-lt gy, crse, hd-frm, blky, micrxln.
No Shows

640-645M:
CLYST (90%); mod red brn-occ brn red, frm, blky occ subfiss, gen hydratable, mod calc.
SAND (10%); clr occ orng-brn, med-crse, subrnd, sph, mod-pr srt, gen good vis por.
LST (TR); Wh, frm-hd, sl arg, micritic.
DOL (TR); lt yel brn, hd, mxln.
No Shows.

645-650M:
CLAYST (90%); A/A, ~5% of sample is greenish clayst which remains mod calcareous. Trace-1% limestone. Limestone is white, firm-soft, amorphous-microcrystalline.
SAND (10%); A/A, gen good vis Ø interpreted, no shows.

650-655M:
CLAYSTONE (95%); Predominantly brownish red to brown, v soft, hydratable, slightly to moderately calcareous.
LIMESTONE (5%); white, v soft, hydratable, argillaceous.
SAND (TR-1%); A/A, good vis Ø interpreted, no shows.

655-660M:
CLAYSTONE (100%); Brownish red; A/A, trace-1% limestone-marl (micritic-argillaceous). No shows (Cal. 12%, Dol 2%).

660-670M:
CLAYSTONE (100%); A/A. Remains predominantly brownish red, sl-mod calcareous, with tr-1% limestone. White, firm to mod hard, microcrystalline, blky, argillaceous, no shows.

670-675M:
SAND (50%); clr-transl, m-crs, subrnd-rnd, sph, occ subelongate, mod srtd, good vis por.
CLYST (50%); mod red-brn, lt rd-brn, frm-sft, swell-blky, mod calc. Tr LST wh-off wh, hd, mxln, blky, pos caliche.

675-680M:
SAND (60%); A/A, predominantly medium to coarse, good vis Ø, no shows.
CLAYST (40%); A/A with tr-1% limestone (Cal: 6%, Dol. 1%).

680-685M:
CLAYST (90%); reddish brown and slightly greenish grey, v soft, hydratable, amorphous, occ blky, mod calcareous, gd trace-1% limestone.
SAND (10%); clear, m-c, subrnd, subsph, mod well sorted, unconsolidated quartz. Good vis Ø. No shows.

685-690M:
SAND (70%); clear, occ varicolored orange, red, f-c, predominantly medium, subang-subrnd, mod sorted, unconsd quartz, good Ø, no shows.
CLAY (30%); lt grey to brownish red, mod calcareous, 5% limestone (as previously described), caliche(?).

690-695M:
SAND (70%); A/A. Tr med grn inclusions. (Pos tuff frags).
CLAYST (20%); Red-brn - lt gy-brn, frm, hydratable, calc.
LST (10%); Off wh, frm-sft, arg gdg to mrl, also mxln.

695-700M:
CLAYST (95%); A/A, sl trace of tuffaceous material(?), green, hard, vf, glassy texture embedded within the claystone.
LST (5%); white, hard, blky, microcrystalline, no shows. (Cal:14%, Dol:1%).

700-705M:
CLAYST (95%); A/A, predominantly brick-red, occ greenish grey, remains mod calcareous.
LST (5%); A/A.

705-710M:
CLAYST (70%); A/A, lt brown, lt reddish brown, tr-5% limestone, as previously described.
SAND (30%); clear, occ red, org, vf-med, predominantly fine, subrnd, good vis Ø interpreted, unconsolidated, no shows.

710-715M:
CLAYST (95%); Predominantly brick red, 5% green to jade colored, soft, rarely firm.
LIMESTONE (TR-5%); A/A, somewhat amorphous-marly.
SAND (TR-5%); A/A, No shows.

715-720M:
CLAYST (60%); A/A, predominantly reddish brown, tr-5% marl/ls. Marl is white, v soft, hydratable. Clayst remains mod calcareous.
SAND (40%); clear, occ greenish, red org, f-m, predominantly fine, mod well sorted, subrnd-subang, subspherical, unconsolid qtz grains, v good vis Ø, no shows. (Cal:16%, Dol:4%).

720-725M:
CLAYST (70%); A/A, good tr-5% limestone, white, occ reddish, mod hard, microcrystalline, ang, blocky fracture. Marl-white, soft, argillaceous, amorphous.
SANDST (30%); A/A, good vis Ø, no shows.

725-730M:
SAND (50%); A/A, however, gen rounded, subspherical grains, good vis Ø.
CLAY (50%); A/A, tr-5% limestone, (as previous).

730-735M:
SAND (60%); clr, occ lt yel, occ lt orng, f-m, sph subrnd-rnd, mod well srtd, gd vis por, tr dk brn incl.
CLAYST (40%); lt red-brn-occ brick red, sft-frm, hydratable, mod calc.
LST (TR); Wh, frm-hd mxln, arg occ gdg to marl.
No shows.

735-740M:
SANDSTONE (90%); clr-mlky, lt yel, lt red, f-m, subang-subrnd, sph, well-mod srtd, good vis por, tr calc cmt, tr arg mtx, tr clayst clasts.
No shows.
CLYST (10%); A/A. Tr LST. (Cal:13%, Dol:3%).

740-745M:
CLYST (90%); brick red, tr grn gy, frm-sft, hydratable, occ blky, mod calc, tr LST.
SAND (10%); A/A. No shows.

745-750M:
CLYST (90%); A/A, with lt gy slty patches.
SAND (10%); clr-mlky, occ lt yel, f-crse, sph, pr srtd, subrnd, good vis por.
No shows.

750-755M:
CLAYST (100%); Brick red, tr dusky red grey, tr med gy, tr grn gy, frm-sft, hydratable, occ blky, occ ang brk, mod calc. Tr LST. No shows.

755-760M:
CLAYST (100%); A/A, Tr dark grey colored clayst, tr limestone.
No shows. (Cal:5%, Dol:1%).

760-765M:
CLAYST (100%); Predominantly brick red, rare lt to med grey, soft, sl firm, occ blocky, (very rare brn claystone is firm), amorphous, mod calcareous.
No shows.

765-770M:
CLAYST (100%); lt to med grey (50%), reddish brown (50%) med grey clayst, firm, blky, slightly calcareous. Rare brick red clayst, firm-soft, blky, overall mod calcareous, tr limestone.

770-775M:
CLAYSTONE (100%); lt to med grey (50%), dark grey (10%), reddish brown (40%), A/A.

775-780M:
CLAYSTONE (80%); A/A.
LIMESTONE (20%); white, soft to mod hard, blky, amorphous (Cal: 18%, Dol:1%) soft material, argillaceous to microcrystalline (mod hard), sl micritic, trace-fair intergranular vis Ø.
No shows.

780-785M:
CLST(90%); lt med gy-lt red grn, frm, plastic occ blky. Sl-mod calc.
LST (10%); A/A.
No shows.

785-790M:
CLAYSTONE (100%); lt red brown, brick red (80%), grey to dk grey (10%), lt green grey (10%), gen mod calcareous. Tr-1% limestone, A/A.
No shows.

790-795M:
CLAYSTONE (95%); Reddish brown, brick red (80%), lt to dk grey (5%), greenish grey (10%), firm, occ soft, blky, generally mod calcareous.
LIMESTONE (TR-5%); White, firm to mod hard, mxstalline, occ marly, micritic, poor vis Ø in mxstalline LS.
No shows.

795-800M:
CLYST (100%); med red brn-orng brn, patches of lt green gray reduction spots (5%), frm, blocky, plastic, hydratable, mod calc, tr LST. Micritic-mxln, no vis por. No shows. (Cal:3%, Dol:2%).

800-805M:
CLYST (100%); A/A. sl-mod calc. No shows.

805-810M:
CLYST (100%); A/A. No shows.

810-815M:
CLYST (100%); med orng-red to red, dk red brn, tr gry grn, frm-sft, hydratable, mod calc.
LST (TR); Wh, hd, brit, slty, micritic. No vis por.
No shows.

815-820M:
CLYST (90%); A/A.
SAND (10%); clr-org-rd, vf-f, mod srt, subrnd, sph, good vis por.
LST (TR); A/A, tr vis intergran por, sl arg.
No shows.

820-825M:
CLAYST (100%); med orng-brn, occ dk red brn, occ lt gy grn, frm plastic, blky, mod calc, sl slty.
SAND (TR); clr-orng red, vf, subrnd, mod sft, sph.
LST (TR); Wh-med gy, hd, blky, mxln. No vis por. (Cal:6%, Dol:1%).
No shows.

825-830M:
CLYST (100%); A/A, Tr med gy, sl slty.
LST (TR); A/A.
SAND (TR);
No shows.

830-835M:
CLYST (100%); A/A.
LST (TR); wh-off wh, lt gy, md-frm, blky, play, mxln-micritic.
No shows.

835-840M:
CLYST (100%); lt grn gy, occ mod grn gy and lt orng brn-red brn, frm, sft, swell, blky, mod calc.
LST (TR); A/A, tr intergran por. (Cal:6%, Dol:1%).
No shows.

840-845M:
CLYST (80%); orng-brn, sft-frm, blky, mod calc, slty.
SAND (20%); clr-mlky, occ lt yel-org, f-m, mod sft, sph, subrnd, gd vis por.
LST (TR); A/A.
No shows.

845-850M:
CLYST (90%); A/A.
LST (10%); A/A.
No shows.

850-855M:
SAND (50%); clr. org yel, f-m, mod sft, well srt, subrnd, sph, gd vis por, tr arg mtx. No shows.
CLAYST (40%); org brn, red brn, sft-frm, mod calc.
LST (10%); Wh-off wh, micritic, no vis por.

855-860M:
CLYST (100%); lt orng brn-med red brn, sft-frm, blky, swel, mod calc. Tr LST (Cal:7%, Dol:0%)
CLYST (TR); Tr grn gy. No shows.

860-865M:
CLYST (100%); lt orng brn-mod rd brn, streaks and patches of lt gy grn, sft-fm, mod calc, sl slty, tr LST. No shows.

865-870M:
CLYST (100%); A/A w/tr SAND. No shows.

870-875M:
SAND (10%); clr-orng-red, vf-f, mod well srt, subang-subrnd, sph, gd vis por, sl arg mtx.
CLYST (90%); A/A. slty. No shows.

875-880M:
CLYST (90%); lt orng brn, tr grn gy, frm, sft, swell, sl slty, mod calc. (Cal:8%, Dol:5%).
SAND (70%); A/A. No shows.

880-885M:
CLYST (100%); lt orng brn with lt grn gy streaks and patches, sft-frm, swel, blky, v sl-non calc. No shows.

885-890M:
CLYST (100%); A/A. v sl-non calc.
SANDST (TR); clr, vf-f, subrnd, sph, well srt, well cmt, calc-sil cmt, pr vis por. No shows.

890-895M:
SAND (50%); clear, reddish-orange hue, f-m, well sorted, subang-subrnded, subspherical unconsolidated qtz grains, good vis Ø, no shows.
CLAYSTONE (50%); lt. reddish brown, soft, dispersive and hydratable, sl to mod calcareous.

895-900M:
CLAYSTONE (100%); A/A, lt greenish grey portion (25% of sample), slightly calcareous. Trace to 5% sand (as previous), no shows. (Cal:4%, Dol:1%).

900-905M:
CLAYSTONE (90%); brown, reddish brown (70%), lt greenish grey (20% of sample), soft, amorphous, slt-mod calcareous (tr limestone).
SANDSTONE (10%); clear, red, org, vf-f, well sorted, subang-subrnded, unconsolidated qtz. grains, good vis Ø, no shows (Cal:4%, Dol:1%).

905-910M:
CLAYSTONE (95%); brick red, reddish brown (80%), lt green-greenish grey (15%), soft, amorphous, occ blocky, sl to generally moderately calcareous.
SAND (TR-5%); clear, occ red, org, vf-m, however, predominantly fine, mod well sorted, subang-subrnd, unconsolidated qtz grains. Good vis Ø interpreted, no shows.

910-915M:
CLAYST (100%); brick-red, red-brn (90%), lt greenish grey/lt green (10%), sl-mod calcareous, tr sand (as previous), no shows.

915-920M:
CLAYSTONE (100%); A/A, brick red-reddish brown (95% of sample), lt green-grey (5% of sample). No shows.

920-925M:
CLAYSTONE (100%); A/A, brick red-reddish brown (95%), lt green grey (5%), clayst remain sli to mod calcareous.

925-930M:
CLAYSTONE (100%); brick red-reddish brown (85%), lt greenish grey (15%), green-grey claystone is firm, blky, mod calcareous.
LIMESTONE (TR); Off white to lt green, mod hard, blky, microxstalline, v poor vis Ø, no shows.

930-935M:
CLAYSTONE (100%); brick red-red brown (90%), lt green-grey (10%) sli-mod calcareous. Slight trace sand (?) (gritty feel to claystone).

935-940M:
CLAYSTONE (100%); brick red-red brown (60%), lt green-grey, med grey (40%), sli-mod calcareous. No shows.

940-945M:
CLYST (100%); lt orng-brn, occ brick red streaks and patches of lt gy grn, frm-sft, blky, swell, sl calc, tr mod gy grn SILT.
LST (TR); lt gy grn, hd, blky microxln-micritic. No shows.

945-950M:
CLAYSTONE (100%); A/A.
LIMESTONE (TR); A/A, nil vis Ø, no shows.

950-955M:
CLAYSTONE (100%); brick-red, reddish brwn (90%), lt grey green-lt grey (10%), gen sli calcareous, mod calcareous in part.
LIMESTONE (TR); lt grey green, mod. hard, microcrystalline, micritic.
No shows.

955-960M:
CLAYSTONE (100%); brick red (70%), lt-greenish grey-lt med grey (30%), A/A.
LIMESTONE (TR); A/A.

960-965M:
CLAYSTONE (100%); brick red (90%), lt greenish-grey, lt med grey (15%), soft, occ firm, blky, slightly calcareous.
LIMESTONE (TR)

965-970M:
CLAYSTONE (80%); brick red (65%), occ purp-red, lt grey-med grey, occ greenish (15%) sli calcareous, soft, generally amorphous, hydratable.
LIMESTONE (20%); white and lt to med grn, mod hard to hard, blky, microxstalline, argillaceous, v poor to nil vis Ø, no shows.

970-975M:
CLYST (100%); lt orng brn, tr mod gy grn, tr lt purp red, sft-frm plastic, swell, blky, sl calc.
LST (TR); med brn, occ off wh, hd, blky, ang, microxln, no vis por, no shows.

975-980M
CLYST (60%); A/A with more grn gy and brick red and lt purp red, also lt yel brn.
LST (20%); off wh-wh, hd, brit, plty-blky, microxln, no vis por.
SAND (20%); clr-lt yel orng, f-m, mod srtd, rnd-subrnd, sph, good vis por.
No shows.

980-985M:
CLYST (100%); lt orng red-brn, occ lt grn gy, sft-frm, swell, mod-v calc gdg to marl.
SAND (TR); A/A. No shows.

985-990M:
CLYST (100%); lt orng-brn, sft-frm, swell, blky, occ grn gy.
LST (TR); wh, hd-blky, microxln. No shows.

990-995M:
CLYST (100%); lt orng-brn, occ streaks and patches of lt gy-orng, rare tr of lt yel-brn, firm-sft, swell, sl calc, sl tr LST. No shows.

995-1000M:
CLYST (100%); A/A. No shows.

1000-1005M:
CLYST (100%); lt orng-brn, tr-med gy brn, tr lt gry grn, frm-sft, swell-blky, sl calc, no shows.

1005-1010M:
CLYST (100%); A/A.
SAND (TR); clr-lt yel, f-m, subrnd, sph, mod srt. No shows.

1010-1015M:
CLYST (100%); lt orng-brn, tr brick red, tr lt gy grn, firm-sft, swell, blky, sl slty, sl-non calc. No shows.

1015-1020M:
CLYST (100%); A/A. No shows.

1020-1025M:
CLYST (100%); lt orng-brn, occ brick red, occ lt gy grn, sft-frm, swell, blky, occ slty, sl-mod calc. No shows.

1025-1030M:
CLYST (100%); A/A.
LST (TR); med gy brn, sl dol, microxln.

1030-1035M:
CLYST (100%); lt orng brn-brick red, patches of grn gy (calc), frm-sft, swell, blky, mod-sl calc.
CLST (TR); lt grn gy, occurrence in streaks, frm, blky.
LST (TR); med brn, hd, blky, mxln, sl dol. No shows.

1035-1040M:
CLYST (100%); lt orng brn, rare brick red, tr lt gy brn, tr dk purp red, frm-sft, blky, swell, sl slty, mod calc.
LST (TR); off wh, hd, brit, plty, mxln, no shows.

1040-1045M:
CLAYSTONE (100%); lt orange-brown (~10%), grey, lt greenish grey, med grey (30%), A/A.
LST (TR); off white, mod hard, microcrystalline. No shows.

