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THE MICROPALAEONTOLOGY, PALYNOLOGY AND STRATIGRAPHY OF THE MOBIL 33/9-3 NORWEGIAN NORTH SEA WELL

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SUMMARY

The oldest rocks found in this well consist of poorly sorted sands with various coloured shales. The red shales and sands near the base may possibly be Triassic,but are here considered to be of Lower Jurassic age and to have been deposited in a continental or fresh to brackish water environment. Marine influences increased through the Lower Jurassic section until in the more argillaceous Upper Sinemurian - Carixian interval,fully marine, inner sublittoral conditions prevailed. The presence of ooliths at the top of the unit suggests that the water was relatively shallow. The succeeding argillaceous Domerian, Toarcian and Upper Toarcian intervals similarly suggest deposition in an inner sublittoral environment.

The Middle Jurassic unit is dominantly arenaceous with rare coals. The basal arenaceous unit suggests deposition in a high energy, probably nearshore environment. Conditions then became more deltaic and in the upper part marine influences are evident with the occurrence of rare marine organisms.

The contact between the Jurassic and Cretaceous is unconformable with chalky Barremian limestones, which were laid down in an inner sublittoral environment, lying directly on the predominantly arenaceous Middle Jurassic.

Another unconformable relationship then occurs with the Upper Cretaceous, Lower Campanian sediments immediately overlying the Barremian. A bathyal environment of deposition is envisaged for these sediments and these

relatively deep water conditions persisted through the Upper Campanian and Maastrichtian.

Since the Danian is missing the Palaeocene rests unconformably on the Maastrichtian. Outer sublittoral - bathyal water depths prevailed in the Palaeocene, Palaeocene - Lower Eocene, Eocene and into the Oligocene up to 3960'. The presence of radiolaria and planktonic foraminifera in the Palaeocene and Palaeocene - Lower Eocene suggests open marine conditions. The presence of tuffaceous shales in the Palaeocene indicates that volcanic activity also occurred at this time.

Above 3960' in the Oligocene the sea shallowed to outer sublittoral depths and continued through the ?Lower Miocene - Middle Miocene and Upper Miocene with a possible break in deposition immediately after the Oligocene had been deposited. Open marine conditions existed until the Upper Miocene when slightly shallower outer sublittoral conditions prevailed.

Further shallowing of the water took place and an inner sublittoral to littoral environment of deposition occurred in the succeeding Pliocene.

II

INTRODUCTION

This report summarises the results of the micropalaeontological, palynological and stratigraphical analyses which have been carried out on material received from the interval 1540' - 9800' from the Mobil 33/9-3 Norwegian North Sea Well under Project No. IIA/756/1017 (IIA/745/1267).

Under this project a total of 535 ditch cuttings and 33 core samples were analysed utilising standard micropalaeontological techniques. In addition 18 single and composited ditch cuttings and 16 core samples covering the interval 7890' - 9800' were treated palynologically.

A summary of the determinations obtained by these analyses has already been communicated by telex and telephone and forms the framework of factual information on which this report is based. A summary of the sequence penetrated in this well can be seen in Table 1.

The terminology adopted for the environmental conclusions follows that of Hedgpeth (1957) from which Table 2 of this report is taken.

The prepared samples and recorded information are now filed and curated in the confidential records section of these laboratories.

We wish to acknowledge the continued co-operation and assistance received from the various members of Mobil Exploration Norway Inc., with whom we have been associated during the course of this work.

III

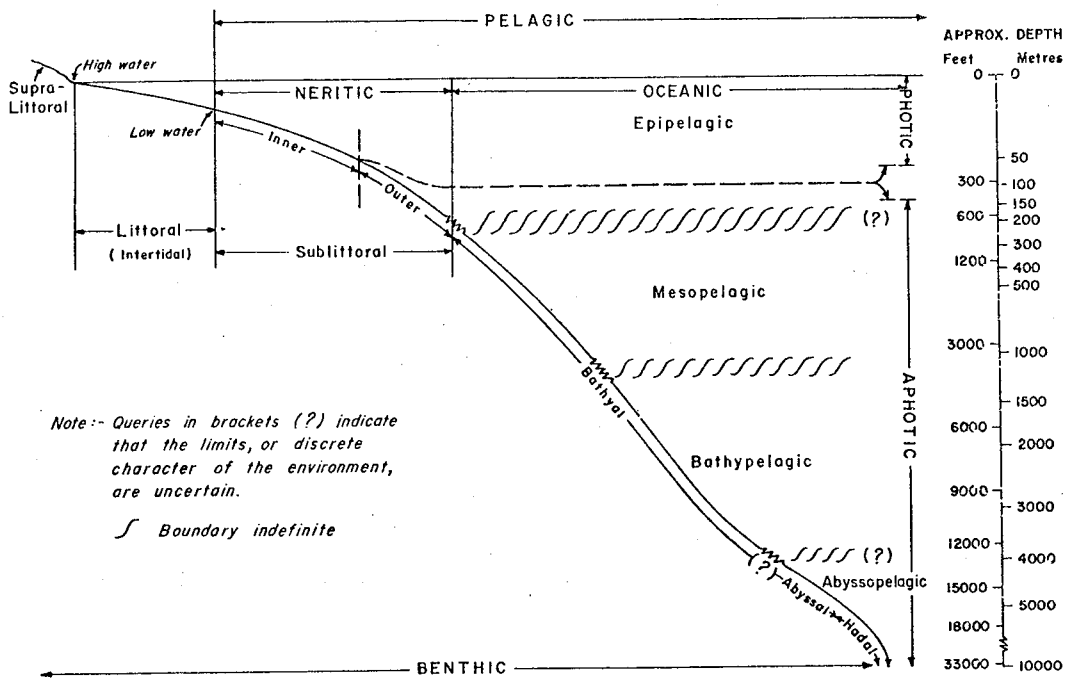
SUCCESSION

TABLE 1

Interval	Thickness	Stage	System/Subsystem
1540' - 1660'	+ 120'	-	Pliocene
1680' - 1700'	± 20'	-	Upper Miocene
1720' - 3020'	± 1300'	-	Middle - ? Lower Miocene
3040' - 4380'	± 1340'	-	Oligocene
4400' - 4780'	± 380'	-	Eocene
4800' - 5340'	± 540'	-	Lower Eocene - Palaeocene
5360' - 6060'	± 700'	-	Palaeocene
6100' - 6440'	± 340'	Maastrichtian	Upper Cretaceous
6460' - 6840'	± 380'	Lower Maastrichtian - Upper Campanian	
6860' - 7830'	± 970'	Lower Campanian	
7850' - 7870'	± 20'	Barremian	Lower Cretaceous
7890' - 8553'	± 663'	-	Middle Jurassic
8553' - 8640'	± 87'	Upper Toarcian	Lower Jurassic
8660' - 8840'	± 180'	Toarcian	
8860' - 9100'	± 240'	Domerian	
9120' - 9340'	± 220'	Carixian - Upper Sinemurian	
9360' - 9800'	+ 440'	-	

TABLE 2

CLASSIFICATION OF MARINE ENVIRONMENTS



The classification of marine environments used in this report is presented in diagrammatic form above. Pelagic (water) and Benthic (bottom) environments are recognised.

PELAGIC	BENTHIC
Neritic	Supralittoral
Oceanic	Littoral (Intertidal)
Epipelagic	Sublittoral
Mesopelagic	Inner
Bathypelagic	Outer
Abyssopelagic	Bathyal
	Abyssal
	Hadal

The classification is after Hedgpeth (1957) and results from several years discussion by a Committee of the Division of Earth Sciences, National Research Council, National Academy of Sciences, Washington D. C.

IV

TERTIARY

INTERVAL 1540' - 1660'; Pliocene.

General Lithology

Light brown, calcareous clay predominates becoming light grey and then dark grey with depth. It contains poorly sorted, fine to coarse sand grains, mainly loose, but some are set in a calcareous cement. Also present are pebbles, mainly of igneous rocks, together with bivalve shells and fragments of other fossil groups.

Cement contaminates all the samples in this interval.

Micropalaeontology and Stratigraphy

Calcareous benthonic foraminifera dominate the assemblage, but both agglutinating and planktonic forms occur in small numbers.

The appearance of Cibicides scaldisiensis, Cibicides lobatulus var. grossa and Cassidulina pliocarinata indicate that deposits of Pliocene age have been penetrated.

Environment

The presence of many shallow water foraminifera including Cibicides sp., Elphidium sp. and Quinqueloculina seminulum indicates a littoral or inner sublittoral environment of deposition.

INTERVAL 1680' - 1700'; Upper Miocene.

General Lithology

As in the lower part of the Pliocene dark grey clay dominates this interval. Bivalves, pebbles and poorly sorted sand grains are again present, but the quantity of pebbles is greater.

Micropalaeontology and Stratigraphy

The presence of Pyrgo bulloides indicates that this interval is of Upper Miocene age.

Environment

The greater diversity of the fauna indicates that the sediments were deposited under more general sublittoral conditions.

INTERVAL 1720' - 3020'; Middle Miocene - ? Lower Miocene.

General Lithology

Dark grey clay is again the dominant lithology becoming gradually lighter grey towards the bottom of the interval. Poorly sorted sands and pebbles are also present. Numerous fragments of macrofossils including bivalves, gastropods, scaphopods, echinoid spines and ophiuroid ossicles are found in the upper part of the unit, but become less frequent near the base. Cement is common near the top of the interval and again at 2020'.

Micropalaeontology and Stratigraphy

The appearance of Pullenia sphaeroides marks the top of the Middle Miocene. The subsequent occurrences of Uvigerina hosiusi, Sigmoilina

celata and Epistomina elegans confirm this Middle Miocene age. Although no palaeontological evidence is seen to indicate the presence of Lower Miocene deposits, our experience in the area suggests that depositions of this age may also be present. We have, therefore, assigned a Middle - ? Lower Miocene age to this interval.

Environment

A diverse microfauna with numerous planktonic species indicates an open marine, outer sublittoral environment of deposition.

INTERVAL 3040' - 4380'; Oligocene.

General Lithology

The light grey clay present at the top of this interval is replaced by brownish grey clay at about 3140'. This becomes brownish green at 3300' due to the presence of glauconite. Dark brownish green clay persists down to 4100' below which the clay becomes light greenish grey.

Glauconite occurs in all, but the uppermost samples of this section. It consists of fine-grained nodules which are generally dark green in colour, but which may also be light green, grey or brown between 3500' and 3540'.

Fragments of non-calcareous brown shale are found scattered through the interval below 3600'. This shale often contains sponge spicules, glauconite and quartz grains.

Sand grains, occurring throughout this sequence are generally fine-grained, but horizons with coarser grains occur between 3700' and 3760' and

again between 4120' and 4260'. Coarse grains are also found at the base of the interval.

Igneous pebbles are common between 3220' and 3380' while pyrite occurs in virtually every sample below 4000'. Sponge spicules are noted below 3200', occurring as a flood below 3540'.

Occasional fragments of friable, glauconitic, calcareous sandstone occur between 3320' and 3500'. Traces of dark brown dolomite, also containing glauconite, are found at 3880'.

Echinoids and bivalves are only found in the upper part of the interval, being replaced by radiolaria and sponge spicules further down reflecting the deeper conditions of deposition.

Cement is common at 3100' and in the immediately underlying samples.

Micropalaeontology and Stratigraphy

The top of the Oligocene has been placed at 3040' on the basis of the lithology, marker fossils being absent. The subsequent appearance of Siphonodosaria hirsuta, abundant glauconite and a flood of sponge spicules confirms that sediments of Oligocene age have been penetrated. The samples between 3500' and 3960' are poorly fossiliferous or barren. Below this agglutinating foraminifera dominate the assemblages.

Environment

An open marine, outer sublittoral environment continues down to 3960'. Below this the dominance of agglutinating types including deep water forms

such as Bathysiphon sp. and Cyclammina sp. suggest an outer sublittoral to bathyal environment of deposition.

INTERVAL 4400' - 4780'; Eocene

General Lithology

Light, greenish grey clay continues through this interval with one or more horizons of grey crystalline limestone. Glauconite, shale and sand continue down to approximately 4450' while pyrite is found down to 4600'.

Radiolaria and sponge spicules continue to occur together with occasional fish remains.

Micropalaeontology and Stratigraphy

The presence of Cyclammina challinori in the uppermost sample of this unit indicates that Eocene deposits have been encountered. The samples of this interval are generally poorly fossiliferous and contain an exclusively agglutinating microfauna.

Environment

The presence of deep water, agglutinating foraminifera including Glomospira charoides and Ammodiscus incertus as well as those forms found in the Oligocene indicates an outer sublittoral to bathyal environment of deposition for this interval.

INTERVAL 4800' - 5340'; Lower Eocene - Palaeocene.