1045-1050M:
CLAYSTONE (100%); A/A, generally blky, mod calcareous.
LST (TR-5%); off white to green, occ brown; A/A. No shows.

1050-1055M:
CLAYSTONE (90%); A/A.
LIMESTONE (10%); green, off-white, yellow, pink, occ clear calcite spar, mod hard-hard, blky, microcrystalline, argillaceous, nil vis Ø. No shows.

1055-1060M:
CLAYSTONE (100%); orangish brown (70%), lt green grey (30%), generally soft, blky to amorphous, sli-mod calcareous, hydratable.
LIMESTONE (TR-5%); off white, occ green, hard, microxstalline.

1060-1065M:
CLAYSTONE (100%); A/A.
LIMESTONE (TR); A/A, nil vis Ø, no shows.

1065-1070M:
CLAYSTONE (100%); A/A, remains generally moderately calcareous.
LIMESTONE (TR-5%); predominantly med-green, hard, blky, microcrystalline, occ white, firm-mod hard, micritic-argillaceous, no shows.

1070-1075M:
CLAYSTONE (100%); A/A, brownish red (70%), greenish grey (30%).
LIMESTONE (TR-5%); A/A, predominantly whitish.

1075-1080M:
CLYST (100%); red-orng brn, A/A.
LST (TR); med grn gy, hd, mxln, blky. No shows.

1080-1085M:
TOP BUNTER FM., D.B. at 1084M RKB.
CLAYST (20%); A/A.
SANDSTONE (80%); clr-mlky, f-crse, mod srtd, subrnd-well rounded, sph-sub sph, v gd vis por, tr calc cmt. No shows.

1085-1090M:
SANDSTONE (90%); clear to occ opaque, occ orange stained, f-course, predominantly medium, well sorted, subrnd to rnded, subspherical-spherical, unconsolidated quartz, v good vis Ø interpreted.
CLAYSTONE (10%); A/A, with tr-2% limestone, A/A.

1090-1095.1M:
(Bottoms up sample prior to swab/condition and logging of 17½" hole.)
SANDST (100%); A/A, v good vis Ø, no shows.
CLAYSTONE (TR); tr, A/A, small fragments (cavings?)

1095-1100M:
SAND (80%); clr/transluc qtz, m/cse, sbang, good sphericity, loose.
No shows.
CLYST (15%); red (brick), soft, slty/sdy, var calc.
CLYST (5%); m gy, soft to firm/hd, sl calc, slty, sl carbonac w/wh, xtln calcite; tr pyr, sl tr dol, tan/gy, xln-microxtln.

1100-1105M:
SAND (100%); A/A, w/brn-red (brick) clyst, sl calc-non calc, mainly m-gn sd w/less coarse gns, tr wh calcite, xtln (no fluor or cut fluor).

1105-1110M:
SAND (85%); clr qtz, m-gn, occ cse gns, sbang, high sphericity poss w/clay mtx in pt; loose, unconsol (no shows).
CLYST (15%); gy, grn, brick red, A/A; v v thin stringers?-noncalc.

1110-1115M:
SAND (85%); clr qtz, m/cse gn, sim to ab, sbrnd, spher, loose.
CLYST (15%); brick-red, poss thin strks, noncal, poss mtrx for part of sand (?); sd bec mainly m-gn.
Tr wh xtln calc.

1115-1120M:
SAND (85%), A/A, (no show of fluor or cut fluor)
CLAYST (15%); brick red, sft, poss intbds, poss mtrx for pt of sd. Tr wh calcite, xtln.
Calcimetry: 2/0 (=calc/dol)

1120-1125M:
SAND (85%); A/A, bec fine/med, mainly med, occ cse gn (no shows).
CLAYST (15%); brick red, A/A, sft, noncalc.

1125-1130M:
SAND (95%); fn/med, clr qtz, abun gns w/brn oxide give spl lite brn appearance (no fluor. or cut fluor).
CLY/CLYST (5%); brn/tan, sft, noncalc-poss strks and/or mtx mtl?
Wh calc, xtln.

1130-1135M:
SAND (95%); clr qtz, fn-gn, sm-med r/cse gns, sbang, spher, less oxidized gns.
CLYST (5%); brn-red, A/A, sft (hydrophyllic)
Wh calc, xtln.

1135-1140M:
SAND (100%); A/A, fn qtz; rare to comm. gns have tremendous dk brn stn suggestive of asphaltic residue, but v v tenuous cut fl & no natural fl (ambiguous).
Calcimetry: 4/0

1140-1145M:
SAND (100%); A/A, fn, sm med-gn qtz (as above-v tenuous brn stn on some grns, w/v v sl dull yel fl of cut only)

1145-1150M:
SAND (100%); A/A, plus occ cse gns; v loose, A/A, blk/dk brn strs more tenuous w/ depth. (No fluor)

1150-55M:
SAND (100%); A/A, fn-med, occ cse gns (no shows) tr wh calc, xtln.

1155-1160M:
SAND (100%); A/A, (no shows).

1160-1165M:
SAND (100%); same - clr qtz, brn/red oxidized gns & cly stn give red-brn color to spls, varying in intensity, tr wh calc, xtln, (no shows).

1165-1170M:
SAND (100%); same - fn/med, occ cse gn clr qtz (no shows), tr calc, wh, xtln.

1170-1175M:
SAND (100%); A/A, but mainly med-gn, sm cse, well srtd, sbrnd/sbang, spheric, good, v loose (no shows).

1175-1180M:
SAND (100%); A/A, but sbrnd mainly; (no shows of fluor); loose.
Calcimetry: 2/0

1180-1185M:
SAND (100%); A/A, but less sorted, and m/cse-gn. Sbang, spher, loose, w/clay poss matrix - brn/brick red, soft, noncalc tr pale grn, transluc qtz grns.
No Shows.

1185-1190M:
SAND (100%); A/A, poor sorting, loose, w/little clay red/brn, A/A, soft, noncalc.
No shows.

1190-1195M:
SAND (100%); A/A, sl better srtg, med-gn, less fn & cse gns, v loose. (No shows). Some brn-red clay - noncalc, matrix??

1195-1200M:
SAND (100%); fn-gn, occ cse/med gns, otherwise sim to ab, v loose, well-srtd, in gen (no shows at all). Little brn-red clay, A/A, - matrix mtrl?
Calc: 0/0

(10 m spls - drill break, 1199m)

1200-1210M:
SAND (100%); fn, w/ occ cse & m gns, v loose, w/brn oxidized surface; little brn/red clay (matrix?); qtz, sbrnd/sbang, fair srtg & sphericity (no shows).

1210-1220M:
SAND (100%); f/m, r/cse-gn, clr qtz, sbang/sbrnd, good spher, fair/good srtg, (no shows oil fluor).
Tr dolo mtl Calcimetry: 0/8 (=calc/dol)

1220-1230M:
SAND (100%); A/A, brn colored due to clay & oxide coating of gns, (no shows).

1230-1240M:
SAND (100%); f/cse, poor srtg, otherwise sim to ab, (no shows).
Calc: 0/12

1240-1250M:
CLAY (50%); red-brn, sft, noncalc, tr pale grn.
SAND (50%); A/A.
Calcimetry: 0/26

1250-1260M:
CLAY (50%); A/A, (trace dolomite continues).
SAND (50%); A/A.

1260-1270M:
CLAY (50%); red-brn, sft, noncalc, A/A, mtrx for sand, loose.
SAND (30%); m/cse, sbrnd qtz, spher, loose.
SS (20%); f/vf, hd, silic, gy/lt grn, noncalc, brn/red from clay matrix, pt fri, noncalc, tr wh calcite, xtln.
No shows.

1270-1280M:
SS (50%); fn, qtz, firm/fri, pt hd, silc, noncalc (poros fair).
SAND (20%); cse, sbang qtz, spher fair, sm gns well rnd/sbrnd.
CLAY (30%); red-brn, A/A, soft, noncalc, tr wh calcite, xtln.
No shows.
Calcimetry: 0/16

1280-1290M:
SS (60%); A/A.
SAND (30%); A/A.
CLAY (10%); A/A.
No oil shows.

1290-1300M:
SAND (70%); f/m, occ cse, qtz, fair srtg, sbang, spher, poros good(?), brn stn, (no shows).
SS (15%); A/A, firm/hd, fn, silic, brn stn from clay.
CLAY (15%); red-brn, soft, noncalc (matrix, prob).

1300-1310M:
SS (65%); f/m-gn, firm/hd, silic, tr calc; brn stn qtz, (no shows).
SAND (10%); loose qtz, cse-gn, sbang/sbrnd, clr, brn-stn, (no shows).
CLAY (25%); brick red, sft, noncalc, hydrophyllic matrix &/or beds?

1310-1320M:
SS (70%); A/A.
SAND (20%); A/A, some v cse, transluc qtz, vein mtrl? (no shows).
CLAY (10%); (trace dolomite continues).

1320-1330M:
SS (65%); A/A, porosity prob fair only.
SAND (20%); A/A.
CLAY (15%); A/A.

1330-1340M:
SS (90%); f/m-gn, occ cse gns, poor/fair srtg, sbrnd/sbang, clr qtz, good spher; w/brick red stn fr clay; poros prob poor/fair, ss is v sl to noncalc, silic; firm/hd; cse gns, loose, generally, (no shows).
CLAY (10%); brick red, soft, noncalc, A/A.
Tr c wh calc, xtln.

1340-1350M:
SS (80%); A/A, but med/cse-gn; fri/hd, fair srtg only; sbrd/sbang, pt v tight, gen fair poros?, brn/red stn (clay; pt oxides?)
CLAY (20%); brick-red, soft, matrix (?), noncalc; sm wh clay (matrix).
Wh calc, tr dolo ls, xtln.

1350-1360M:
SS (80%); fn/v cse, qtz, brn, A/A, fri to hd, silic in pt; non-calc, (no shows), porosity prob poor/fair only.
CLAY (20%); A/A; common wh clay, soft; wh xtln calc.

1360-1370M:
SS (90%); red/brn, f/cse, firm/hd, prly srtd, silic, small pt mod calc/dolomitic cmt, (no shows), poor poros.
CLAY, red-brn, soft, non-calc - matrix &/or beds.
Wh calc, xtln, loose.

1370-1380M:
SS (95%); A/A, red/brick, A/A, pr srtg, firm/hd, silic, pt sl calc, (no fluor) poor vis poros.
CLAY (5%); A/A, common wh clay, soft, non-calc.

1380-1390M:
SS (90%); A/A, vis poros poor, (no oil fluor).
CLAY (10%); brick red, as ab, some wh, pt mod calc, soft, poss caliche(?) in small pt.

1390-1400M:
SS (85%); brick red, fn/cse, prly/unsrtd, sbrnd/sbang, loose to firm, silic; poor to fair (?) vis poros, (no shows).
CLAY (10%); brick red, A/A.
CLAY (5%); wh, sft, pt mod calc (caliche?).
(Minor metal shavings and lower ROP may be indicative of bit wear).

1400-1410M:
SAND (50%); clear to occ opaque, common red-orange, iron oxide stain, m-c, subrnd, spherical, well sorted unconsolidated qtz, good interpreted vis Ø, no shows.
SANDSTONE (30%); red-brown, vf to occ fine grained, mod hard to hard; well sorted, subang-subrnd, siliceous, qtz grains; poor to nil vis Ø (clayey matrix), no shows.
CLAY (20%); A/A, extremely hydratable.

1410-1415M:
SS (20%); red brn, fn-gn, qtz, sbang/sbrnd, poor poros, no shows, pt calc cem, pt mtrx of brick-red/brn clay, mod calc, soft.
SS (80%); cse, qtz, sbang/sbrnd, sphericity good (poss from SS), no shows.
CLAY (20%); brick-red, soft, mod, calc, w/abund calcite, xtln, wh, & ls, arg, off wh.

1415-1420M:
SD (60%); A/A.
SS (15%); A/A.
CLAY (20%); A/A.
LS (5%); off wh, pt micritic, soft, pt hd, microxtln; fri calcite, xtln, pt wh, pt clr.

1420-1425M:
SD (40%); A/A.
CLAY (25%); A/A.
SS (25%); A/A.
LS (10%); wh, earthy/marly, soft; w/ sm micritic, sl firm.

1425-1430M:
SAND (60%); m/cse, loose, sim to ab, sbang/sbrnd, spher, no show.
CLAY (20%); red/brn, A/A, var calc to noncalc.
SS (15%); A/A, no shows, poros prob poor.
LS (5%); noted decrease.

1430-1435M:
SAND (75%); m-gn, loose, poor/fair poros?, mtrx prob clay, no show.
CLAY (25%); A/A.
Calc, tr ls - A/A.

1435-1440M:
SAND (65%); fn/med.
CLAY (35%); red-brn, soft, poss both as mtrx & bds.
Calcite, xtln, wh & clr.

1440-1445M:
SAND (70%); qtz, red-brn/gy, f/m, sbrnd, fair/well srtd, prob good poros, no shows.
CLAY (30%); A/A.
Calc, tr ls.

1445-1450M:
SAND (65%); m-gn, sm fn, A/A, loose, prob good/fair poros, no shows.
CLAY (35%); A/A, red-brn, soft, hydrophyllic, pt sl calc.

1450-1455M:
SAND (60%); qtz, fn/cse, unsrtd, sbrnd, good spheric, no shows, prob poor poros.
CLAY (25%); A/A, brick-red.
LS (15%); off wh, sft, earthy, marly; pt bec firm, micritic w/calc, xtln, wh/clr.

1455-1460M:
SAND (65%); A/A, brick-red stained by oxide &/or clay, no shows.
CLAY (35%); A/A.
LS (30%); calc.

1460-1465M:
SAND (65%); m/gn, less fn and cse, loose, poor/fair poros? no shows.
SANDST (5%); fn, fri/firm, sl calc, no shows.
CLAY (30%); A/A.
Tr calcite; tr ls - A/A - soft, wh/off wh, earthy marly.

__1465-1470M__:
__SAND__ (20%); m/cse, sbrnd, good spheric, fair poros, no shows, lithics of v fn-gn volcanics, meta(?), qtzite.
__SS__ (30%); f/vf, rd, pt sl calc mainly silic, dk gy.
__CLAY__ (50%); red brn, soft, A/A, tr buff gy dol, microxtln, w/calcite, tr ls, A/A.

__1470-1475M__:
__CLAY__ (50%); brick-red, soft, non-calc to v sl calc mtrx (?) &/or beds.
__SAND__ (30%); brick-red, med/cse-gn, qtz & incr abund dk gn, blk, reddish, gy, v fn-gn lithics; fair/poor Ø, no shows.
__SS__ (20%); v fn/fn, gy-red, w/oxide stns, firm/hd, pt sl calc; poor poros, no shows.
Tr calcite; tr wh, sft, ls, arg/micritic.

__1475-1480M__:
__CLAY__ (65%); A/A.
__SD__ (30%); A/A, w/tr dol buff, microxtln, v hd, tr wh ls, sft, arg; abund ang frags of volcanics, qtz; v fn-gn, lt/med gy, gy-grn, some blk, dk grn, xtln & amorph rocks.
__SS__ (5%); v fn gn, A/A; tr calc; sft ls, A/A.

__1480-1485M__:
__CLAY__ (90%); brick red, A/A, sft, noncalc.
__LITHIC FRAGS__ (10%); fn-cse qtz; angular/subrnd-cgl(?) w/clay matrix(?); calc mtl-porosity(?) prob poor.

__1485-1490M__:
__CLAY__ (85%); A/A.
__LITHIC__ (15%); debris & qtz, fn to cse, A/A. Tr calcite, dolo mtl.

__1490-1495M__:
__CLAY__ (80%); brick red, A/A.
__LITHICS__ (20%); debris, qtz, A/A, tr cgl w/clay matrix?

__1495-1500M__:
__CLAY__ (80%); A/A.
__LITHICS__ (20%); debris, A/A, w/qtz; cgl w/clay matrix.
Calcimetry: 3/1.

__1500-1505M__:
__SALT-MUD__ (95%); (Sample heavily contaminated with salt additive).
__LITHICS__ (5%); debris: igneous & volcanics, qtz, cse, ang to subang.
Practically no clay in spls (or shaker).

1505-1510M:
(Sample quality vastly improved - excess salt added to mud has circulated through).
LITHIC CONGLOMERATE (30%); A/A; fn to v cse-gn, igneous & volcanic debris-dk grey, occ purple, green angular fragments, aphanitic, hard, noncalcareous with occ green glassy inclusions, heavy minerals (poss magnetite/illmenite). (Clay fraction most likely matrix of congl).
CLAY (55%); brick red, sl calcareous, soft, amorphous (matrix(?)).
SANDSTONE (10%); brick red, v f, poor to nil vis Ø, siliceous, hard, occ brittle. No shows.
SAND (5%); clear to yellowish and red (stained), gen f, subang-subrnd, unconsolidated.