General Lithology

The clays and limestones of the Eocene continue through this interval.

Some coarse sand occurs at 5300', but otherwise the lithology is very uniform.

Micropalaeontology and Stratigraphy

The microfaunas again consist almost exclusively of agglutinating foraminifera. Spiroplectammina spectabilis occurring in the uppermost sample of this unit indicates a Lower Eocene - Palaeocene age. This is supported by the subsequent appearance of large flattened radiolaria, first at 4880', then as a flood at 5060'.

Environment

An open marine, outer sublittoral to bathyal environment is again indicated by the presence of deep water agglutinating foraminifera and abundant radiolaria.

INTERVAL 5360' - 6060'; Palaeocene.

General Lithology

The lithology of the Palaeocene is marked by the appearance of mottled and tuffaceous shales.

The greenish grey clay of the previous two intervals continues into the Palaeocene, but the limestones are now white rather than grey. Fine sand occurs spasmodically through the interval and pyrite is found in a few samples, most noticeably at 5500'.

The large flattened radiolaria continue through the interval together with Coscinodiscus sp. 1. Coscinodiscus sp. 2, however, is only recorded from 5700' and 5820'.

Micropalaeontology and Stratigraphy

The microfauna of this interval can be divided into two units.

The upper unit from the top down to 5540', contains both agglutinating and calcareous forms. This unit contains the marker fossils Globigerina triloculinoides, Coscinodiscus sp. 1 and Coscinodiscus sp. 2 which enable a Palaeocene age to be assigned to this unit.

The lower unit from 5560' to the base of the interval contains only agglutinating forms.

The presence of tuffaceous shales indicates that volcanic activity occurred and this further confirms the Palaeocene age for this interval.

The absence of chalk and Danian planktonic foraminifera suggest that an unconformity exists with the Palaeocene resting directly on the Upper Cretaceous.

Specimens of the Cretaceous species Heterohelix globulosa and Pseudotextularia elegans elegans are present in the sample at 6060'. However, their preservation suggests that they are probably reworked.

Environment

An outer sublittoral to bathyal environment is again suggested for this interval. The presence of radiolaria and planktonic foraminifera indicate some open marine influence.

Volcanic activity, as shown by the tuffaceous shales, also occurred during the Palaeocene.

V

CRETACEOUS

INTERVAL 6100' - 6440'; Maastrichtian, Upper Cretaceous

General Lithology

Shale is the main lithotype of this interval. It is soft, light to medium grey and frequently calcareous. There are also trace amounts of fine sand, light grey, calcareous siltstone/very fine sandstone, and white, chalky limestone.

Micropalaeontology and Stratigraphy

A solitary Heterohelix globulosa recovered in the sample at 6100' is taken to mark the top of the Cretaceous. Other forms, notably planktonic, restricted to the Cretaceous occur throughout the interval and include Pseudotextularia elegans elegans, Pseudotextularia elegans fructicosa, Rugoglobigerina rugosa rugosa, Praeglobotruncana citae, Globigerinelloides asper and Biglobigerinella multispina.

The assemblage is dominated by the former planktonic species, but both agglutinating and calcareous benthonic foraminifera are also present. The most common are Pelosina sp., Gavelinella vombensis and Dorothia sp.

The interval can be subdivided into three units which may have correlative values in the area. These are as follows:

6100': This unit is distinguished by the presence of Heterohelix globulosa.

6120' - 6200': The appearance and abundance of Rugoglobigerina rugosa rugosa characterises this unit.

6220' - 6440': This unit is recognised by the presence of Reussella szajnochae with common Abathomphalus mayaroensis and Dorothia sp.

Radiolaria are common throughout the interval, but many may be caved from the Tertiary.

Environment

The abundance of planktonic foraminifera with some deep water arenaceous species suggests that the sediments were deposited in an open marine, deep outer sublittoral environment.

INTERVAL 6460' - 6840'; Lower Maastrichtian - Upper Campanian, Upper Cretaceous

General Lithology

Light to medium grey shale continues into this interval, but siltstones rarely occur. Trace amounts of creamy white chalk are present, but may have caved from the overlying section.

Micropalaeontology and Stratigraphy

Foraminifera are less abundant than in the overlying interval, and arenaceous forms represent a higher percentage of the microfaunas.

The assemblage includes species such as Pelosina sp., Trochammina sp., Bathysiphon sp., Heterohelix globulosa, Rugoglobigerina rugosa rugosa, Globigerinelloides asper and Reussella szajnochae.

The surge in the number of Rugoglobigerina sp., with a notable increase in the size and rugosity of the specimens at 6460' suggest that the Lower Maastrichtian has been penetrated.

The boundary between the Lower Maastrichtian and Upper Campanian cannot be determined, therefore, the whole interval, 6460' - 6840', has been assigned an age range of Lower Maastrichtian - Upper Campanian.

Environment

The relative increase in the abundance of deep water arenaceous species suggests that the water depth was greater than that of the overlying unit; the sediments probably having been deposited in an outer sublittoral - upper bathyal environment.

INTERVAL 6860' - 7830'; Lower Campanian, Upper Cretaceous

General Lithology

At the top of this interval the shale becomes red or rarely light green in colour, but it soon passes back into grey shales. Above about 7000' it is associated with small amounts of buff coloured dolomite, but the section between 7000' and 7160' appears to be predominantly shaly, although cement contaminates many of the samples around 7100'. Pyrite becomes quite common at 7170' and at 7190' it occurs together with light grey siltstone and very fine sandstone which are sometimes relatively hard and calcareous with glauconite and mica. Siltstones and very fine sandstones of this type are present throughout the rest of the interval and appear to be interbedded with light grey shales. In addition, between 7290' and 7370' some clear, angular, fine to coarse sand occurs.

Micropalaeontology and Stratigraphy

Foraminifera decrease in abundance throughout the unit, and the assemblage is dominated by agglutinated faunas. Common species include Pelosina complanata, Bathysiphon sp., Ammodiscus incertus, Haplophragmoides spp. and Gaudryina bentonensis. Rare planktonic species occur in some samples, but it is most likely that they have caved. Radiolaria are present throughout the interval,but again may have also caved.

No diagnostic Lower Campanian microfossils have been recorded,but the top of the Lower Campanian has been placed at 6860' on the pink preservation of the faunas at this depth. This coincides with a red shale from which the foraminifera are obviously derived. This is a feature which has occurred at the top of the Lower Campanian in other wells in this area.

Environment

The dominance of deep water arenaceous species such as Bathysiphon sp. suggests that the environment of deposition was bathyal.

INTERVAL 7850' - 7870'; Barremian, Lower Cretaceous

General Lithology

This interval is dominated by creamy white, fairly soft, strongly pyritic, chalky limestone.

Micropalaeontology and Stratigraphy

A marked microfaunal change occurs at 7850' with the appearance of a moderate assemblage containing both agglutinating and calcareous benthonic

foraminifera. The occurrence of Patellina subcretacea, Uvigerinammina moesiana, Marssonella kummi, Trocholina infragranulata and Aulotortus (Spirillina) neocomiana in this microfauna indicates a Barremian age for these sediments.

Environment

The presence of agglutinating and calcareous benthonic foraminifera in association with echinoderm debris and sponge spicules suggest that deposition took place in an inner sublittoral environment.

VI

JURASSIC

INTERVAL 7890' - 8553'; Middle Jurassic

General Lithology

This interval is one of predominantly arenaceous sediments. The cores examined are described in detail in Appendix I. The sand is mostly poorly sorted and consists of subangular to subrounded, mainly medium to very fine, clear quartz grains. Horizons which contain coarser grains are present. Shales and mudstones are associated with the sands, and these usually occur as dark grey, often silty and sometimes micaceous thin interbeds or streaks within the sandstone. Fragments and streaks of lignite and rare pyrite are sometimes seen. The sandstone is generally friable, but light grey, well-cemented, hard, calcareous sandstone horizons are occasionally present. At 8553' a thin bed of small, well rounded pebbles and coarse sand is noted.

Micropalaeontology, Palynology and Stratigraphy

Although all the ditch cuttings from this interval have been examined as well as 26 core samples no in situ foraminifera or ostracoda have been recorded.

Rich miospore assemblages are recovered from the cored interval 8044.5' - 8262.3' and a poor assemblage from the depth 8286'. From this level until 8540' the massive sandstones present yielded no suitable palynological samples. The assemblages are generally dominated by bisaccates, Deltoidospora spp., Cerebropollenites mesozoicus, Baculatisporites/Osmundacidites group, Perinopollenites elatoides, and Lycopodiumsporites spp. with Tsugaepollenites

spp., Inaperturopollenites turbatus, Classopollis torosus and Klukisporites spp., including K. variegatus, being persistent and sometimes common elements. Other relatively common forms are spores of the Contignisporites/Duplexisporites group, Densoisporites velatus, Staplinisporites caminus, Sestrosporites pseudoalveolatus, Uvaesporites cf. argenteaeformis and Chasmatosporites hians. The records of Leptolepidites bossus, Lycopodiacidites rugulatus and Neoraistrickia gristhorpensis are also notable.

The only definite marine elements recorded are rare specimens of Pareodinia ceratophora from 8044'5"and a single specimen of Nannoceratopsis gracilis from 8166'.

The assemblages recorded from above the sand are typical of the Middle Jurassic particularly the association of numerous Klukisporites variegatus with Leptolepidites bossus and Neoraistrickia gristhorpensis. The assemblage from 8540' could, however, be of Upper Toarcian age.

Environment

The lower part, which is essentially sandstone, suggests deposition in a high energy, probably nearshore environment. The upper part, however, contains a few coals and is partially argillaceous containing sandstones and shales. A more continental, deltaic environment is envisaged for this upper part,although the presence of rare microplankton in the highest part indicates slight marine influences.

INTERVAL 8553' - 8640'; Upper Toarcian, Lower Jurassic

General Lithology

Medium to dark grey shales occur in this interval along with minor amounts of fine sand and pyrite.

Micropalaeontology, Palynology and Stratigraphy

This interval is characterised by an influx of small, relatively fine-grained, agglutinated foraminifera. This fact and the significant occurrence of Trochammina spp., Haplophragmoides cf. cushmani and Verneuilinoides mauritii indicate an Upper Toarcian age.

The occurrence of the lowermost Bajocian - Upper Toarcian ostracode Aphelocythere undulata at 8584' supports this determination.

The first sample of this interval, 8557'3", yielded an impoverished assemblage consisting entirely of Bathysiphon spp. At 8564'4" rich assemblages have been recovered, and these persist until the base of the cored interval (8592'). The foraminifera from 8589' and below are generally coarser grained. The ditch cuttings samples at 8580' at 8600' yielded moderate numbers of agglutinated foraminifera,but that at 8620' is impoverished. A resurgence in numbers occurs at 8640'.

The highest record of definite Nannoceratopsis gracilis is from 8561'4". Tsugaepollenites spp. occur in the core samples to 8595' and these, together with N. gracilis, support an Upper Toarcian age to at least this level. Of interest is the presence of numerous reworked spores such as Ricciisporites tuberculatus, Heliosporites reissingeri and striate bisaccates in the core samples from 8582' and 8595'.

Environment

The occurrence of a rich assemblage of small agglutinated foraminifera, in which Trochammina spp. are prominent, suggests an inner sublittoral environment of deposition for these sediments.

INTERVAL 8660' - 8840'; Toarcian, Lower Jurassic

General Lithology

There is an increase in very fine sand, sandstones and pyrite at the top of this interval,although shales still appear to be dominant. At 8680' light grey, calcareous, siltstone/sandstone and hard pyritic limestone become quite common. They pass down into a section of very fine to fine sands. In addition, at 8700'-20' there are small,but significant amounts of sphaerosiderite and chamosite ooliths. Traces of dark brown, silty, micaceous, glauconitic shale also occur. The lowermost part of the interval consists mainly of medium grey shales.

Micropalaeontology, Palynology and Stratigraphy

This interval is, on micropalaeontological criteria, a relatively poorly defined interval lying between the Upper Toarcian and the Domerian. We have,therefore,suggested a Toarcian age for the unit.

Initially the samples contain impoverished assemblages, but from 8720' to 8840' poor to moderate microfaunas occur, which are again dominated by agglutinated foraminifera. The general composition of the assemblage is essentially similar to that of the Upper Toarcian,although Trochammina spp. and Verneuilinoides mauritii are less common. Rare ooliths are noted in

the picked slides at 8700', and 8720'. The dinoflagellate cyst Nannoceratopsis gracilis occurs throughout this unit and its presence is consistent with a Toarcian age. The miospore assemblages recovered are non-diagnostic.

Environment

The predominance of small agglutinating foraminifera suggests that deposition took place in an inner sublittoral environment.