1510-1515M:
CGL (55%); lithic frags, A/A, w/clay matrix-var calc.
CLAY (30%); brick-red, soft, sli/mod calc in pt.
SAND (15%); ±15%, poss is part of the cgl, fn/cse qtz, subrnd, spher. No oil shows.

1515-1520M:
CONGLOMERATE (45%); A/A.
CLAY (45%); A/A.
SAND (10%); A/A, poor vis Ø interpreted.
No oil shows.
Calcimetry: 8/1.

1520-1525M:
CONGLOMERATE (40%); A/A, predominantly grey volcanic-aphanitic ign fragments.
CLAY (50%); A/A, remains gen mod calcareous in part.
SAND (10%); clr, occ orange, yellow, f-m, subang, mod sorted, unconsolidated qtz.
No shows.

1525-1530M:
CLAY (60%); A/A, brick red, soft.
SAND (25%); A/A, f/cse qtz, subrnd to subang, good spheric, poor srtg.
No shows.
CGL (15%); A/A, decr in amount of ign & volc frags, cse, ang to subrnd. Poor srtg.
Tr-comm calc, calcar mtl pt v soft, wh ls, micritic/earthy.

1530-1535M:
CLAYST (90%); brick-red, A/A; main lith-soft, sl/mod calc.
LITHIC FRAGS (10%); qtz sd, marked decr (poss 100% clayst/clay fm).
Tr-comm wh sft ls/calc.

1535-1540M:
CLAY/CLAYST (98%); A/A.
LITHIC FRAGS (2%); gns, qtz, A/A. Tr calc, wh, soft, ls, arg/earthy, wh.
Calcimetry: 6/2.

1540-1545M:
CLAYST (95%); red brick, sft, sli calc.
LITHICS (5%); debris, occ qtz gn A/A, w/tr wh, sft ls, calc mtl.

1545-1550M:
LS (35%); wh, sft, sli firm, v fn, micritic, pt bec m-lt gy, sli tr carb mtl; ls is argillac.
CLAYST (65%); A/A; Q: can clayst now be only cvgs?
Note: LS has dull yell/wh min fluor. Tenuous yellowish cut flour may be fm contam or carbonac mtl within ls. (No heavies on chrom).

1550-1555M:
LS (45%); A/A, w/ m gy more abund, sli firmer, carb mtl more abund, some on blk surfaces, laminae.
CLAYST (55%); A/A, (poss largely or in pt cvgs).
LS has dull yell/wh min fluor; tenuous yell cut fl may be spurious. (No chromatographic pick-up of oil ends).

1555-1560M
LS (100%); A/A, sm clr xtln calc (veins), abund carb mtl, incl and as thin laminae. (No oil shows). (Red clayst-cvgs).
Calcimetry: 24/8.

1560-1565M:
LS (30%); A/A, (No shows) w/tr clr, amorph anhydrite.
CLYST/SH (20%); red brn, firm-sft, mod calc, & mod gy-grn, firm-sli soft, noncalc.

1565-1570M:
LS (25%); w/clayst (and salt from supersat salt mud), tr anhyd.
(Poor sample quality).
CLAYST/SH (75%); A/A.

1570-1575M:
CLAYST/SH (95%); red brn, brick-red, A/A; less gy-grn, as ab.
LS (5%); A/A, wh-lt gy, soft, micritic/earthy & clay-red, fr uphole.

1575-1580M:
CLAYST (85%); A/A, red brn, less grn-gy, firm.
SH (10%); dk purplish-red, firm-hd, sli fiss/fiss, pt mod calc & less gy-grn, firm, noncalc.
CALC (5%); wh, sft.
Calcimetry: 8/0.

1580-1585M:
CLAYST (95%); lt reddish brn, v soft, mod calc.
SH (5%); m gy-grn, firm, sbfiss/fiss.
Tr wh calc.

1585-1590M:
CLAYSTONE (95%); A/A, sli reddish brown, v soft, amorphous, mod calcareous; trace anhydrite-white, v soft, amorphous, tr ls.
SHALE (5%); A/A, grey green, firm, subfissile, continues nil vis Ø.
No shows.

1590-1595M:
CLAYST (90%); red, A/A.
SHALE (10%); grn-gy, dk reddish-purple, sli fiss/fiss, firm.

1595-1600M:
CLAYST (90%); A/A.
SH (10%); A/A.

1600-1605M:
CLAYST (85%); A/A, mod calc, soft.
SH (15%); A/A, reddish/purple is sli calc, grn-gy non calc.

1605-1610M:
CLAYSTONE (95%); A/A, tr anhydrite, tr limestone. Limestone is lt to med grey, microcrystalline, hard to mod hard, micritic in part, nil vis Ø, no shows.
SHALE (5%); A/A.

1610-1615M:
CLAYSTONE (90%); A/A, predominantly med brown-sli reddish, with trace of anhydrite: white, soft, extremely dispersive, amorphous.
SHALE (10%); A/A, brown, sli purple, mod hard, subfissile, non calcareous.

1615-1620M:
CLAYST (90%); A/A.
SHALE (10%); A/A, w/little med gy-grn; tr slickensided. Tr anh, clr/transluc wh, sft/firm.

1620-1625M:
CLAYST (90%); A/A.
SH (10%); Incr tr to comm anhydrite, transluc/wh, amorph.

1625-1630M:
CLAYST (90%); w/tr lt gy-grn.
SH (10%); tr anhy.

1630-1635M:
CLAYST (90%); red w/less gy-grn, c/lt green, v soft.
SH (10%); A/A, but remaining purplish red, less gy-grn.

TOP OF ZECHSTEIN

1635-1640M:
DOL (50%); lt brn, v fn-gn, v hd (No oil shows).
LS (50%); off wh, lt med gy, firm to mod hd, microxtln in pt, sli carbonac; dull yell min fl only. (No cut or oil fl). Clay/clayst, - poss fr uphole? Tr-comm anh.

1640-1645M:
DOLO (75%); A/A.
LIMESTONE (25%); off white; lt brown and grey, A/A, v abundant mineral fluorescence - as in previous sample. No shows, nil to poor vis Ø. Trace calc, anhydr.

1645-1650M:
DOL (35%); A/A. Trace calc anhydrite.
LS (65%); A/A. Off wh, v sft, ang. About 50% of the ls is marly, lt gy/m gy, soft, v calc, sl carbonac in pt, v arg.
No shows.

1650-1655M:
LS (85%); m gy, less off-wh, marly, sl carb, v ang, soft.
DOL (15%); A/A. Tr calc, anhydr.

1655-1660M:
LS (95%); A/A, med gy, soft, v ang, marly; tr wh vein calc.
DOL (5%); A/A, lt tan, hd, v f-gn, xtln.
Note: small pt of LS bec dk gy, hd, v fn, xtln.
Calcimetruy: 60/6.

1920-1925M:
CLAYST (40%); A/A. No shows.
SAND (50%); A/A. No shows.
SLTST (10%); sim to ab, dk purple-red, hd, calc.

1925-1930M:
CLAYST (100%); A/A, brite brick red, soft in cuttings but shown by end bit sple to be not so.
Tr sltst, sd (no shows).

1930-1935M:
CLAYST (55%); brick red, A/A.
SD (40%); fn/m, c/cse grn, subrnd, good sphericity. Loose - good poros? No shows.
SLTST (5%); Tr/v little - A/A, dk purplish-red, hd, calc, c/anh, wh/translucent.

1935-1940M:
CLAYST (95%); A/A, plus tr lt gy-grn. Tr sd, cse qtz, tr anhydrite.
SLTST (5%); A/A.

1940-1945M:
CLAYST (95%); A/A. No shows.
SLTST (5%); A/A. No shows.
Tr sd, anhydrite, A/A. No shows.

1945-1950M:
CLAYST (75%); brick red, & incr lt gy, soft.
SLTST (15%); A/A, hd, calc, dk purple-red.
SD (10%); A/A, fn/m. No shows.
Calc: 2/0.

1950-1955M:
CLAYSTONE (90%); orange/red, soft, amorphous, mod calcareous, gd tr anhydrite, white, soft, amorphous-generally non crystalline.
SILTSTONE (10%); red/bwn to lt-med gray, grading to v f sandst in part.
SAND (GD TR); A/A.

1955-1960M:
CLAYSTONE (85%); A/A, gd tr-3% anhydrite A/A.
SILTSTONE (10%); A/A.
SAND (5%); orange, translucent, gen fine grained, occ m, mod well sorted. No shows.

1660-1665M:
LS (90%); A/A.
DOL (5%); tan, v hd, v f-gn, xtln.
ANHY (5%); transluc, gy, firm-soft, amorph.
No shows.
Note: V abund clay/clayst, m-lt gy, v sticky, hydrophyllic.

1665-1670M:
LS (95%); A/A, m-lt gy, sft, micritic.
DOL/ANH (5%); A/A.
No shows.
Note: Clay/clayst, A/A, v abund (may be fm).
Calcimetry: 43/6

1670-1675M:
LS (100%); A/A, lt gy, occ m gy, sft/sl firm, micr; and clayst, A/A.
Tr dol, anh. No shows.

1675-1680M:
LS (40%); A/A, m-lt gy, soft, marly to sl firm, micritic.
CLAYST (60%); m gy, soft, marly, mod-v calc, hydrophyllic, sticky, tr pyr incl in ls/clay.
No shows.
Calcimetry: 61/3.

1680-1685M:
CLAY/CLAYST (70%); A/A, v sft, pt v sticky, water-______, var calc.
LS (30%); tr anh, tr dol, all as ab.
No shows.
Calimetry: 22/4.

1685-1690M:
CLAYSTONE (90%); brown/gy to med grey, v soft, mod calcareous, amorphous.
LIMESTONE (10%); white and lt to med grey, soft to sl firm, marly, rarely microcrystalline, tr dolomite, tr anhydrite, as previous, nil Ø, no shows.

1690-1695M:
CLAYSTONE (80%); A/A.
LIMESTONE (20%); A/A, tr dolomite, sl tr anhydrite, nil Ø, no shows.
(5% of sample represents red claystone L Triassic cavings).

1695-1700M:
CLAYSTONE (75%); A/A, mod calcareous, sl dolomite.
LIMESTONE (25%); A/A, dolomitic in part (based on alizarin red staining).
Nil Ø, no shows.
Calcimetry: 18/9.

1700-1705M:
CLAYST/CLAY (70%); lt/m gy, v soft, mod/v calc; pt sticky, hydrophyllic, sl carbonac.
LS (30%); lt/m gy, soft, v arg/marly. (V poor poros, no shows. Occ m gy, firm, v f, xtln. Calc: v little dol, transluc, tan/gy, firm, xtln. Occ fossil frags.

1705-1710M:
LIMESTONE (85%); lt to med grey, soft to v firm, generally marly, sl-mod carbonaceous, occ microcrystalline. No shows.
DOLOMITE (5%); lt buff color, mod hard, sucrosic, poor vis Ø.
CLAYSTONE (10%); A/A. V calcareous, occ banded w/carbonaceous material.
Calcimetry: 70/2.

1710-1715M:
LIMESTONE (35%); A/A, (tr goniatite fossils).
CLAYSTONE (65%); brick red, soft, mod calcareous, generally amorphous, tr siltstone, v firm, nil vis Ø, no shows. (cavings?)

1715-1720M:
LIMESTONE (40%); A/A, continue yellow min fluor, no cut, no shows, tr bivalve casts.
CLAYSTONE (55%); red brick, tr volcanic material (?) cavings? - very similar to basal Bunter sequence.
SLTST (5%); red/brn, firm, sl calc to mod calc; tr v f ss, fm, sl calc, gy.
Calc: 19/2.

1720-1725M:
SLTST/VVF SS (50%); reddish/pink, less grn-gy, firm, mod calc, tr cse qtz, red stn (cvg?/subrnd, sphr, tr wh anhy. Nil poros, min fluor. No cut or oil fl.
CLAYST (50%); red, soft A/A.
Calc: 28/3.

1725-1730M:
SILTSTONE (55%); A/A, dark red: sl cal (25%), orange-brown: mod to v cal (10% of sample).
CLAYSTONE (40%); A/A, generally light orange-brown, mod calcareous, nil vis Ø, no shows.
LIMESTONE (5%); drk grey, mod hard, marly in part, microcrystalline (cavings?).
Calc: 26/2.

1730-1735M:
SILTSTONE (75%); A/A, v mod cal tr cse quartz grains, subrnd, spherical, iron stain.
CLAYSTONE (25%); A/A. Nil vis Ø, no shows.
LIMESTONE (2-5%); white-marly, grey-microcrystalline (cavings?).
Calc: 24/2.

<u>1735-1740M</u>:
<u>SILTSTONE</u> (55%); A/A, remains mod calcareous, nil vis Ø, no shows.
<u>CLAYSTONE</u> (45%); A/A.
(Tr-2% LS cavings)
Calc: 20/2.

<u>1740-1741M</u>:
<u>SILTSTONE</u> (40%); A/A, nil vis Ø, no shows.
<u>CLAYSTONE</u> (60%); A/A.
(spot spl: 1742.5M: clyst, sltst, red/brn &-tr ls, gy-grn/gy, soft to hd, tr anh. Spot spl 1743M: same.
Calc: 22/1

<u>1741-1745M</u>:
<u>SILTSTONE</u> (45%); A/A, tr limestone (cavings?).
<u>CLAYSTONE</u> (55%); A/A, sltst - dk purplish red, mod calc.
(Spot sample: 1748M: same A/A, Clyst, little sltst, tr anhy).

<u>1745-1750M</u>:
<u>CLAYSTONE</u> (55%); A/A, tr anhydrite.
<u>SILTSTONE</u> (35%); generally A/A, color-dark purplish red, moderately calcareous, nil vis Ø, no shows.
(Sample contains a good amount of bit metal scrap).
Calc: 18/1.

<u>1750-1755M</u>:
<u>CLAYST</u> (70%); red-brn, sft, mod calc, hydrophyllic, A/A.
<u>SLTST</u> (30%); dk purplish-red, firm, mod calc yst hd tr ls, marly, gy, soft.
Calc: 26/3.

<u>1755-1760M</u>:
<u>CLAYST</u> (60%); A/A, tr ls, marly, gy, soft.
<u>SLTST</u> (40%); A/A, tr ls, marly, gy, soft.
Calc: 12/4.

<u>1760-1765M</u>:
<u>CLAYST</u> (70%); reddish-brn, soft, mod/sl calc.
<u>SLTST</u> (30%); dk reddish/purple, hd, mod calc, tr.ls, marly, gy, soft. Tr anh.
Calc: 1.

<u>1765-1770M</u>:
<u>CLAYST</u> (65%); A/A.
<u>SLTST</u> (35%); A/A.
Calc: 1.

1770-1775M:
CLAYST (65%); No change.
SLTST (35%); No change.
Calc: 1.

1775-1780M:
CLAYST (75%); Same.
SLTST (25%); Same.
Calc: 1.

1780-1785M:
CLAYST (60%); red/brn, A/A, mod calc, c/microfossils: dk, spherical, 0.1-0.5mm.
SLTST (40%); Same as clayst.

1785-1790M:
CLAY (75%); light reddish/brn, v soft, sl calc (less calc & less consolid than before). Marked decr in c/microfossils-spher, 0.1-0.5mm.
SLTST (25%); A/A.

1790-1795M:
CLAYST (80%); Same A/A, c/microfossils: spherical, 0.1-0.5mm .
SLTST (20%); Same A/A.

1995-1800M:
CLAYST & MARL (85%); A/A, w/abund 0.1-0.5mm spherical microfoss.
SLTST (15%); less than above.
Calcimetry: 13.6.

1800-1805M:
CLAYST & MARL (80%); Same A/A. Microfoss, A/A, decr in no.
SLTST (20%); A/A.
Calc: 11/5.

1805-1810M:
CLAYST/MARL (75%); A/A.
SLTST (25%); abund spher microfossils, A/A.
Calc: 10/5.

1810-1815M:
CLAYST/MARL (85%); A/A. (Abund microfossils). No shows.
SLTST (15%); Same A/A.
Calc: 12/8.

1815-1820M:
SILTSTONE (30%); A/A, mod to v calcareous, nil vis Ø, no shows.
CLAYSTONE (65%); A/A, mod to v calcareous, nil vis Ø, no shows.
SAND (5%); clear, occ orange, f-c, subrnd, spherical, mod sorting (?) unconsolidated quartz grains, good vis Ø, no shows.
Calc: 16/6.

1820-1825M:
SILTSTONE (30%); A/A, nil Ø, no shows.
CLAYSTONE (60%); A/A.
SAND (5%); A/A.
ANHYDRITE (5%); clear to white, crystalline, as rind and vein fill.
Calc: 16/3.