INTERVAL 8860' - 9100'; Domerian, Lower Jurassic

General Lithology

This interval consists mainly of relatively soft, medium to dark grey shales,although small,but consistent amounts of very fine sand and silt occur throughout, suggesting the presence of thin sandy interbeds. Some dark grey, micaceous shale is also present in small quantities. Rare calcareous ooliths occur at 9000'.

Micropalaeontology, Palynology and Stratigraphy

The microfauna recovered from these sediments is essentially similar, although generally more fossiliferous, to that of the Toarcian. The appearance of several specimens of Hungarella amalthei at 8860' indicates that the Domerian has been penetrated. Support for this determination is provided by the subsequent occurrence of Procythereidea sp. E (APOSTOLESCU), Hungarella Nr. 4 (KLINGLER) and Saracenaria sublaevis.

Nannoceratopsis gracilis is relatively common at the top of this unit, a feature which would support a Domerian age. The miospore assemblages

are dominated by bisaccates with Deltoidospora spp., Baculatisporites/ Osmundacidites group, Cerebropollenites mesozoicus and Araucariacites australis being fairly common.

Environment

A similar, inner sublittoral environment of deposition to that of the Toarcian is indicated for this unit by the microfauna recorded.

INTERVAL 9120' - 9340'; Carixian - Upper Sinemurian, Lower Jurassic

General Lithology

At the top of this interval there is an occurrence of rare, light grey, calcareous ooliths along with grey shale. At 9140' ooliths become more common and associated with very fine to coarse, angular to rounded, yellowish sand. Siderite also occurs in small quantities. At 9160' there is less sand and ooliths,but pyrite becomes fairly common. The section from 9180' to the base of the interval consists of very fine, white sand and silt, medium grey shale and silty shale, and in the lower part, pyrite and rare glauconite.

Micropalaeontology, Palynology and Stratigraphy

Little change in the microfauna occurs in this section in comparison to that of the Domerian. The appearance of ?Dentalina matutina, Marginulina praepupa and Healdia mouhersensis suggests a Carixian - Upper Sinemurian age,although the assemblage is by no means diagnostic. The occurrence of a prominent section of calcareous ooliths at 9120' and 9140', however, strongly suggests the presence of rocks of Carixian - Upper

Sinemurian age. Nannoceratopsis gracilis persists through this unit and is again relatively common. The miospore assemblages are basically the same as those from the overlying interval.

Environment

The predominance of small agglutinating foraminifera in the microfaunas of this unit suggests that inner sublittoral conditions prevailed during the deposition of these sediments.

INTERVAL 9360' - 9800'; Lower Jurassic

General Lithology

This is a predominantly arenaceous unit consisting of white, generally poorly sorted, fine to very coarse, angular sand. It is interbedded with variable shales or mudstones which are light to dark grey, light green, purplish grey and brown-red. The reddish shales tend to be more common in the lower part of the interval where they are associated with some red sand. The shales are also frequently waxy, sandy and mottled. Minor lithologies include lignite at 9400' and hard, light grey limestone at 9720'-9740'.

Micropalaeontology, Palynology and Stratigraphy

Most, if not all, of this unit is thought to be Lower Jurassic in age, but with the occurrence of small amounts of red shales and sand, lithotypes normally thought of as Triassic, it is possible that the lower part extends into the Triassic. No clean cut boundary occurs.

Nannoceratopsis gracilis is again fairly common, the deepest specimens seen being in the composited ditch cutting sample over the interval 9650' - 9700'. Spores of the Baculatisporites/Osmundacidites group are relatively frequent in the top part of the unit to 9500'. The assemblages are again generally dominated by bisaccates with Araucariacites australis, Deltoidospora spp. and Cerebropollenites mesozoicus being relatively common. The association of forms is consistent with a Lower Jurassic age and no palynological evidence for the Triassic having been penetrated was obtained.

No foraminifera are seen within this interval.

Environment

The poorly sorted sands, reddish shale and sands near the base of this unit suggest that deposition took place in a continental or fresh to brackish water environment. In the upper part of this interval the disappearance of the red beds suggests that more marine conditions prevailed.

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APPENDIX

CORE DESCRIPTIONS

CORE 1

7940' - 7944'	Sandstone. Buff, very friable, mainly medium-grained, but with coarse, fine and very fine grains.
7944' - 7950'	Shale/Clay. Non-calcareous, bluish grey.
7950' - 7960'	Sandstone. Buff, very friable, mainly medium-grained with coarse, fine and very fine grains.

CORE 2

8000' - 8002'	Sandstone. Very friable, buff, non-calcareous, with thin, very coarse horizon. Thin black lignite parting.
8002' - 8003'	Sandy lignite. Grading into coarse, dark grey brown, poorly sorted, pebbly sandstone, subrounded grains.
8003' - 8006'	Sandstone. Friable, buff to greyish, poorly sorted, fine to medium and coarse, micaceous.

CORE 3

8011' - 8044'	Sandstone. Friable, buff to brownish, very fine to medium, silty micaceous.
8044' - 8048'6"	Mudstone. Dark grey, silty, non-calcareous, slightly carbonaceous.

CORE 4

8051' - 8060'	Mudstone. Moderately hard, dark grey, silty, often carbonaceous, with thin streaks of silty lignite; with hard, grey, fine-grained, fairly argillaceous sand showing cross-bedding, becoming more sandy downwards.
8060' - 8075'	Sandstone. Fairly friable, buff, medium to very fine-grained, with carbonaceous streaks.
8075' - 8078'	Sandstone. Friable, buff, very fine-grained, silty and slightly argillaceous, cross-bedded.

8078' - 8087'	Sandstone. Fairly friable, buff, fine to medium-grained, silty, with very thin, dark grey mudstone and silty mudstone interbeds, with occasional lobate, brown, medium sandstone patches.
8087' - 8090'	Sandstone. Fairly friable, buff, medium-grained.
8090' - 8091'	Sandstone. As above with thin mudstone intercalations.
8091' - 8097'	Mudstone. Fairly hard, dark grey, non-calcareous, with sandstone interbeds. Becomes carbonaceous at 8095'.
8097' - 8098'	Mudstone. As above with increase in lignite.
8098' - 8099'	Mudstone. Fairly hard, grey and dark grey, non-calcareous, with rare buff sandstone interbeds.
8099' - 8100'7"	Sandstone. Fairly friable, buff, mainly medium-grained, non-calcareous, with occasional wavy, carbonaceous streaks, also micaceous, fine-grained.
8100'7" - 8103'	Mudstone. Fairly hard, dark grey, non-calcareous, occasionally silty and sandy with thin lignitic layers.
8103' - 8105'	Sandstone. Friable to soft, buff, non-calcareous, with wavy, probably bioturbated, carbonaceous streaks; increase in fragments of lignite downwards.
8105' - 8109'	Sandstone. Fairly friable, buff, fine to medium-grained with thin mudstone streaks.

CORE 5

8109' - 8112'	Sandstone. Fairly friable, buff, fine-grained, with carbonaceous and argillaceous layers and minor cross-bedding. Some micaceous partings.
8112' - 8114'5"	Sandstone. Fairly friable, buff, fine-grained, non-calcareous.
8114'5" - 8118'	Sandstone. Fairly friable, buff, medium-grained, with dark, carbonaceous and micaceous partings; ripple marks.
8118' - 8121'2"	Sandy Mudstone.

8121'2"- 8121'8"	Sandstone. Fairly friable, buff, medium-grained, with black, carbonaceous, mudstone streaks.
8121'8"- 8123'8"	Sandy mudstone/argillaceous sandstone.
8123'8" - 8126'5"	Argillaceous sandstone. Grey to buff with carbonaceous streaks and traces of pyrite.
8126'5"- 8127'	Sandstone. Moderately hard, very finely structured, very fine-grained to siltstone, with silty mudstone.
8127' - 8130'	Mudstone. Waxy brown, fairly hard.
8130' - 8133'	Mudstone. Brown, fairly hard, silty mudstone with brown silty, fine to medium-grained sand.
8133' - 8135'	Mudstone. As above, rubbly.

CORE 6

8164' - 8173'	Sandstone. Moderately hard, buff, very fine-grained to siltstone, with graphic carbonaceous streaks and wavy bedding.
8173' - 8181'	Sandstone. Fairly friable, buff to grey, fine to very fine-grained, silty and argillaceous. Trace pyrite.
8181' - 8182'	Mudstone. Moderately hard, fairly friable, dark grey to black, waxy.
8182' - 8183'	Mudstone. As above, silty and carbonaceous.
8183' - 8203'	Sandstone. Moderately hard, grey to buff, argillaceous, silty to very fine-grained, grading to mudstone, with waxy and parallel bedding.
8203' - 8210'	Sandstone. Friable, brown to buff, silty to very fine-grained.
8210' - 8217'5"	Sandstone. Soft, buff, fine-grained, becoming lignitic at 8217'5".
8217'5"- 8219'	Mudstone. Fairly hard, light grey, silty with horizontal, parallel bedding.
8219' - 8221'5"	Mudstone. As above, with silty and sandy partings.
8221'5" - 8224'	Sandstone. Soft, buff to brown, fine-grained.

CORE 7

8224' - 8227'	Sandstone. Fairly friable, buff to brown, fine-grained with thin silty and carbonaceous partings.
8227' - 8228'5"	Sandstone. As above with frequent carbonaceous mudstone streaks.
8228'5" - 8242'	Mudstone. Fissile, soft, dark grey, silty and carbonaceous, trace pyrite.
8242' - 8242'8"	Sandstone. Friable, buff to brown, fine to medium-grained, with mudstone laminae, and carbonaceous partings $\frac{1}{4}$" thick.
8242'8" - 8246'6"	Mudstone. Dark grey, with lignite band 4" thick, and medium carbonaceous sandstone at 8244'. Waxy mudstone at 8246'6". Trace pyrite.

CORE 8

8261' - 8263'	Mudstone. Light grey, slightly silty and carbonaceous
8263' - 8270'	Sandstone. Friable, buff to brown, medium to fine, with faint mudstone laminae.
8270' - 8279'	Sandstone. As above with occasional irregular carbonaceous partings.
8279' - 8288'	Sandstone. As above, with lignitic partings at 8285'7". Becoming coarse-grained at base.
8288' - 8309'	Sandstone. As above, medium, occasionally coarse.

CORE 9

8321' - 8333'	Sandstone. Friable, buff to brown, medium to coarse-grained.
8333' - 8346'3"	Sandstone. As above, slightly micaceous.

CORE 10

8381' - 8390'	Sandstone. Fairly friable, buff to brown, fine-grained, slightly micaceous.

8390' - 8399'	Sandstone. Soft, poor recovery.
8399' - 8400'	Sandstone. Fairly soft, buff, fine-grained, slightly micaceous.
8400' - 8405'	Sandstone. Hard, light grey, well-cemented, calcareous, micaceous, fine-grained.
8405' - 8408'	Sandstone. Soft and very soft, buff, fine-grained.
8408' - 8432'	Sandstone. As above, rubbly or loose, poor recovery.

CORE 11

8441' - 8468'	Sandstone. Friable to soft, fine and very fine, slightly micaceous, trace calcareous at 8459'.
8468' - 8486'5"	Sandstone. Fairly friable, buff, fine-grained, with occasional dark, waxy partings and carbonaceous flecks.
8486'5"- 8487'	Sandstone. Hard, light grey, calcareous, fine-grained.
8487' - 8498'	Sandstone. Fairly friable, buff, fine to medium-grained, with parallel bedded dark grey, slightly micaceous, silty mudstone, and lignitic partings with depth.

CORE 12

8498' - 8507'	Sandstone. Fairly friable, buff, fine to medium-grained, with dark, micaceous partings.
8507' - 8515'	Sandstone. Fairly friable, buff, fine-grained, with 6" light grey, hard, calcareous band at 8509'.
8515' - 8516'	Sandstone. Fairly friable, buff, fine and very fine, grading to siltstone, with wavy, micaceous and lignitic partings.
8516' - 8525'	Sandstone. Massive, fine to very fine-grained, grading to siltstone with wavy and reticulate, micaceous, mudstone partings.
8525' - 8534'	Sandstone. Fissile, medium grey, fine-grained, grading to siltstone with frequent wavy, micaceous partings, becoming soft with plant traces at 8531' 5"- 8532'.

8534' - 8535'	Sandstone. Hard, light grey, calcareous, fine to medium-grained.
8535' - 8540'	Sandstone. With frequent micaceous and mudstone partings.
8540' - 8543'	Mudstone/Shale. Fissile, dark grey, with light, silt to very fine sand streaks.
8543' - 8552'	Mudstone/Shale. Fissile, dark grey, with thin, light grey siltstone partings. Slightly micaceous and sandy.
8552' - 8555'	Shale. Fissile, dark grey, non-calcareous, with thin band of well-rounded, coarse sand and small pebbles at 8553'.