1825-1830M:
SILTSTONE (30%); A/A, good tr anhydrite, nil vis Ø, no shows.
CLAYSTONE (65%); A/A.
SAND (5%); A/A, no shows.
SILTSTONE (GD TR); off-white, occ dk gr grains, med hard, blky, mod calc, tight - nil vis Ø.

1830-1835M:
SILTSTONE (30%); purplish red-brown, A/A.
SILTSTONE (10%); off white
CLAYSTONE (55%); A/A.
SAND (5%); A/A, generally fine-med grained, crs fraction occ subangular.
Calc: 17/4.

1835-1840M:
SILTSTONE (30%); purple-red/brown, A/A.
CLAYSTONE (60%); purple-red/brown, A/A.
SILTSTONE (5%); off-white, A/A.
SAND (5%); A/A.

1840-1845M:
SILTSTONE (30%); red/brwn, non to mod calcareous, tr off-white siltstone.
CLAYSTONE (55%); A/A, gd tr anhydrite.
SAND (15%); A/A, f-c, moderately sorted, subrnd, subspherical-spherical, good vis Ø, no shows.
Calc: 9/2.

1845-1850M:
CLAYSTONE (50%); A/A.
SILTSTONE (30%); A/A.
SAND (20%); predominantly fine grained, occ m, rare crse, mod well to well sorted, subrnd, spherical to subsph, unconsolidated. No shows.
Calc: 8/2.

1850-1855M:
CLAYST (60%); A/A. Tr anh, transluc, wh, soft.
SLTST (30%); A/A. Tr anh, transluc, wh, soft.
SD (10%) loose qtz, fn, sm, m, tr cse, clear; tr red oxide stn. No shows.
Calc: 6/2.

1855-1860M:
CLAYST (65%); A/A, lt reddish/pink to brick red, v soft, sl calc.
SLTST (30%); A/A, dk purplish red, sm brn-gy; hd, mod calc.
SD (5%); clr qtz, fn/m, tr cse subrnd/rnd, spher, fairly well srtd. Tr anhydrite. No shows.
Calc: 5/1.

1860-1861M:
(B.U. - Drill break 6/8/12m/hr w/20,000 lbs less WOB).
CLAYST (50%); A/A.
SLTST (20%); A/A.
SD (20%); Fn/med, tr cse, fair srtg, subrnd/rnd, loose. No shows.
Calc: 4/1.

1861-1865M:
CLAYSTONE (50%); A/A.
SILTSTONE (15%); A/A, occ dark purple-bwn, hard, blky, non to sli calcareous.
SAND (35%); predominantly f/m, A/A, no shows.

1865-1870M:
CLAYSTONE (65%); A/A, some platy fracture to claystone (slight fissility?) good tr anhydrite (white, soft, amorphous generally).
SILTSTONE (30%); A/A, nil Ø, (very tight), no shows.
SAND (5%); A/A.

1870-1873M:
(B.U. before bit change trip).
CLAYST (65%); A/A.
SILTSTONE (30%); A/A.
SAND (5%); A/A, tr sandstone, v f grained, loosely cemented, friable.
ANHYDRITE (2-3%); white, soft, amorphous, occ clear, crystalline. No shows.

1873-1875M:
CLAYST: brick red, soft, m/sl calc. Tr anh. Tr blue-gy clyst.
SLTST: dk red/purple red, hd/firm, m calc. Nil poros. No shows.

1875-1880M:
CLAYST (60%); red/brn, brick red, soft, sl calc.
SILTST (40%); hd, dk purplish-red, mod calc sl tr qtz, cse, well-rnd. Tr anhydrite.
Calc: 18/4.

1880-1885M:
CLAYST (80%); bright brick-red, soft in sple, m calc.
SLTST (20%); A/A, m calc, hd.
Calc: 6/2.

18815-1890M:
CLAYSTONE (90%); A/A. No shows.
SILTSTONE (10%); A/A. No shows.
Tr SD.
Calc: 6/1.

1890-1895M:
(Circulate B.U. due to drill break, B.U. = 1895.1M).
(Circ. bottoms up at 1893; drill break top at 1891).
CLAYST (85%); A/A.
SAND (10%); qtz, clr/orange stns, fn-grn, tr fr grn, loose. No shows.
SLTST (5%); A/A.
Calc: 3/1.

1895-1900M:
CLAYST (75%); A/A.
SAND (20%); qtz, f/m, c/cse, subrnd, fair srtg, loose, no shows.
SLTST (5%); w/tr ss, v fn, gy/red - poor/nil porosity.
Calc: 3/1.

1900-1905M:
CLAYST (70%); brick red, tr m/lt gy & tan, soft/firm, m calc.
SLTST (10%); v fn ss, red & tr gy, frm/hd, calc, v poor poros. No shows.
SD (20%); A/A, fn/m, tr cse qtz loose. No shows.
Calc: 4/1.

1905-1910M:
CLAYST (80%); brite brick red. Tr m gy-grn, soft.
SAND (20%); A/A, loose. No shows.
Tr sltst, A/A.

1910-1915M:
CLAYST (95%); A/A, tr sltst.
SAND (25%); fn/cse, porosity, subrnd/rnd qtz, clr/transluc, no shows. Poss good poros, if discrete sand.

1915-1920M:
CLAYST (40%)
SAND (50%); A/A, but fn/m, some cse, fair srtg. No shows.
DK SLTST (10%); A/A, purple/red, hd, calc.

1960-1965M:
CLAYST (80%); A/A.
SAND (15%); A/A.
SILTST (5%); A/A.

1965-1970M:
CLAYST (70%); Same A/A. No shows.
SAND (20%); Same A/A. No shows.
SLTST (10%); Same A/A. No shows.

1970-1975M:
CLAYST (65%); A/A (brite brick red, sl/mod calc, soft/firm).
SAND (25%); fn/m, sm cse, subrnd/rnd, good spheric, well srtd. No shows. (Good poros?).
SLTST (10%); A/A (brick red/dk purplish red, hd, var calc).

1975-1980M:
CLAYST (80%); A/A (no difference). No shows.
SLTST (10%); A/A (no difference). No shows.
SD (10%); A/A (no difference). No shows.
Calc: 3/0.

1980-1985M:
CLAYST (75%); Same. No shows.
SLTST (10%); Same. No shows.
SD (15%); Same. No shows.
Calc: 6/1.

1985-1990M:
CLAYST (75%); A/A. No shows - poros prob good in loose sd.
SLTST (10%); A/A. No shows - poros prob good in loose sd.
SAND (15%); A/A. No shows - poros prob good in loose sd.
Calc: 6/0.

1990-1995M:
CLAYST (70%); brite brick red, soft, less lt gy-pink; var calc.
SAND (20%); qtz, fn/m, less cse, subrnd/rnd, spheric, good,fair srtg. No shows. Good poros.
SLTST (10%); dk purplish red, hd, mod calc. No shows.
Calc: 6/0.

1995-2000M:
CLAYSTONE (80%); A/A, tr anhydrite.
SILTSTONE (10%); A/A.
SAND (10%); A/A.
(Formation probably much more arenaceous, sample not indicative of MWD response in general).
Calc: 5/1.

2000-2005M:
CLAYSTONE (85%); A/A, mod calcareous.
SILTSTONE (5%); A/A, mod to v. calcareous.
SAND (10%); clear, gen medium to fine, well sorted, rnded, gen spherical unconsolidated quartz, no shows.

2005-2010M:
CLAYSTONE (65%); A/A, gd tr-5% anhydrite white, soft, amorphous and grey, crystalline, firm.
SILTSTONE (25%); A/A, varicolored, tr violet, tr black, var cal nil vis Ø.
SAND (10%); A/A, occ varicolored.
Calc: 5/1.

2010-2015M:
CLAYSTONE (50%); A/A.
SILTSTONE (20%); A/A, with ~5% lt aqua green colored (continues varicolored).
SAND (30%); predominantly med, f-c however, no shows.
Calc: 4/0.

2015-2020M:
CLAYSTONE (35%); A/A, occ banded with white amorphous anhydrite.
SILTSTONE (25%); A/A.
SAND (40%); A/A.
(MWD indicates thin distinct interbeds of sand-sandstone in a sequence that overall appears more shaly).
Calc: 4/0.

2020-2025M:
SAND (35%);
CLAYSTONE (45%); A/A, rare subfissility, tr anhydrite, sl calcareous.
SILTSTONE (20%); dk purplish red and lt to med grey.
(Limestone: up to 5% of sample, cavings(?)).

2025-2030M:
SAND (35%)
CLAYSTONE (50%); A/A, sl to mod calcareous, tr anhydrite.
SILTSTONE (15%)
(Much less cavings).
Calc: 2/0.

2030-2035M:
CLAYST (65%); brick red, soft/firm, sl calc.
SLTST (20%); dk red, firm/hd, calc.
SAND (15%); fn/m, occ cse grns, clr/transluc qtz, poor/fair srtg, subrnd/rnded, good sphericity. No shows. Poss fair poros.

2035-2040M:
CLAYST (75%); A/A.
SLTST (20%); Same as 2035M.
SAND (5%); ID - No shows.

2040-2045M:
CLAYST (60%); tan/orange-brn, sft; occ brick red; var calc.
SLTST (20%); dk red/brn, firm/hd, var calc.
ANH (& GYPSUM?) (20%); wh, soft, var calc (gypsum pt?). No shows. Tr dol, gy, hd, microxtln. Tr cse qtz, rnded; tr ang clr, v cse.

2045-2050M:
CLAYSTONE (75%); A/A, c/m, gy-grn, soft, var calc.
SLTST (15%); A/A.
SD (5%); qtz, fn/cse, unsrtd, subrnd, clr/transluc, gy. No shows.
ANH (5%); wh, soft (Gyps?).

2050-2055M:
CLAYSTONE (75%); A/A, continue common sli gn md-gy claystone (10% of sample).
SILTSTONE (10%); A/A, occ dk gray.
SAND (15%); A/A, clear to translucent, orange, red, no shows, v sl trace anhydrite.

2055-2060M:
CLAYSTONE (65%); A/A.
SILTSTONE (20%); A/A.
SAND (15%); gen A/A, well sorted, tr-3% black grains (hematite?). No shows.

2060-2065M:
CLAYSTONE (60%); orangish red/bwn, soft to firm, sli calcareous.
SILTSTONE (20%); A/A, gen sli to non calcareous.
SAND (20%); A/A. No shows. (Overall much less calcareous).

2065-2070M:
CLAYST (85%); A/A. No shows.
SLTST (10%); Same. No shows.
SD (5%); No change, less abund. Tr wh/transluc anhydrite. No shows.

2070-2075M:
CLAYSTONE (75%); M grn-gy, sh-firm, fissil/subfiss mod calc.
SLTST (15%); Same. No evidence of conglomerate. No shows.
SAND (10%); Same. No evidence of conglomerate. No shows.

2075-2080M:
CLAYST (50%); m orange-brn, brick red, less m gy-grn, soft/sl firm, var calc, occ tr hard, gy-grn & dk brn-red, subfiss.
SLTST (50%); dk purple-red, dk red brn, hd/sl soft, pt v hd, mod calc grading to v fn ss, calc cement. No porosity. No shows.
SD (TR); cse/m gn qtz, clear, loose, & tr wh/transluc anh, lt gy/off white, amorphous, non-calc.

2080-2085M:
Spot spls - 2082: same CLYST & SLTST, 2083: CLYST, SLTST, 45/50. A/A + 5% sh, firm, m gy-grn, sl calc, tr SD & tr anhydrite.
CLAYSTONE (60%); orange red, A/A, sl calcareous.
SHALE (10%); reddish brown, occ grey, firm to med hard, subfissile, non to v sli calcareous.
SILTSTONE (25%); A/A.
SAND (5%); A/A, no shows.

2085-2090M:
CLAYSTONE (30%); A/A, gd tr anhydrite.
SHALE (5%); A/A, subfissile to occ fissile.
SILTSTONE (45%); generally A/A, grey fraction (~15%), grading to vf ss, calcareous cement sl hard, nil vis Ø.
SAND (20%); clear, orange stain, occ translucent, f occ med, well sorted, rnded, spherical, no shows.

2090-2095M:
CLAYSTONE (50%); A/A.
SHALE (10%); grey, greenish-grey and lt red; A/A.
SILTSTONE (40%); A/A, grading to v f sandstone, sandstone appears to contain a small percentage of dark (lithic?) fragments, tr sand, no shows.

2095-2100M:
(B.U. at 2099.1M-drill break @ 2096.99M).
CLAYST (75%); A/A, (brite brick red, soft, sli calc).
SLTST/SS (10%); ss v fn, fri, A/A.
SHALE (10%); A/A, red-brn, less gy-grn.
SD (5%); cse qtz, subrnd/rnd, sphericity good. No shows.

2100-2105M:
CLAYST (75%); A/A.
SLTST/SS (10%); A/A.
SH. (10%); A/A.
SD (5%); A/A.

2105-2110M:
Bit change @ 2008M.
CLAYST (65%); A/A.
SLTST (15%); w/ ss, A/A.
SH (10%); A/A.
SD (5%); qtz, cse/fn, subrnd, tr dk-grn silic gns, cse, subrnd.
ANHY (5%); transluc, brittle, wh, v soft.

2110-2115M:
SLTST (60%); A/A, dk red/brn, soft/sl firm.
SS (20%); dk brn, v fn, fri/sl firm, argillac, mod calc. Poor poros. No shows.
SH (5%); brick red, firm/soft, A/A.
CLAYST (5%); red, tr gy-blue/gy, soft, sli calc. Tr/c anhydrite.

2115-2120M:
CLAY (80%); blue-gy, soft, pt sl/mod calc, sticky on shakers, v sl carb, pt sl slty.
SH (10%); brick red, soft/sl firm, subfiss.
SLTST (10%); brn-red, soft, calc argillus.

2120-2125M:
CLAY (95%); A/A, v sl carbonac, variably calcareous.
SH (5%); tr/c v firm/brittle thin strk, sli carbonous, noncalc, slickensided. No shows.

2125-2130M:
CLAY (100%); A/A, soft, gummy/sticky on shakers, sples, tr w/blk, carbonac lam/surfaces, good part silty, w/tr tiny spherical pyritized microfossils.

2130-2135M:
CLAY (100%); A/A, pt silty.

2135-2140M:
CLAY (95%); A/A, grading to SH in small pt.
SH (5%); m/lt gy, sli firm, subfiss to massive, sl calc, pt sl silty.

2140-2145M:
CLAYSTONE (80%); med grey, soft, occ firm, amorphous to occ blocky, sl carbonaceous, sli calcareous.
SHALE (10%); med to dk grey, firm, subfissile to fissile, micromicac.
CLAYSTONE (10%); red/bwn, no shows.

__2145-2150M__:
__CLAYSTONE__ (75%); lt-med grey, carbonaceous debris v finely interlaminated.
__SHALE__ (10%); lt-dk grey.
__CLAYSTONE__ (15%); red/bwn, no shows.

__2150-2155M__:
__CLAYSTONE__ (85%); A/A, grading to siltst in part.
__SHALE__ (10%); A/A, to dk grey-black in part.
__CLAYSTONE__ (5%); red/bwn, no shows.

__2155-2160M__:
__CLAYSTONE__ (85%); A/A, with undulating carbonaceous lamination, grading to siltst.
__SHALE__ (10%); A/A.
__CLAYSTONE__ (5%); red/bwn, no shows.

__2160-2165M__:
__CLAY__ (55%); A/A, var silty, carbonac, calc.
__SH__ (45%); A/A, subfiss/firm; var carbonac, slty, calc, micromicac, pt grades to v arg sltst, carbonac, calc, firm/soft. No shows.

__2165-2170M__:
__SHALE__ (60%); A/A, carbonac, mtl abund. No shows.
__CLAY__ (40%); A/A, carbonac, mtl abund. No shows.

__2170-2175M__:
__CLAY__ (60%); A/A. No shows.
__SHALE__ (40%); A/A. No shows.

__2175-2180M__:
__CLAY__ (60%); A/A, soft, stky (lt gy).
__SHALE__ (60%); slty, A/A, (m gy); micromicac. No shows.

__2180-2185M__:
__CLAY__ (50%); Ident to above.
__SHALE__ (50%); Ident to above.
Tr sltst, m gy, arg, v fri, sl calc. No shows.

__2185-2190M__:
__CLAY__ (50%); A/A, sl/mod calc. No shows.
__SHALE__ (50%); A/A, sl/mod calc. No shows. Tr sltst.

2190-2195M:
CLAY (50%); Ident to above. No shows.
SHALE (50%); Ident to above. No shows. Tr sltst.

2195-2200M:
CLAY (50%); A/A. No shows.
SH (50%); A/A. No shows.

2200-2210M:
CLAY (60%); A/A. No shows.
SH (40%); A/A. No shows.