CORE 13

8556' - 8596'3"	Mudstone/Shale. Fairly massive, uniform, dark grey, slightly micaceous. Belemnites at 8588', 8591'5", 8596'.

ROBERTSON RESEARCH
INTERNATIONAL LIMITED

SUMMARY LOG 33/9-3

AREA : NORWEGIAN NORTH SEA

SPUD DATE : 15 · 9 · 74

COMPANY : MOBIL EXPLORATION NORWAY INC.

COMPLETION DATE : 14 · 11 · 74

INTERVAL STUDIED : 1540' – 9800' T. D. 9800'

Dr. No. 115/1017/2912

SCALE 1 : 5000

Date : 10 · 4 · 75

I Cored Interval

▲ Casing Shoe

The lithological symbols are a generalisation of those shown on Biostratigraphical Analysis Charts

SYSTEM	SUB-SYSTEM	STAGE / FORMATION	THICKNESS	CASING AND CORING DETAILS	DEPTH METRES / FEET	GENERALISED LITHOLOGY	ENVIRONMENT OF DEPOSITION: CONTINENTAL	FRESHWATER	BRACKISH/DELTAIC/LAGOONAL	LITTORAL	INNER SUBLITTORAL	OUTER SUBLITTORAL	BATHYAL
PLIOCENE			120'	20" ▲ 1670'	1500'	CMT CMT							
MIOCENE	U. MIOCENE		20'	1710'									
MIOCENE	MIDDLE – ? LOWER MIOCENE		1300'		2000'	CMT							
				3030' 13 3/8" ▲	2500'								
OLIGOCENE			1340'		3000'	CMT CMT G G G							
				4380'	3500'	G G G							
EOCENE			380'		4000'	G G P G P							
EOCENE – PALAEOCENE	LOWER EOCENE – PALAEOCENE		540'	4790'	4500'	G G P							
				5340'	5000'								
PALAEOCENE			700'		5500'	V V V V V V							
				6080'	6000'								
CRETACEOUS	UPPER CRETACEOUS	MAASTRICHTIAN	340'	6450'	6500'	P							
		LOWER MAASTRICHTIAN – UPPER CAMPANIAN	380'	6850'									
		LOWER CAMPANIAN	970'	95/8" ▲	7000'	P G P G							
		L. CRET. BARREMIAN	20'	7840' 7880'	7500'	P P P P							
JURASSIC	MIDDLE JURASSIC		663'	7940' CORES 1-13	8000'								
	LOWER JURASSIC	UPPER TOARCIAN	87'	8553' 8614'	8500'	I I							
		TOARCIAN	180'	8650'		P							
		DOMERIAN	240'	8850'	9000'	I							
		CARIXIAN – UPPER SINEMURIAN	220'	9110'		P G							
			440'	9350'	9500'								

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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No. 1	LOCATION
12:11:74	1540' - 2000'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	DJS, IRH, CWH.

ROBERTSON RESEARCH INTERNATIONAL LTD.

BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No. 2	LOCATION
15.11.74.	2000' - 3000'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	DJS, CWH, IRH.

LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE
Cement CMT
F Shell fragments
DIAGNOSTIC SPECIES *

ENVIRONMENT: CONTINENTAL | BRACKISH / DELTAIC / LAGOONAL | LITTORAL | INNER SUBLITTORAL | OUTER SUBLITTORAL | BATHYAL

AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
% FORAMINIFERAL ASSEMBLAGES

Foraminifera & Ostracoda | Other fossils

MICROFOSSILS

- Bulimina marginata
- Cassidulina laevigata
- Quinqueloculina seminulum
- Nonion affine
- Islandiella teretis
- Cibicides lobatulus var. grossa
- Elofsonella concinna
- Islandiella islandica
- Globorotalia inflata
- Bulimina elongata var. marginata
- Cibicides lobatulus
- Bulimina gibba
- Angulogerina fluens
- Rotalia beccarii
- Pyrgo bulloides
- Textularia sp.
- Sigmoilina celata
- Elphidium ustulatum
- Pullenia sphaeroides
- Nonion pompilioides
- Globigerina bulloides
- Angulogerina angulosa
- Cibicides peetensis
- Bulimina elongata
- Lenticulina sp.
- Polymorphinids
- Epistomina elegans
- Cibicides scaldisiensis
- Elphidium antoninum
- Aurila convexa
- Elphidium groenlandicum
- Elphidiella hannai
- Dentalina sp.
- Echinocythereis scabra
- Nonion granosum
- Bolivina dilatata
- Globigerina angustiumbilicata
- Oolina sp.
- Triloculina circularis
- Siphonodosaria cf. hirsuta
- Lyigerina hosiusi
- Loxostomum sinuosum
- Globigerina spp.
- Bolivina subspinescens
- Lenticulina grandis
- Nodosaria cf. soluta
- Dentalina koninecki
- Virgulina complanata
- Globigerina praebulloides
- Lagena sulcata
- Bivalves
- Echinoids
- Gastropods
- Ophiuroids
- Sponge spicules
- Scaphopods
- Fish remains

INTERPRETED LITHOLOGY | DEPTH IN FEET | SYSTEM | STAGE

C M T

100
200
300
400
500
600
700
800
900
1000

? LOWER MIOCENE - MIDDLE MIOCENE

ROBERTSON RESEARCH INTERNATIONAL LTD.

BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No.	LOCATION
20.11.74.	3000' - 4000'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	DJS, CWH, IRH.

LIMESTONE · DOLOMITE · WHITE CHALK · MARL · CLAY · SHALE · SILTY/SANDY SHALE · SILTSTONE

SANDSTONE · COARSE SAND · CONGLOMERATE · GYPSUM/ANHYDRITE · SALT · CHERT · PYRITE · GLAUCONITE

COAL / LIGNITE

Cement CMT

DIAGNOSTIC SPECIES *

ENVIRONMENT: CONTINENTAL · BRACKISH / DELTAIC / LAGOONAL · LITTORAL · INNER SUBLITTORAL · OUTER SUBLITTORAL · BATHYAL

AGGLUTINATING FORAMINIFERA · CALCAREOUS BENTHONIC FORAMINIFERA · PLANKTONIC FORAMINIFERA

% FORAMINIFERAL ASSEMBLAGES

INTERPRETED LITHOLOGY · DEPTH IN FEET · SYSTEM · STAGE

DEPTH IN FEET: 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000

SYSTEM: OLIGOCENE

STAGE:

MICROFOSSILS

Foraminifera

- Cibicides lobatulus var. grossa
- Cibicides lobatulus
- Nonion affine
- Cassidulina cf. crassa
- Angulogerina fluens
- Islandiella teretis
- Quinqueloculina seminulum
- Angulogerina angulosa
- Islandiella islandica
- Globigerina praebulloides
- Oolina sp.
- Cassidulina laevigata
- Lenticulina sp.
- Globigerina spp.
- Bulimina aculeata
- Sigmoilina celata
- Dentalina sp.
- Bulimina marginata
- Triloculina circularis
- Globigerina praecpis
- Bulimina gibba
- Cibicides peelensis
- Lagena sulcata
- Polymorphinids
- Globigerina ouachitaensis
- Lagena cf. isabella
- Bolivina dilatata
- Lagena hispida
- Guttulina gibba
- Siphonodosaria hirsuta
- Lagena cf. striata
- Uvigerina rugulosa
- Spiroplectammina sp.
- Sigmoilina schlumbergeri
- Cyclammina placenta
- Recurvoides sp.