2210-2220M:
CLAY (60%); A/A. No shows.
SH (40%); A/A. No shows.

2220-2230M:
CLAY (45%); A/A, lt/m gy, v soft, milky calc, carbonac, sl silty.
SH (55%); A/A m/lt gy, firm/sl sft, carb, calc, slty, micromicac. No shows.

2230-2240M:
CLAY (50%); A/A.
SH (50%); A/A, some v slty, grading to sltst; sh micromicac in general. No shows.

2240-2250M:
CLAY (60%); A/A. No shows.
SH (40%); A/A. No shows.

2250-2260M:
CLAY (60%); Same as overlying. No shows.
SH (40%); Same as overlying. No shows.

2260-2270M:
CLAY (75%); Same. Less calcareous.
SHALE (25%); Same. Less Calcareous. Tr sltst, A/A. No shows.

2270-2280M:
CLAY (70%); As before (lt/m gy sft, carbonac, calc, micromicac, w/slty sections, lam w/dk carb mtl).
SHALE (30%); As before (m gy, firm, sl fiss, micromicac, sl calc, variably carbonac w/microlaminae. No shows.

2280-2290M:
CLAY (65%); gy, soft, sl calc, carbonac, micromicac.
SHALE (35%); m gy, frm, subfiss, calc, carbonac, micac, tr sltst. No shows.

2290-2300M:
CLAY (80%); A/A, tr/little brick red w/gy-grn mottling (cvgs?).
SH (20%); A/A. No shows.

2300-2310M:
CLAY (75%); A/A, (little brick red, cvgs, soft, v sl calc). No shows.
SH (25%); A/A, (little brick red, cvgs, soft, v sl calc). No shows.

2310-2320M:
CLAY (40%); gy, A/A, 5% brick red, as uphole.
SH (60%); gy A/A, w/tr cse/granular qtz, & dark silic gns, rnded, good sphericity. Tr pyrite, fine xtals. No shows.

2320-2330M:
SH (60%); A/A, slty/carb/sl calc, gy, pt subfiss.
CLAY (30%); gy, little red (5%) w/2% qtz sd, fn/m, occ cse qtz, subrnd/rnd. No shows. Tr large muscovite mica flakes. No shows.

2330-2340M:
SH (60%); A/A, slty, grades to sltst. Tr ss v v fn, lt gy, fm/sl firm, v calc cem.
CLAY (40%); A/A. Tr wh/transluc anh, tr qtz, cse, clr. No shows.

2340-2350M:
SH (50%); No change. Tr sltst/v v fn gy ss, fri, calc. No shows.
CLAY (50%); No change. Tr sltst/v v fn gy ss, fri, calc. No shows.

2350-2360M:
SH (60%); A/A. Tr wh, soft, calc, clay/calc. No shows.
CLAY (40%); A/A. Tr wh, soft, calc, clay/calc. No shows.

2360-2370M:
SH (60%); Same; mod to v calc in pt. No shows.
CLAY (40%); Same; mod to v calc in pt. No shows.

2370-2380M:
SHALE (50%); No change. Tr anhy (cvg?), occ slickensides, tr pyr xtals. No shows.
CLAY (50%); No change. Tr anhy (cvg?), occ slickensides, tr pyr xtals. No shows.

2380-2390M:
SHALE (50%); No change. Tr pyr. No shows.
CLAY (50%); No change. Tr pyr. No shows.

2390-2400M:
CLAY (50%); A/A, exactly - m/v calc, sli carbonac. Tr wh, v soft anhy/gyps. No shows.
SHALES (50%); A/A, exactly - m/v calc, sli carbonac. Tr wh, v soft anhy/gyps. No shows.

2400-2410M:
CLAY (50%); A/A.
SH (45%); A/A.
SST (5%); v fn-gn, wh, fri, calc, w/ pyrite. No shows.

2410-2420M:
CLAY (50%); No change. Tr ss, A/A. No shows.
SH (50%); No change. Tr ss, A/A. No shows.

2420-2430M:
SH (65%); m/lt gy, subfiss, slty, calc, carbonaceous (lam & dissem).
CLAY (35%); lt gy, soft, calc, pt slty, carbonacous (lam & dissem).
Tr/little wh clay/gyps/anhy. No shows.

2430-2440M:
(@ 2439 circ bottoms up for short trip).
SH (65%); As overlying. No shows.
CLAY (35%); As overlying. No shows.

2440-2450M:
CLAY (60%); lt grey, occ med grey, soft, amorphous, hydratable, variable carbonaceous (finely disseminated, occ interlaminated), sl to mod calcareous, hydratable.
SHALE (40%); med to dark grey, firm, subfissile, sl calcareous, sl carbonaceous, grading to dk grey siltstone (~10% of sample), med hard, cal cement, nil vis Ø, no shows. (~5% cavings of red/bwn claystone - following wiper trip).

2450-2460M:
CLAY (70%); A/A, occ buff-tan (35%), tr anhydrite wispy carbonaceous laminations.
SHALE (30%); A/A, grading to siltstone in part (~5%). No shows.

2460-2465M:
CLAY (55%); A/A, firm in part, carbonaceous debris (anthracitic coal-hard, vitreous luster), tr sandstone - greenish, v f grained, tight cal cement.
SHALE (45%); A/A, fissile commonly, no shows.

2465-2470M:
CLAY (50%); A/A, ~15% buff to tan color with grey clay and carbonaceous interlaminations.
SHALE (50%); A/A, grading to siltstone (5%).
SANDSTONE (TR); off white, v f grained, dk grains, subang (?) to subrnd, trace vis Ø, no shows.

2470-2475M:
SAMPLE MISSED

2475-2480M:
CLAY (60%); lt grey to buff in part, A/A.
SHALE (40%); A/A, continues micromicaceous, no shows.

2480-2485M:
CLAY (55%); A/A, tr anhydrite.
SHALE (45%); A/A, occ grading to siltstone to v f sandstone (5%), off white, friable to firm, subang-subrnd, subspherical, poor vis Ø, no shows.

2485-2490M:
CLAY (50%); A/A.
SHALE (50%); A/A, no shows.

2490-2495M:
CLAY (50%)
SHALE (50%); carbonaceous debris observed. No shows.
(Sample is highly pulverized).

2495-2500M:
CLAY (50%); A/A, trace anhydrite.
SHALE (50%); A/A.

2500-2505M:
CLAY (50%); A/A, continues buff-tan in part.
SHALE (50%); A/A, grading to siltstone, no shows.

2505-2510M:
CLAY (45%); A/A.
SHALE (55%); A/A, no shows, tr v f ss.

2510-2515M:
CLAY (40%); A/A.
SHALE (60%); A/A, grading to siltstone (~20% of sample), nil vis Ø, no shows.

2515-2518M: (T.D. - Bottoms up).
CLAY (50%); No change.
SHALE (50%); No change.
T/ wh anh(?)/gyps(?).

2518M: MD RKB- TOTAL DEPTH.
(±4:00 AM JULY 7, 1989).

AMOCO DENMARK EXPLORATION COMPANY
SIDEWALL CORE DESCRIPTIONS
5414/7-1 (STINA-1) WELL, BALTIC SEA

RUN NO. 1 RECOVERED 50 EMPTY BULLET(S) 10 MISFIRED 0 BULLET LOST 0
DESCRIBED BY: REVILLA & FARRELLY DATE: JULY 8, 1989

NO.	RECOVERED	(M) DEPTH	LITHOLOGIC DESCRIPTION	SHOWS & REMARKS
1	3/4"	2498.	Clayst - m gy, soft/sl firm, blky, fract, mod calc.	Badly contam. (mud)
2	1/2"	2482.5	Sltst - m/lt gy, soft, argillac, mod calc, arenac, fair to poor poros.	None. Mud-contam.
3	1"	2467.5	Clayst - m gy, sft/sl firm, blky/platy fract, mod calc.	-
4	3/4"	2451.25	Sltst - m gy, soft, mod calc, arenac, pyritic.	None.
5		2432.5	(Mud w/cuttings/cvgs of clayst)	(Refused)
6	1/2"	2419.5	Clayst - m gy, soft/sl frm, blky/platy fract, mod calc, silty, carbonac.	Mud contam.
	3/4"	2404.	Clayst/sh - m gy, sl firm, blky/platy fract, mod calc w/ fine carbonac laminae.	Mud contam.
8	3/4"	2390.	Clayst - m gy, soft/sl firm, blky/platy, mod/sl calc.	Mud contam.
9	3/4"	2369.5	Clayst - m gy, soft, sl blky fract, mod calc, sl silty.	-
10	1/2"	2353.	Sltst - m/lt gy, clay matrix, v pyritic w/finely div grns/xtals dissem & in patches, abund laminae of lt/m gy clay/silt, calc.	None.
11	1"	2341.25	Clayst - m gy, platy fract, silty, mod calc.	-
12	1/4"	2327.5	Clayst - m gy, calc, soft, blky fract.	Bad mud contam.
13	3/4"	2312.75	Clayst - m gy, w/lite gy bands/laminae, mod calc, silty, w/fine carbonac laminae.	-
14	1½"	2295.	Clayst - m gy, sl firm/blky, v silty, micro-micac, mod calc.	-

NO.	RECOVERED	(M) DEPTH	LITHOLOGIC DESCRIPTION	SHOWS & REMARKS
15	1/2"	2275.5	Sh - m gy, firm, platy fract/subfiss, mod calc, silty.	V bad mud contam.
16	1"	2258.	Clayst - lt/m gy, soft, platy, slty in pt, micromicac, sl/mod calc.	-
17	3/4"	2242.5	Clayst - m gy, soft/sl firm, platy fract, sl calc, sl slty in pt.	-
18	1"	2227.	Clay - m/lt gy, soft, amorphous, sl calc.	V bad mud contam.
19	1"	2210.	Clayst - m gy, soft/sl firm, platy fract, sl/m calc, sl micromicac in bands.	-
20	1¼"	2195.	Clayst - m gy, soft, amorph, micromicac.	-
21	1"	2180.	Sltst - m dk gy, soft, clay matrix, platy fract, mod calc.	Bad mud contam.
22	1"	2169.5	Sh - m gy, firm, subfiss platy, fine lt gy laminae, micromicac, sl silty.	-
23	3/4"	2156.25	Sh - m/dk gy, firm, subfiss platy, lt gy laminae (as 2169.5), sl silty, micromicac.	-
24	-	2135.25	(No recovery)	
25	1/2"	2118.	Clayst - m/dk gy, w/lt gy lam & bands, platy, m/sl calc, fn carbonac lam.	Bad mud contam.
26	1"	2108.25	Conglomeratic sd w/dk brick red mtrx; sand fn to v cs, granular, sbrnd/rnd, unsorted, clay v sl calc, sticky/tough, w/ minor green reduction spots. Nil porosity.	No shows.
27	-	2104.75	(No recovery)	
28	1¼"	2100.	Clayst - dk red/brn, firm, mass, sl calc, v/sl slty.	-
29	1½"	2094.	Clayst - dk red/brn, as 2100, but w/ abund cs qtz, less fn/med, well-rnded, lithic silic grns, unsrtd. Nil porosity. Tr xtln anhyd, clear/transluc to wh amorph anhyd.	No shows.
30	-	2091.	(No recovery)	

JR/JLT277A/2

NO.	RECOVERED	(M) DEPTH	LITHOLOGIC DESCRIPTION	SHOWS & REMARKS
	3/4"	2074.	Cgl, w/ brite brick red clay matrix, sd fn to v cs, gran, well rnded lithics & qtz, no sorting. Clay only v sl calc, stiff.	No shows. Nil poros.
32	3/4"	2018.5	Cgl, clay matrix, ident to 2074. Nil poros.	No shows.
33	1/2"	1991.	Sand, red-brown, fn/med, qtz, some cs grns, well rnded, fri, fair to good sorting, mod calc clay matrix/cem. Porosity good.	No shows.
34	1/2"	1983.	Sand, ident to 1991. Good porosity	No shows.
35	1"	1976.	Sand, as 1991 & 1983. Good porosity. V fri.	No shows.
36	2"	1973.	Sand & Clay - interbedded finely. Sand sim to 1991-1976 but fn-gn mainly, red-brown w/ red clay cem/matrix & red clay interbeds.	Poor/fair porosity. No shows.
37	3/4"	1962.	Sand, as at 1991-1976. Good porosity.	No shows.
38	3/4"	1939.75	Sand & Clay, as 1973. Fair to poor poros.	No shows.
39	1"	1927.	Sand, as at 1991-1973. Good porosity.	No shows.
40	3/4"	1915.5	Cgl sd w/ clay matrix, red, as at 2074-2018.	No shows. Poor porosity.
41	3/4"	1899.	Sand, sim to 1991 but finer, occ med-cs, v fri. Good porosity.	No shows.
42	1"	1898.	Sand, brick red, v v fn to fn-gn w/ red clay cem. & thin interbeds; mod/sl calc.	No shows.
43	3/4"	1889.75	Sand: brick red, v fine to fine grained, well sorted with red clay matrix-cement(?), mod calcareous, slightly micromicaceous. Good porosity.	No shows.
44	-	1867.	(No recovery)	-
45	1/2"	1863.5	Clay: reddish brown, soft to sl firm, mod to v calc, amorphous, good tr anhydrite. Abnd sand grains, gen v fine to fine. V poor vis porosity.	No shows.
46	1/4"	1687.	Clay: med to dark grey, firm, rarely subfissile, mod calcareous, micromicaceous.	-

NO.	RECOVERED	(M) DEPTH	LITHOLOGIC DESCRIPTION	SHOWS & REMARKS
[illegible]	3/4"	1640.5	Anhyd & Clay: Anhyd is wh to gy, transluc, firm, xtln; clay is off-wh & wh, soft, sl carbonac (dissem in rock), blocky fract.	-
48	-	1637.	(No recovery)	-
49	1/4"	1547.25	Marly limestone: lt grey-greenish, soft, amorphous, extremely micritic, nil visible porosity.	Mud contaminated.
50	-	1520.5	(No recovery)	-
51	3/4"	1491.5	Sand: crimson red, predominantly very fine, occ fine grained, sl firm, calcareous clay-rich matrix, rare green reduction spots, trace anhydrite, fair visual poros.	No shows.
52	3/4"	1465.	Sand: sim. to 1491.5 m overall. Fair to poor visible porosity.	No shows.
53	3/4"	1421.	Clayey sand: red/brown, v f to silty, firm, very argillaceous, occ green reduction spots. Clay matrix is mod calcareous, poor to nil visible porosity.	No shows.
54	-	1364.	(No recovery)	-
55	1/2"	1352.5	Sand: Red/brown, predominantly medium, fine to coarse overall, firm, mod sorting, subang-subrnded, sl clay matrix.	No shows.
56	1/4"	1320.5	Sand: Clear to translucent, red-orange (iron oxide staining), medium to occ fine grained, subrnded, subspherical, well sorted, unconsolidated quartz, good vis porosity.	No shows.
57	-	1304.	(No recovery)	-
58	1/2"	1279.25	Sand, as 1320.5. Good porosity.	No shows.
59	1"	1256.5	Sand, sim. to 1320.5 but v f/f-gn only. Good vis porosity.	No shows.
60	-	1155.5	(No recovery)	-

GEOLOGICAL REPORT NO. 1 - JUNE 13, 1989

1. **PRESENT DEPTH:** 127m
2. **PRESENT OPERATIONS:** Installing well head "A" section
3. **PROGRESS:** 40m
4. **SAMPLED INTERVAL (IN 24 HOURS):** 67-134m
5. **FORMATION TOPS AND/OR CORRELATIONS:** Quaternary 67m (S.B.) U. Cretaceous? - 115m
6. **LITHOLOGY (BY INTERVAL):** Samples taken from drill floor. 67-85m: Sand - 100%, f-med G.R., subang-subrnd, glauc., good vis. por. 85-115m: conglomerate - 70%, sand 30%, varicoloured frag of meta sediments. 115-124m: interbedded clay (40%) cong./sand (50%) and dolomite (10%). 124-133: Sand (80%), clr, f-m gr., subang-subrnd, dolomite (20%).
7. **SHOW SUMMARY:** None
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 8.6
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** N/A
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** Interval 67-83m, Max. Rate 60m/hr, Ave. ROP 60m/hr; Interval 83-134m, Max. Rate 60m/hr, Ave. ROP 23m/hr
18. **COSTS:** 65,401 (Daily), 542,256 (Cumulative)
19. **REMARKS:** Depths are only approximate as samples were taken from drill floor while drilling 20" conductor. Formation tops based on crude correlation with K-5 well.

GEOLOGICAL REPORT NO. 2 - JUNE 14, 1989

1. **PRESENT DEPTH:** 161m
2. **PRESENT OPERATIONS:** Drilling 26" hole
3. **PROGRESS:** 24m
4. **SAMPLED INTERVAL (IN 24 HOURS):** 134-155m
5. **FORMATION TOPS AND/OR CORRELATIONS:** Quaternary - 67.19m; Cretaceous? - 115m; Middle Jurassic - 127m
6. **LITHOLOGY (BY INTERVAL):** Sand with mnr coal and Fe-Dol. 134-155m: Sand: 80% clr-mlky, loose, m. crse-v. crse, pr srtd, rnded-subrnded, sph, rare dol cmt, uncons. Clay: 10% lt gy, sft, swel, slty, abnt pyr nodules. Ferroan Dol: tr-5%: lt brn-buff, v. hd, ang-hkly brk, minutely frac, microxln-microsucr. Coal: 5%
7. **SHOW SUMMARY:** No shows
8. **BACKGROUND GAS:** Total 0-.001%; C_1 4-5 ppm
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 9.0
13. **DxC/TREND:** .56-1.07/8.6 ppg/rend
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.6 ppg
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:**
18. **COSTS:** 197,880 (Daily), 740,136 (Cumulative)
19. **REMARKS:** Interbedded sands, coals and fe-dol is felt to be typical of Middle Jurassic in Bornholm. ROP range 4-90m/hr. 134-148m ROP av. 50m/hr. 148-161m ROP av. 7m/hr.

JR/DAM264/36

GEOLOGICAL REPORT NO. 3 - JUNE 15, 1989

1. **PRESENT DEPTH:** 360m

2. **PRESENT OPERATIONS:** Circulating hole at T.D.

3. **PROGRESS:** 200m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 155-360m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Lower Jurassic 304m KB, 268m SS (see remarks)

6. **LITHOLOGY (BY INTERVAL):** 155-225m Clay with Sand/Coal/Fe Dolomite intbds). Clay: 70%: lt-med gy, sft, swel, non-calc, slty, abnt pyr nodules. Sand: 20%: clr-mlky, uncons, f-crse, pr srt, subrnd, sph, tr calc cmt, good vis por. Coal: 10%: blk-v dk brn, frm brit, fibrous, vit-res lust, some pyr repl't. Fe Dol: <5%: lt brn occ yel grn, hd, ang-blky brk, occ microsucr, microxln, ferroan. 225-304m Sand with coal interbeds. Sand: 80%: clr-transl occ opq, uncons, f-m, w srtd, subrned, sph-subsph, tr calc cmt, sl-carb, w/ associated pyrite, v gd vis por. Coal: 20%: blk occ v dk brn, frm, brit, fibrous, vit-res, occ pyr repl't. Clay: <5%: med gy-dk gy, frm-sft, semi-hydratable, sl calc, earthy, abnt pyr. 304-360m Clay with slts and sandstone intbds. Clay: 60%: med gy, sft, occ frm, plastic, swel, slty, abnt nod pyr, non calc. Siltstone: 30%: med gy, hd-frm, blky, arg, occ grdg to v f sst, tr mica. Sandstone: 10%: med gy, hd, blky, v f, subrnd, mod srt, v arg, calc - silic cmt, v pr vis por.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** Total .001-.002; C_1 10-20 ppm

9. **MAX. GAS - DEPTH:** 330m, .005%; C_1 41 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 9.1

13. **DxC/TREND:** .71-1.14/8.6 ppg

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.6 ppg

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A

17. **DRILLING BREAKS:** Interval 255-260m, Max. Rate 20m/hr, Prev. Rate 6m/hr, Ave. ROP 18m/hr

18. **COSTS:** 93,564 (Daily), 833,700 (Cumulative)

19. **REMARKS:** The clean good porous sand with thick interbedded coals from 225-304m seems to fit quite well with the Middle Jurassic Baga Formation of Bornholm Island rather than anything observed on well K/5-1. For this reason it is felt that the Lower Jurassic occurs deeper than prognosed at 304m KB, 268m SS. Corresponding to an abrupt change to argillaceous fine sandstones/siltstones and clay of a more open marine environment. No shows observed from drilling break at 255m.

GEOLOGICAL REPORT NO. 4 - JUNE 16, 1989

1. **PRESENT DEPTH:** 360m
2. **PRESENT OPERATIONS:** Running 20" casing
3. **PROGRESS:** No new formation drilled in last 24 hrs
4. **SAMPLED INTERVAL (IN 24 HOURS):** N/A
5. **FORMATION TOPS AND/OR CORRELATIONS:** Lr Jurassic: 304m KB, 268m SS; 300m log, 264m SS
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** N/A
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 9.5
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.6
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 87,892 (Daily), 921,592 (Cumulative)
19. **REMARKS:** Logging operation, suite N°1 26" hole.

Run	Log	Interval
1	GR-ISF-BHC (Excentralized)	363-137.5 GR to seabed 67m
2	GR-CAL-BHC (Centralized)	363-137.5 GR to seabed 67m

Total time from rig up to rig down = 5 hrs 18 mins.

GEOLOGICAL REPORT NO. 5 - JUNE 17, 1989

1. **PRESENT DEPTH:** 360m
2. **PRESENT OPERATIONS:** Nipple down 30" diverter
3. **PROGRESS:** N/A
4. **SAMPLED INTERVAL (IN 24 HOURS):** N/A
5. **FORMATION TOPS AND/OR CORRELATIONS:** Lower Jurassic 304m KB, 268 MSL, 300m (log) 264 MSL
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** N/A
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 9.5
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.6
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 172,264 (Daily), 1,094,856 (Cumulative)
19. **REMARKS:** None

GEOLOGICAL REPORT NO. 6 - JUNE 18, 1989

1. **PRESENT DEPTH:** 363m
2. **PRESENT OPERATIONS:** Circulate to displace to new mud (PHPA mud)
3. **PROGRESS:** 3m
4. **SAMPLED INTERVAL (IN 24 HOURS):** no sample to surface
5. **FORMATION TOPS AND/OR CORRELATIONS:** Lr. Jur. 304m KB, 268m SS. Drilling Lower Jurassic
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** N/A
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 9.5
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.6
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** No leak off FCCT at 12.0 ppg
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 78,473 (Daily), 1,173,329 (Cumulative)
19. **REMARKS:** Test BOP, drill out cement and shoe. Drill 3m of formation. Do F.C.C.T. Bit #3 17-1/2" SDGHC.

GEOLOGICAL REPORT NO. 7 - JUNE 19, 1989

1. **PRESENT DEPTH:** 645m

2. **PRESENT OPERATIONS:** Drilling ahead

3. **PROGRESS:** 282m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 363-640m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Upper Triassic (Keuper) - 555m RKB, 519m SS

6. **LITHOLOGY (BY INTERVAL):** 360-555m: Interbedded Clay (80-100%) Sand (10%) Coal (10%). Clay: med gy-light gy, sft, plastic, non-calc. Sand - clr, mlky, f-m, subrnd, w. srt, uncons., good vis por. Coal - blk, blocky, vit res lustre, with stringers of lignite. 555-595m - brick red - lt green gy-lt brown red, soft, clyst, hydrofissile, sl. dol, mod-sl-calc. tr lst, dol. 595-640m - clyst (50%) red-brn and lt gy green, mod. calc. marl (30%) minor sand, tr lst.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** Total .001-003; C_1 10-30 ppm

9. **MAX. GAS - DEPTH:** 500m, .006%; C_1 55 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 9.3 (PHPA mud)

13. **DxC/TREND:** .7-1.77/8.6 ppg

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.6 ppg

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.1

17. **DRILLING BREAKS:** Interval 630-645, Min. Rate 3m/hr, Prev. Rate 15-20m/hr, Ave. ROP 4m/hr (reverse)

18. **COSTS:** 65,474 (Daily), 1,238,804 (Cumulative)

19. **REMARKS:** Abrupt change in lithology at 555m RKB from gy shales to brick red-brwn-lt green clay which could be Upper Triassic (Keuper?) clyst. Survey at 482m 1/2° N10°W.

GEOLOGICAL REPORT NO. 8 - JUNE 20, 1989

1. **PRESENT DEPTH:** 854m

2. **PRESENT OPERATIONS:** Drilling 17-1/2" hole

3. **PROGRESS:** 209m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 640-845m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Up Triassic 555m KB 519m SS

6. **LITHOLOGY (BY INTERVAL):** Clyst with sand intbds, tr lst
   640-740: Clyst: 70% med red brn, frm-sft, swel, mod calc. sand 30% clr-mlky, orng-red, yel-orng, vf to crse, mod-fr srtd, occ well srtd, subrnd-subang, sph, good vis por. Lst: <5%: wh-lt gy, hd-frm, sl arg, blky, mxln-micritic, rare intergran por.
   Clyst with tr Lst and tr sand
   745-845: Clyst: 100%, lt orng-brn-dk rd brn, with patches of lt gy grn, sft-frm, swel-blky, mod calc, Lst: <5% minor strngs, wh-lt-med gy, hd-frm, mxln-micritic, rare intergran por. Sand: tr rare stringers, clr-orng-red, vf-f, mod well srtd, sph, subrnd, sl arg mtx, mod gd vis por.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** Total 001-002%; C_1 4-24 ppm

9. **MAX. GAS - DEPTH:** 695, 003%; C_1 23 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 648, .074%; C_1 740 ppm

12. **MUD WEIGHT (PPG):** 9.4

13. **DxC/TREND:** .7-12/8.6 ppg

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.6 ppg

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.1

17. **DRILLING BREAKS:** N/A

18. **COSTS:** 346,460 (Daily), 1,585,245 (Cumulative)

19. **REMARKS:** Av. ROP 25m/hr 5m samples collected. On present prognosis top Bunter Sst. expected at ~1050m. Muschelkalk equiv expected ~950m. The following hot shot samples were dispatched today to Robertson's research via Ronne: 330m; 500m; 540m; 570m; and 600m.

JR/DAM264/29

GEOLOGICAL REPORT NO. 9 - JUNE 21, 1989

1. **PRESENT DEPTH:** 1095m

2. **PRESENT OPERATIONS:** P.O.O.H. for wiper trip - hole tight

3. **PROGRESS:** 241m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 845-1095m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Lr Trias (Bunter Sst) 1084m RKB 1048m SS

6. **LITHOLOGY (BY INTERVAL):** Clyst with sand intbds
   845-905m: Clyst: 80% - lt orng-brn - mod red-brn with lt gy grn strks, frm-sft; swell, blky, sl-mod calc. Sand: 20% - clr-orng-red, vf-f, occ m, well srtd, sph, swbrnd, tr arg mtl, fair-gd vis por.
   Clyst with tr Lst stringers
   905-1084m: Clyst: 100% - lt orng-brn, occ intbds of lt grn gy, rare lt purp-red, rare lt yel-brn, sft, swell, sl-mod calc, tr slt strks. Lst: <5% - thin stringers and poss caliche.
   Sst (Bunter Equiv)
   1084-1095m: Sst: 100% clr, occ lt yel, m-crse, occ f, well srtd, well-rnd-subrnd, sph, fair-gd vis por.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** .001%; C_1 3-11 ppm

9. **MAX. GAS - DEPTH:** N/A

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 9.6

13. **DxC/TREND:** .7-.9/8.6

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.6

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.1 EMW at 355m

17. **DRILLING BREAKS:** Interval 1084-1095, Max. Rate 50m/hr, Prev. Rate 25m/hr, Ave. ROP 30m/hr

18. **COSTS:** 99,855 (Daily), 1,686,900 (Cumulative)

19. **REMARKS:** Muschelkalk equiv. not fully developed. The increase in occurrence of thin limestone stringers from 970m may correlate roughly with the limestone interval on K/5-1 before the Bunter equiv. Circulate bottoms up at 1095m not so much because of drill break but rather a reduction on WOB from 10-12 to 2-3 kilolbs. Bunter Sst found at 1084m KB.

GEOLOGICAL REPORT NO. 10 - JUNE 22, 1989

1. **PRESENT DEPTH:** 1095m meas. depth RKB

2. **PRESENT OPERATIONS:** Running in hole to condition for 13-3/8" csg.

3. **PROGRESS:** 0m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 0m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Lr. Triassic (Bunter SS) 1084m RKB; 1048m subsea

6. **LITHOLOGY (BY INTERVAL):** N/A

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** N/A

9. **MAX. GAS - DEPTH:** N/A

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** (Wiper) 1095m, 0.21%; C_1 1237 ppm

12. **MUD WEIGHT (PPG):** 9.8

13. **DxC/TREND:** N/A

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A

17. **DRILLING BREAKS:** N/A

18. **COSTS:** 97,390 (Daily), 1,785,290 (Cumulative)

19. **REMARKS:**

Run	Log	Scale	1:500	1:200	Depth Logged	Csg
1	ISF-BHC-SP-GR		X	X	1087m	355m
2	LDL-CNL-GR-CAL		X	X	1087m	355m
3	SHDT-GR			X	1087m	355m

Runs 1 and 2 on scale 1:500, Run 3 on scale 1:200.

GEOLOGICAL REPORT NO. 11 - JUNE 23, 1989

1. **PRESENT DEPTH:** 1095m
2. **PRESENT OPERATIONS:** Rigging down Halliburton after cementing 13-3/8" casing in hole.
3. **PROGRESS:** 0
4. **SAMPLED INTERVAL (IN 24 HOURS):** 0
5. **FORMATION TOPS AND/OR CORRELATIONS:** ISF log top of a SS. at 1083m may be top of the Bunter (tenatively).
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** None
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** 1095m, 0.01%
12. **MUD WEIGHT (PPG):** 9.6
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.6
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15./EMW at 355m
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 241,159 (Daily), 2,026,449 (Cumulative)
19. **REMARKS:** None

GEOLOGICAL REPORT NO. 12 - JUNE 24, 1989

1. **PRESENT DEPTH:** 1095m
2. **PRESENT OPERATIONS:** Testing BOP. Note: 13-3/8" csg. shoe at 1080.24m depth
3. **PROGRESS:** 0
4. **SAMPLED INTERVAL (IN 24 HOURS):** 0
5. **FORMATION TOPS AND/OR CORRELATIONS:** N/A
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** N/A
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 9.6
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** N/A
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 118,329 (Daily), 2,144,778 (Cumulative)
19. **REMARKS:** Faxed in summary of tentative log evaluation yesterday.

GEOLOGICAL REPORT NO. 13 - JUNE 25, 1989

1. **PRESENT DEPTH:** 1111m
2. **PRESENT OPERATIONS:** Drilling ahead
3. **PROGRESS:** 16m
4. **SAMPLED INTERVAL (IN 24 HOURS):** 15m
5. **FORMATION TOPS AND/OR CORRELATIONS:** Last poss. top Bunter at 1084
6. **LITHOLOGY (BY INTERVAL):** 1095-1105m Sand, clr qtz, mainly med-gn, some coarse, sbang, good sphericity; w/ traces dol. pyr. brick red clyst. med gy clyst/siltstone, var. calc. to non-calc, sft/mod hd. ROP 15 to 35m/hr, avg. 22m/hr.
7. **SHOW SUMMARY:** No fluor. or cut fluor. Negligible gas - note: both total gas and chromatographic equipment checked and calibrated at 0530 hrs. today.
8. **BACKGROUND GAS:** Total 0.0%
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** 10.0
13. **DxC/TREND:** 0.8-1.18
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** 8.7
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** None
18. **COSTS:** 66,794 (Daily), 2,220,334 (Cumulative)
19. **REMARKS:** Lack of gas shows is being met by special care to check equipment frequently (see 7 above).

GEOLOGICAL REPORT NO. 14 - JUNE 26, 1989

1. **PRESENT DEPTH:** 1472m

2. **PRESENT OPERATIONS:** POOH to change bit.

3. **PROGRESS:** 361m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 360m (1110-1470m)

5. **FORMATION TOPS AND/OR CORRELATIONS:** Nothing new

6. **LITHOLOGY (BY INTERVAL):** 1110-1240m-Sand (85-100%), clear, occ. orange/red brn (iron oxide stained), fine to cse.-gn, gen. fn. to med.-gn, sbang to sbrnd., fair to mod. well-srtd, occ poorly srtd; poss. clay matrix; unconsol. qtz sand; v good to good vis. poros, prob. becomes fair to poor where clay matrix most pronounced. No oil shows of fluor. or fluor. of cut. ROP: 30-35m/hr. Clay (0-15%), red-brn, brick red, soft, amorph., hydrophyllic; traces of wh, xtln calcite.
   1240-1260m-Clay (50%), as above, w/tr dolomitic material; Sand (50%)-as above, good vis. poros., no oil indications.
   1260-1470m-Sand/Sandstone (50-95%). Sand, as above, varying only in grain size from fn/med. to med/cse, with sorting gen. good to fair; vis. poros. fair to good. and no oil indications. Sandstone dominantly brick-red/brn, occas. lit to med. gy with reddish iron oxide stains; v. fn. to fn-gn, hard, blky, well-srtd, gen. silic. w/occ. sl calc. cem; poor to fair vis. poros., no oil indications. Clay (5-35%), as above, becoming main lith. toward and at bottom; traces of white and clear xtln. calcite, becoming incr. comm. with depth; below about 1415m, up to 15% limestone (caliche?), soft, off-wh, marly/earthy, with trace of buff dolomite, hard, microxtln, esp. in last sample.

7. **SHOW SUMMARY:** No indications of oil show - no natural fluorescence, no fluoresc. of cut. Occas. very tenuous blk. to dark brown stains on qtz. sand gns., with no natural fluoresc., but giving extr. tenuous dull yell. fluoresc., could be poss. asphaltic residue, but ambiguous, doubtful.

8. **BACKGROUND GAS:** Total 0.00%

9. **MAX. GAS - DEPTH:** 1210-1230, 0.0% hotwire; C_1 28-32 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 10.4-10.5 Mud Temp (out): 53.6°C

13. **DxC/TREND:** 0.66-1.59

JR/DAM264/21

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** Interval 1128-1130, Max. Rate 40m/hr, Prev. Rate 20m/hr, Ave. ROP 40m/hr; Interval 1150-1170, Max. Rate 50m/hr, Prev. Rate 15-20m/hr, Ave. ROP 40m/hr; Interval 1201-1224, Max. Rate 60m/hr, Prev. Rate 15-30m/hr, Ave. ROP 49m/hr; Interval 1258-1273, Max. Rate 80m/hr, Prev. Rate 30-40m/hr, Ave. ROP 54.5m/hr; Interval 1318-1340, Max. Rate 60m/hr; Prev. Rate 30-40m/hr; Ave. ROP 39m/hr; Interval 1345-1360, Max. Rate 60m/hr, Prev. Rate 15-30m/hr, Ave. ROP 45.5m/hr

18. **COSTS:** 73,721 (Daily), 2,294,054 (Cumulative)

19. **REMARKS:** None

GEOLOGICAL REPORT NO. 15 - JUNE 27, 1989

1. **PRESENT DEPTH:** 1534m

2. **PRESENT OPERATIONS:** Drilling ahead

3. **PROGRESS:** 62m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1470-1530m

5. **FORMATION TOPS AND/OR CORRELATIONS:** N/A

6. **LITHOLOGY (BY INTERVAL):** 1470-1530m: Lithic conglomerate, brick red clay matrix; fine to coarse-gn. fragments of volcanics, igneous rocks, and quartz; ign. rocks aphanitic to fine-gn. xtln, dk gy, dk grn, blk, buff. purplish and jasper red; fn-gn to cse-gn qtz and finer-gn ign. rock frag's. sbrnd to rnded; poor srtg., prob. v. poor poros. NO OIL INDICATIONS. Clay/Claystone - brick red, soft, sl. calc. in pts., matrix (&/or beds?) ROP variation 4 to 6m/hr, average 4.8m/hr.

7. **SHOW SUMMARY:** No fluoresc. and no fluoresc. of cut.

8. **BACKGROUND GAS:** Total 0.000%

9. **MAX. GAS - DEPTH:** 1490m, 0.005%; C_1 50 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 1472m, 0.000%

12. **MUD WEIGHT (PPG):** 11.1 Mud Temp. (out): 51.6°C

13. **DxC/TREND:** 1.16-1.58

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. **COSTS:** 96,189 (Daily), 2,390,243 (Cumulative)

19. **REMARKS:** EXLOG MWD tool in hole and operative since bit change trip at 1472m. Chart attached. Reason for sudden shift in GR and Resistiv. values at 1480m unknown. One possibility, almost discounted, is that the further addition of halite salt to bring mud up to supersaturated con. could have caused the lowering of both the GR and Resistivity values of the system sensed by the MWD tool.

GEOLOGICAL REPORT NO. 16 - JUNE 28, 1989

1. **PRESENT DEPTH:** 1650m

2. **PRESENT OPERATIONS:** Drilling

3. **PROGRESS:** 116m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1530-1645m

5. **FORMATION TOPS AND/OR CORRELATIONS:** 1636m - possible top of Zechstein

6. **LITHOLOGY (BY INTERVAL):** 1530-1545m lithic conglomerate angular and fine to coarse grained quartz, subrounded/round, like the finer igneous rock fragments; poor sorting; various igneous rock. Clay/Claystone matrix, some interbedded clay/claystone; porosity poor. 1545-1570m: Limestone, off-wh, light to med. grey, soft to slightly firm, argillaceous, micritic to very fn-gn xtln var. carbonac., finely div. and in fine laminae. tr. transluc./white/clear anhydrite, firm/soft, amorphous, clayst. interbeds, in part of interv. brick red, soft, mod. calc. massive. 1570-1636m: Claystone massive lite reddish-brown, soft to v. sl. firm, mod. calc.; w/minor thin interbeds of shale, dark purplish-red, firm, subfiss/fissile, var. calc. or med. grey-green, firm, subfiss/fissile, noncalc. tr. to common white v. argillaceous limestone and calc. tr. anhydrite. 1636-1645m: Limestone. v. fn-grained xtln, with dolomite; no vis. por. No shows.

7. **SHOW SUMMARY:** No shows

8. **BACKGROUND GAS:** Total 0.00 to 0.004%, C_1 12-86 ppm

9. **MAX. GAS - DEPTH:** 1637m, 0.02%; C_1 240 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 11.2 (out): 56.8°C

13. **DxC/TREND:** 1.16-1.58

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. COSTS: 104,173 (Daily), 2,494,415 (Cumulative)

19. REMARKS: Hot shot sample for palynological analysis in a chopper today.

GEOLOGICAL REPORT NO. 17 - JUNE 29, 1989

1. **PRESENT DEPTH:** 1690m

2. **PRESENT OPERATIONS:** Drilling

3. **PROGRESS:** 40m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1645-1690m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Tentative Zechstein top at 1636m now seems firm.

6. **LITHOLOGY (BY INTERVAL):** 1645-1690m: Limestone, Dolomite and Clay/Claystones interbedded with occas. thin Anhydrite crust. Limestone: light to medium gray, very soft to slightly firm, variably argillaceous, marly, to fine/very fine-grained crystalline in small part. Vis. porosity very poor. Dolomite: minor interbeds, thin, light tan to brownish gray, very finely crystalline and fine-gn. grainstone, firm to hard; vis. porosity nil. Clay/Claystone: light to medium gray, soft, hydrophyllic, sticky, mod. calc.; part marly, slightly firm, grading to Limestone. Clay(st.) main constit. below 1676m.

7. **SHOW SUMMARY:** No fluoresc. of hydrocarbons, and no fluoresc. of cut.

8. **BACKGROUND GAS:** Total 0.00% to 0.10%; C_1 70-131 ppm

9. **MAX. GAS - DEPTH:** 1670m, 0.07%; C_1 113 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 0.00%, 1676m, 0.00%

12. **MUD WEIGHT (PPG):** 11.4 Mud Temp. (out): 57.7°C

13. **DxC/TREND:** 1.47-1.50 - Steady

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. **COSTS:** 76,397 USD (Daily), 2,570,813 USD (Cumulative)

JR/DAM264/16

19. **REMARKS:** (1) New MWD tool in hole since bit change at 1676m is giving "more dependable" curves of GR and Resistivity (copy attached). Prev. run of MWD log believed to be completely "undependable" and unacceptable (in the MWD operators' own words). (2) No salt observed in cuttings as yet; confirmed by no indications on Gamma Ray or Resistivity of any salt penetrated by bit-Gamma Ray should decrease noticeably, Resistivity increase, and ROP would increase also.

GEOLOGICAL REPORT NO. 18 - JUNE 30, 1989

1. **PRESENT DEPTH:** 1741m

2. **PRESENT OPERATIONS:** Running in hole with new bit no. 7 (JK SMIT, MK 171, 12-1/4").

3. **PROGRESS:** 51m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1690-1741m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Nothing new.

6. **LITHOLOGY (BY INTERVAL):** 1690-1710m: Interbedded Ls. & Claystone, with occas. thin Dolomite and very thin Anhydrite. ROP avg. 3.6m/hr. Ls: (20-85%) light to med. gray, sft. to firm. var. argillac., marly, occas. v. finely microxtln.; rare bivalve fossils 7 goniatites (?), fragmented; sl. to mod. carbonac., & w/sl. trace Anhydrite. Very poor vis. porosity; no oil fluoresc. or cut fluoresc. Claystone: (10-80%) light to med. gray, v. soft to sft., mod to v. calc., sticky in part, variably carbonac. Dolomite: (0-5%) transluc. buff to gray, firm to mod. hard, microxtln to occ. sucrosic. Nil vis. porosity; no oil shows. 1710-1741m: Claystone and Siltstone interbedded, with minor Ls. interbeds above 1720m. Avg. ROP: 3.3m/hr. Clayst: (50-65%) brick red, soft, mod. calc., generally amorphous. Siltstone: (0-50%) red-brn, firm to mod. hard, sl to mod. calc., grading in small part to SS, very fine to fine-gn, red/brn, to occ. gray, firm, sl. calc.; trace cse. gns, sbrnd, good sphericity, qtz, w/red hematitic (?) stns. Nil vis. porosity; no oil shows.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** Total 0.00-0.01%; C_1 45-50 ppm

9. **MAX. GAS - DEPTH:** 2720m, 0.02%; C_1 117 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 11.3 Mud Temp. (out): 52.0°C

13. **DxC/TREND:** 1.32-1.61

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. COSTS: 122,496 (Daily), 2,693,308 (Cumulative)

19. REMARKS: MWD run to bit change depth (copy enclosed) believed to be dependable unlike previous run. Some time lost due to mechanical problems of rigging up before running in hole with new bit 7.

GEOLOGICAL REPORT NO. 19 - JULY 1, 1989

1. **PRESENT DEPTH:** 1779m

2. **PRESENT OPERATIONS:** Drilling ahead with NB #8 (Smith F-1)

3. **PROGRESS:** 38m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1741-1775m

5. **FORMATION TOPS AND/OR CORRELATIONS:** N/A

6. **LITHOLOGY (BY INTERVAL):** & ROP: 1741-1775m: Claystone and Siltstone interbedded. AVG. ROP: 4.2m/hr. Claystone: (60-70%): Reddish-brown, soft, plastic/hydrophyllic, variably calcareous; part marly, grading to soft, marly limestone, v. argillac. Siltstone: (30-40%): dark purplish red, red-brown, firm to mod. hard, variably calcareous, argillac. Vis. porosity nil.

7. **SHOW SUMMARY:** No fluorescence of oil; no cut fluorescence.

8. **BACKGROUND GAS:** Total 0.000-0.001%, C_1 9-10 ppm

9. **MAX. GAS - DEPTH:** 1740m, 0.010%; C_1 85 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 0.000%, 1749m

12. **MUD WEIGHT (PPG):** 11.4 Mud Temp. (out): 51.4°C

13. **DxC/TREND:** 1.52-1.62 - Steady

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. **COSTS:** 73,175 (Daily), 2,766,483 (Cumulative)

19. **REMARKS:** No hole problems on bit change.

GEOLOGICAL REPORT NO. 20 - JULY 2, 1989

1. **PRESENT DEPTH:** 1873m

2. **PRESENT OPERATIONS:** Tripping out of hole to change bit.

3. **PROGRESS:** 94m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1775-1873m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Top of Rotliegend may be indicated by quartz sand interbeds in massive red claystones, below 1815m. It is not clear, however, as Rotliegend is expected to be massive sand. (Note MWD resistivity decrease, ROP increase, opposite sands from about 1858m.)

6. **LITHOLOGY (BY INTERVAL):** 1775, 1810m, Interbedded claystone and siltstone: avg. ROP about 4.0m/hr. Claystone: brick-red-brown, sft, plastic, hydratable, gen. mod. calc., part marly. Occ. to abund. very small microfossils (dk. brn-red, spherical, 0.1 to 0.5mm diam.). Siltstone: dark purplish red, firm to mod. hard, var. calc.; occ. tr. Anhydrite; nil vis. porosity. No shows. 1815-1873m: Claystone, some siltstone, and interbedded quartz sand. ROP, 6.8-7.0m/hr above 1858m, avg. about 12m/hr below, to 1868m, 3.2m/hr to TD (dull bit, less sand). Claystone and siltstone, as in overlying unit. Sand: clear quartz, occ. orange stns (oxide, clay), fn to med.-gn., occ. cse. sbrnd to rnded, good sphericity, fair sorting, prob. good porosity, although loose, unconsolidated condition observed. No oil shows. Note that so far as may be judged from cuttings, sands are not massive, but thin interbeds in the massive red claystone section. This may indicate that the Retliegend has not, in fact, yet been penetrated, as suggested above (Section 5, Formation Tops).

7. **SHOW SUMMARY:** None (no fluorescence of oil, and no cut fluorescence)

8. **BACKGROUND GAS:** Total 0.01%; C_1 avg. 75 ppm

9. **MAX. GAS - DEPTH:** 1866m, 0.05%; C_1 560 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 11.5 Mud Temp. (out): 58.6°C

13. **DxC/TREND:** 1.28-1.81 (Normal shale trend)

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

JR/DAM264/11

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** 1858-1868m (see Remarks below)

18. **COSTS:** 76,695 (Daily), 2,843,179 (Cumulative)

19. **REMARKS:** (1) Hot shot samples sent out last night: 1540, 1610, 1635, 1650, and 1745m (on boat to Ronne). (2) Circ. bottoms up at 1861m in drill break topped at 1858m. Quartz sand, interbedded in Claystone/siltstone, no shows. Drilled ahead. (3) Tight hole spots encountered in trip out of hole at 7 to 10 stands off bottom (approx. at 1680 to 1596m depths).

GEOLOGICAL REPORT NO. 21 - JULY 3, 1989

1. **PRESENT DEPTH:** 1952m

2. **PRESENT OPERATIONS:** Drilling

3. **PROGRESS:** 79m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1873-1950m

5. **FORMATION TOPS AND/OR CORRELATIONS:** N/A

6. **LITHOLOGY (BY INTERVAL):** 1873-1950m: Claystone with minor interbeds of Siltstone, occasional thin quartz sands. AVG. ROP: 4.5m/hr above 1892m; 15.5m/hr to 1898m; 6.9m/hr to T.D. Claystone (40-100%): as prev. described: bright brick red, soft (in cuttings, though apparently a hard rock in large bit sample), variably calcareous; occas. light gray-green, soft, non-calc.; Siltstone, also as in overlying intervals: dark purplish red, hard, mod. calcareous; Sand: clear qtz, some with iron-stains (oxide), fine to medium grained, some coarse, sbround to rnded, well sorted to fair sorting, good sphericity; prob. has good porosity, if in discrete beds; no shows.

7. **SHOW SUMMARY:** None

8. **BACKGROUND GAS:** Total 0.01%; C_1 30-80 ppm

9. **MAX. GAS - DEPTH:** 1913m, 0.04%; C_1 249 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 11.5, Mud Temp. (out); 52.2°C

13. **DxC/TREND:** 1.35-1.62

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** (Circ. out btms.) Interval 1893-1898m, Max. Rate 20m/hr, Prev. Rate Avg. 6m/hr, Avg. ROP 16.4m/hr

18. **COSTS:** 61,130 (Daily), 2,910,309 (Cumulative)

19. **REMARKS:** None

GEOLOGICAL REPORT NO. 22 - JULY 4, 1989

1. **PRESENT DEPTH:** 2040m

2. **PRESENT OPERATIONS:** Trip to change bit.

3. **PROGRESS:** 88m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 1950-2040m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Nothing new.

6. **LITHOLOGY (BY INTERVAL):** & AVERAGE ROP: 1950-1994m (average ROP: 10.3m/hr): Claystone, minor siltstone and occasional Sand interbeds, all identical or very similar in general to overlying sequence. Claystone (35-90%); bright brick red, rare m. gray-green; cuttings soft, but large bit sample recently showed that in fact it is a hard rock indeed; variably calcareous, becoming somewhat less calcareous with depth (as shown by calcimetry results). Siltstone (5-25%); dark purplish red & jasper red, occas. brownish red; very hard in general, moderately calcareous, occas. light to med. gray, softer, less calc. Sand (5-40%); loose, unconsolidated quartz, clear to gray translucent (or off-white), fine to medium-grained, occas. some coarse gns, sbrnd to well-rounded, good sphericity; fair to good sorting; prob. good poros. to poorer (difficult to judge in loose cuttings state). No oil shows. 1994-2025m (avg. ROP: 4.3m/hr): sequence similar to overlying interbedded claystone, siltstone and sand beds, sands less common.

7. **SHOW SUMMARY:** No oil shows (no natural fluoresc., no cut fluoresc.)

8. **BACKGROUND GAS:** Total 0.01%; C_1 50-100 ppm

9. **MAX. GAS - DEPTH:** 1990m, 0.05%; C_1 629 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** N/A

12. **MUD WEIGHT (PPG):** 11.5 Mud Temp. (out): 51.2°C

13. **DxC/TREND:** 1.22-1.74

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 19.0

17. **DRILLING BREAKS:** Interval 1962-1965m, Max. Rate 20m/hr, Prev. Rate 10m/hr, Avg. ROP 17m/hr; Interval 1984-1990, Max. Rate 18m/hr, Prev. Rate 12m/hr, Avg. ROP 14m/hr

18. **COSTS:** 67,862 (Daily), 2,978,171 (Cumulative)

19. **REMARKS:** None

GEOLOGICAL REPORT NO. 23 - JULY 5, 1989

1. **PRESENT DEPTH:** 2080m

2. **PRESENT OPERATIONS:** Drilling ahead at 1.7 m/hr

3. **PROGRESS:** 40m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 2040-2075m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Nothing new.

6. **LITHOLOGY (BY INTERVAL):** WITH AVERAGE ROP: 2040-2075m (ROP 2.9m/hr): Claystone, Siltstone and very minor Sand interbeds, with occasional thin Anhydrite; all lithologies very similar, even identical, to those of overlying sequence. Claystone (60-85%); brick red to orange red, rare greenish, medium to dark gray-green, soft to firm, rare subfissile, generally amorphous, slightly calcareous overall; occasional interlaminated thin Anhydrite: white, soft, amorphous, observed in particular abundance at 2040 to 2045m (most seems to have been converted to gypsum in cuttings at surface). Siltstone (10-20%): dark reddish-brown, occ. dark gray, firm to hard, variably calcareous, generally blocky. Sand (5-20%): clear to translucent, orange, red stained by oxides of iron; fine to coarse, generally medium gn., moderately well-sorted, subrounded to well-rounded, good sphericity; prob. with good porosity, if discrete beds (as is indicated by MWD curves--see attached).

7. **SHOW SUMMARY:** None (no fluoresc. of oil, no cut fluorescence)

8. **BACKGROUND GAS:** Total 0.01%; C_1 65 ppm

9. **MAX. GAS - DEPTH:** 2055m, 0.02%

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 2040m, 0.01%; C_1 only

12. **MUD WEIGHT (PPG):** 11.4 Mud Temp. (Out): 50.0°C

13. **DxC/TREND:** 1.52-2.00

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** None

18. **COSTS:** 69,218 (Daily), 3,047,389 (Cumulative)

19. **REMARKS:** (1) MWD resistivity sensor failed at bit depth of 2045m (sensor depth is 9.8m higher than bit). Memo and log copy attached. (2) Weekly report data packages sent in mail pouch on today's crew change helicopter to Ronne (July 5th).

GEOLOGICAL REPORT NO. 24 - JULY 6, 1989

1. **PRESENT DEPTH:** 2165m

2. **PRESENT OPERATIONS:** Drilling

3. **PROGRESS:** 85m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 2075-2140m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Change of formation: top of soft gray Clay at 2115m (sample at 2120). Poss. top Carbonif.?? (Compare core descriptions and sample descriptions, well K/5-1, below 4035 & 4095m.)

6. **LITHOLOGY (BY INTERVAL):** & AVG. ROP: 2075-2116m (ROP avg. 2.4 above 2095: 21.6 below - diff. bit): Claystone with much Siltstone, rare Shale and v. thin sand interbeds. Clayst (30-80%): as above interval - brick red, soft to hd., calc.; Siltstone (10-50%): also sim. to overlying siltstones - drk. purplish red to red-brn, firm, sbfiss., calc. Shale (0-10%): thin, dark red-brn, firm, sl. calc. sbfiss. Rare sand, cse qtz, sbrnd/rnd, no shows. Tr. dk. grn silic. lithic gns., wellrnded. 2115-2140m (ROP avg. 24.3m/hr). Massive gray clay with occas. thin Shale interbed. Clay 95-100% - med. to lt. gy, v. sft, var. calc., pt sl to mod. carbonac., becomes sl. silty with depth. Sh: 0-5% - med. to lt. gy, firm, sbfiss. sl. carbonac. and silty, sl. calcar.

7. **SHOW SUMMARY:** No natural fluorescence of oil, no oil cut fluorescence.

8. **BACKGROUND GAS:** Total 0.02-0.12%; C_1 40-215 ppm. Below 2115m: Total Gas 0.12-0.15%, C_1 903-1248 ppm; C_2 81-117 ppm; C_3 9-13 ppm. No IC_4.

9. **MAX. GAS - DEPTH:** 2122m, 0.15%; C_1 1248 ppm; C_2 117 ppm; C_3 14 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 2082m, trace

12. **MUD WEIGHT (PPG):** 11.4 Temp: 57.7°C

13. **DxC/TREND:** 1.91-0.94 (Stratapak bit)

14. **SHALE DENSITY (GM/CC)/TREND:** N/A

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** Circulated out top: Interval 2096-2099m, Prev. Rate 2.4m/hr; Continued Drilling: Interval 2099-2160m, Prev. Rate 21.6m/hr

18. **COSTS:** 103,440 (Daily), 3,150,830 (Cumulative)

19. **REMARKS:** Full report by EXLOG on MWD failure will be faxed later.

GEOLOGICAL REPORT NO. 25 - JULY 7, 1989

1. **PRESENT DEPTH:** 2518m (meas. depth, RKB)

2. **PRESENT OPERATIONS:** Circulating and conditioning hole and mud for final wireline logging run.

3. **PROGRESS:** 353m

4. **SAMPLED INTERVAL (IN 24 HOURS):** 2140-2518m

5. **FORMATION TOPS AND/OR CORRELATIONS:** Based on paleo/palynological information received from Robertson Research last night, top of Silurian sediments at about 2120m.

6. **LITHOLOGY (BY INTERVAL):** & AVG. ROP: 2140-2518m (avg. ROP 30m/hr): Interbedded Clay(stone) and Shale. Clay(stone): 35-85%): light to medium gray, occas. tan/buff, soft to occas. firm, amorphous, rarely blocky, slightly to very carbonac. with thin undulatory laminae of blk. carbonac. debris and disseminated throughout; generally sl. calcareous, parts moderately so, micromicaceous, slightly pyritic below 2300m; tr. Anhydrite below 2330m. Sl. tr. Sandstone (2310-2340m), white to pale greenish, v. fn-gn, well rnded, firm to fri., strongly calcareous cem; poor vis. porosity; no shows. Shale (10-65%); light to med. gray, rarely dark gray, firm, occas. blky; subfiss. to fissile, sl. to mod. calcareous, sl. to very carbonac., micromica. Grades to siltstone in v. small part. No vis. porosity; no shows.

7. **SHOW SUMMARY:** No oil shows at all - no natural hydrocarbon fluorescence - no cut fluorescence.

8. **BACKGROUND GAS:** Total 0.02-0.12%; C_1 400-1000 ppm; C_2 25-160 ppm; C_3 3-12 ppm

9. **MAX. GAS - DEPTH:** 2290m, 0.36%; C_1 2466 ppm; C_2 373 ppm, C_3 43 ppm; NC_4 10 ppm

10. **CONNECTION GAS - MAX.:** N/A

11. **TRIP GAS - MAX.:** 2439.5m, 0.16%; C_1 1200 ppm; C_2 150 ppm; C_3 18 ppm; NC_4 7 ppm

12. **MUD WEIGHT (PPG):** 11.3 Mud Temp. (out): 63.3°C

13. **DxC/TREND:** 0.81-1.40 (increasing)

14. **SHALE DENSITY (GM/CC)/TREND:** 2.45-2.50

15. **CALCULATED FORMATION PRESSURE:** 8.7

16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** 15.7

17. **DRILLING BREAKS:** Entire interval was like drill break: 2165-2518m, Max. Rate 56m/hr, Prev. Rate 40m/hr, Avg. ROP 30m/hr above 2305, 20m/hr below 2305m* (*Controlled drilling int.)

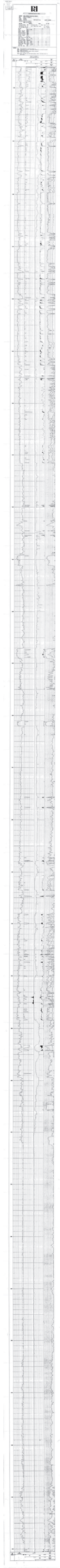
18. **COSTS:** 73,759 (Daily) 3,224,589 (Cumulative)

19. **REMARKS:** (1) Controlled drilling exercised below about 2305m to facilitate safer and more timely evaluation of cuttings samples. (2) Sampling interval expanded to 10m due to rapidity of drilling coupled with lack of lithological variation in drilled section. (3) EXLOG MWD logging tool continued inoperative (although data was stored in memory downhole for later playback) - see Report 25 and EXLOG special report later, July 6.

GEOLOGICAL REPORT NO. 27 - JULY 9, 1989

1. **PRESENT DEPTH:** 2510m md (Logger)/2518m md (EXLOG)
2. **PRESENT OPERATIONS:** Running Multishot Survey
3. **PROGRESS:** 0
4. **SAMPLED INTERVAL (IN 24 HOURS):** 0
5. **FORMATION TOPS AND/OR CORRELATIONS:** Not Applicable (N/A)
6. **LITHOLOGY (BY INTERVAL):** N/A
7. **SHOW SUMMARY:** N/A
8. **BACKGROUND GAS:** N/A
9. **MAX. GAS - DEPTH:** N/A
10. **CONNECTION GAS - MAX.:** N/A
11. **TRIP GAS - MAX.:** N/A
12. **MUD WEIGHT (PPG):** N/A
13. **DxC/TREND:** N/A
14. **SHALE DENSITY (GM/CC)/TREND:** N/A
15. **CALCULATED FORMATION PRESSURE:** N/A
16. **FRACTURE GRADIENT AT CASING SHOE (PPG):** N/A
17. **DRILLING BREAKS:** N/A
18. **COSTS:** 231,828 (Daily) 3,527,731 (Cumulative)
19. **REMARKS:** (1) Hand carry : SWC samples and weekly (final) data packages to Amoco Copenhagen. Geologists due to arrive CPH ~16:30 July 9, 1989, (R. L. Terry has logging package as well). (2) SWC descriptions faxed in early today.

Enclosures



GEUS

EXLOG

HOLE SIZE

CASING SIZE

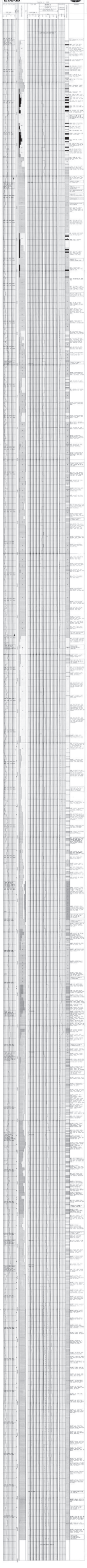
MUD TYPES

LITHOLOGY TYPES

ABBREVIATIONS

EXLOG

Formation Evaluation Log



GEUS Report file no. /03
1785 (3/5)

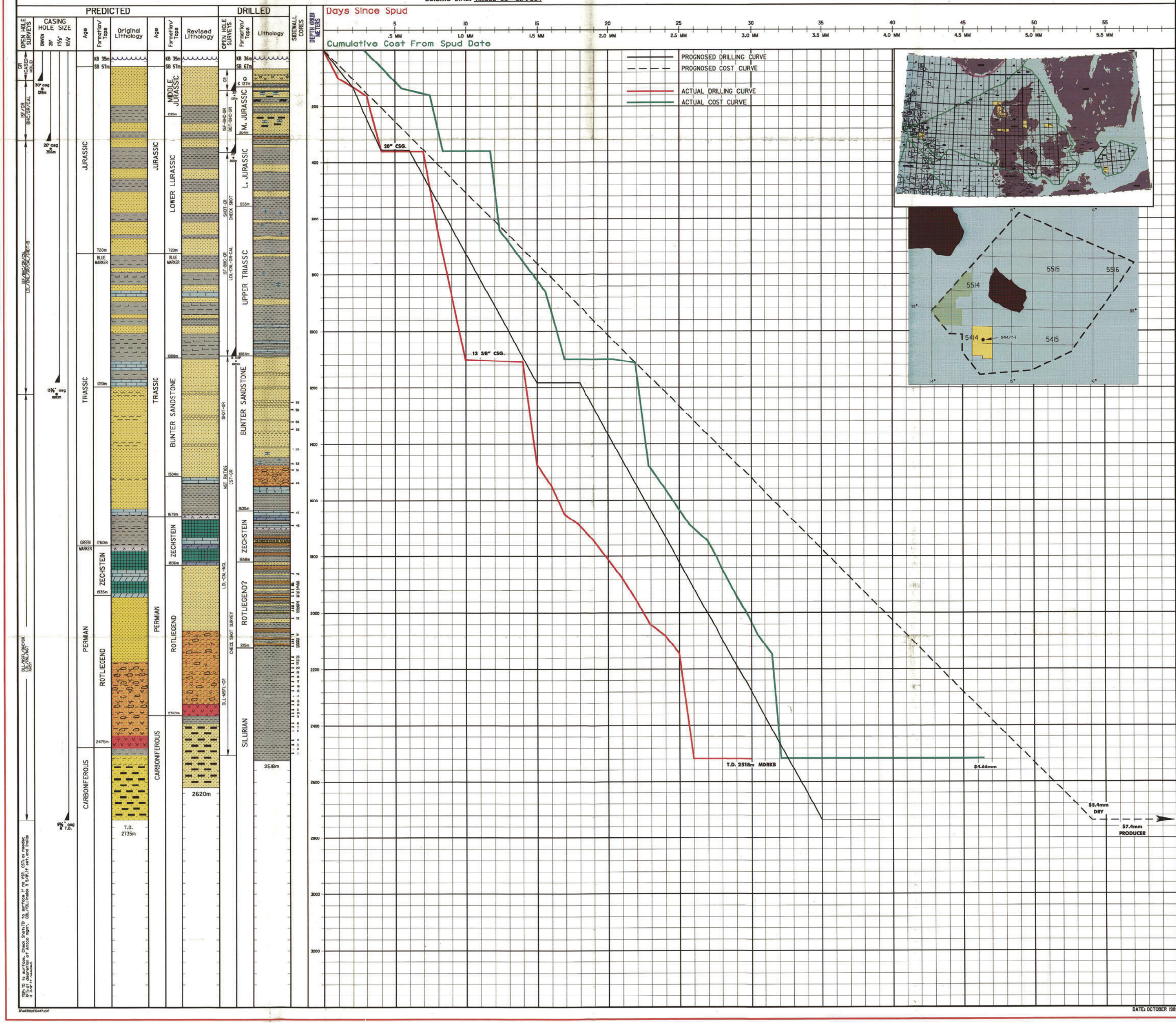
Amoco Denmark Exploration Company

WELL: 5414/7-1
COUNTRY: Denmark

Area: Offshore Bornholm Island
Latitude: 54° 47′ 19.92″ N
Longitude: 14° 37′ 43.38″ E
Seismic Line: AM88B-05 S.P. 394

Spud Date: June 11, 1989
Rig Release Date: July 13, 1989
Wtr. Depth/K.B. Elev.: 31m/36.2m

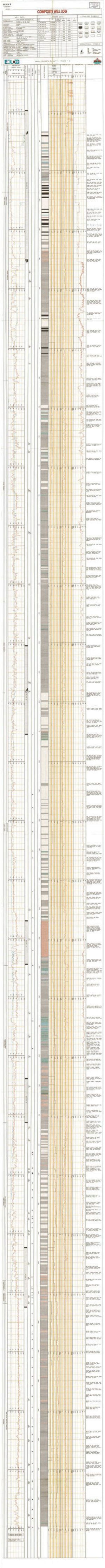
Projected T.D. 2700m
Final T.D. 2518m RKB
STATUS: P&A



DATE: OCTOBER 1989

10-OCT-1989 541471 07:38 ZFB3:[PLOTS]541471.PRF;1 11ASMH HOUVAX2

COMPOSITE WELL LOG



AMOCO WELLSITE LITHOLOGIC LOG

WELL NAME:
COUNTRY:
LOCATION:
LATITUDE:
LONGITUDE:
OPERATOR:
CONTRACTOR/RIG:
SPUD DATE:
T.D. DATE:
TOTAL DEPTH: LOGGER: DRILLER:
WATER DEPTH:
K.B. ELEVATION:
STATUS:

GEOLOGICAL TOPS

PROGNOSED ACTUAL

WIRELINE SURVEYS

RATE OF PENETRATION

SAMPLE DESCRIPTIONS AND REMARKS

Danish Ministry of Climate,
Energy and Utilities

Geological survey of
Denmark and Greenland (GEUS)

Øster Voldgade 10
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