Other fossils

- Radiolaria
- Bivalves
- Echinoid remains
- Fish remains
- Sponge spicules type B
- Sponge spicules type A
- Coscinodiscus cf. sp. 1

ROBERTSON RESEARCH INTERNATIONAL LTD.

BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No.	LOCATION
26.11.74.	4000' - 5000'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	DJS, CWH, IRH.

LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE

DIAGNOSTIC SPECIES *

ENVIRONMENT: CONTINENTAL | BRACKISH / DELTAIC / LAGOONAL | LITTORAL | INNER SUBLITTORAL | OUTER SUBLITTORAL | BATHYAL

AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA

% FORAMINIFERAL ASSEMBLAGES

Foraminifera

Other fossils

INTERPRETED LITHOLOGY	DEPTH IN FEET	SYSTEM	STAGE	MICROFOSSILS
	100	OLIGOCENE		Haplophragmoides sp.
	200			Recurvoides sp.
	300			Trochammina globigeriniformis
	400	EOCENE		Bathysiphon sp.
	500			Trochammina sp. 2
	600			Ammodiscus sp.
	700			Sigmoilina cf. celata
	800			Glomospira sp.
	900	LOWER EOCENE - PALAEOCENE		Cyclammina challinori
	1000			Glomospira charoides
				Ammodiscus incertus
				Reophax sp.
				Spiroplectammina spectabilis
				Karrerella sp.
				Radiolaria
				Sponge spicules type A
				Sponge spicules type B
				Coscinodiscus cf. sp. 1
				Fish remains
				Scaphopods
				Large flattened radiolaria

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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No. 5	LOCATION
27.11.74.	5000' - 6000'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	DJS, CWH, IRH.

LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE
V Volcanics

DIAGNOSTIC SPECIES *

ENVIRONMENT: CONTINENTAL | BRACKISH / DELTAIC / LAGOONAL | LITTORAL | INNER SUBLITTORAL | OUTER SUBLITTORAL | BATHYAL

AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA

% FORAMINIFERAL ASSEMBLAGES

Foraminifera

MICROFOSSILS

- Ammodiscus incertus
- Recurvoides sp.
- Bathysiphon sp.
- Cyclammina challinori
- Ammolagena sp.
- Karreriella sp.
- Haplophragmoides sp.
- Sigmoilina schlumbergeri
- Nodosaria cf. torsicostata
- Trochammina globigeriniformis
- Globigerina triloculinoides
- Lenticulina cultrata
- Acarinina sp.
- Glomospira charoides
- Angulogerina abbreviata
- Haplophragmoides cf. watersi
- Verneuilina subcocaena
- Lenticulina sp.
- Trochammina sp.
- Nodosaria sp.
- Cibicides sp.
- Ammodiscus sp.
- Spiroplectammina spectabilis
- Rzehakina sp.
- Trochammina sp. A.
- Pelosina sp.
- Saccammina cf. placenta
- Cystammina sp.
- Hyperammina sp.

Other fossils

- Large flattened radiolaria
- Radiolaria
- Fish remains
- ?Coscinodiscus sp. 1.
- Coscinodiscus sp. 1.
- Coscinodiscus sp. 2.

INTERPRETED LITHOLOGY	DEPTH IN FEET	SYSTEM	STAGE
	100	LOWER EOCENE - PALAEOCENE	
	200		
	300		
	400		
P	500		
V			
V	600		
V			
V	700		
V			
V	800		
V	900		
	1000		

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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No. 6	LOCATION
13. 2. 75.	6000' - 7000'	Norwegian North Sea Well 33/9-3

FOR: Mobil Exploration Norway Inc.

ANALYST: CGL, DJS, GLT.

LIMESTONE · DOLOMITE · WHITE CHALK · RED MARL OR SHALE · CLAY · SHALE · SILTY/SANDY SHALE · SILTSTONE

SANDSTONE · COARSE SAND · CONGLOMERATE · GYPSUM/ANHYDRITE · SALT · CHERT · PYRITE · GLAUCONITE

COAL / LIGNITE · Sphaerosiderite · REWORKED SPECIES R

DIAGNOSTIC SPECIES *

INTERPRETED LITHOLOGY

DEPTH IN FEET: 100 200 300 400 500 600 700 800 900 1000

SYSTEM: PALAEOCENE · MAASTRICHTIAN · LOWER MAASTRICHTIAN - UPPER CAMPANIAN · LOWER CAMPANIAN

STAGE

ENVIRONMENT: CONTINENTAL · BRACKISH / DELTAIC / LAGOONAL · LITTORAL · INNER SUBLITTORAL · OUTER SUBLITTORAL · BATHYAL

% FORAMINIFERAL ASSEMBLAGES: PLANKTONIC FORAMINIFERA · CALCAREOUS BENTHONIC FORAMINIFERA · AGGLUTINATING FORAMINIFERA

MICROFOSSILS

Foraminifera

Recurvoides sp.	
Spiroplectammina spectabilis	*
Bathysiphon spp.	
Hyperammina spp.	
Trochammina spp.	
Trochammina globigeriniformis	*
Pelosina complanata	
Cyclammina spp.	
Ammodiscus incertus	
Glomospira charoides	*
Pseudotextularia elegans elegans	R
Verneuilina subeocaena	
Lenticulina sp.	
Pullenia cretacea	
Heterohelix globulosa	R
Dorothia bulletta	
Heterohelix globulosa	*
Ammosphaeroidina sp.	
Haplophragmoides spp.	
Pseudotextularia elegans elegans	*
Rugoglobigerina rugosa rugosa	*
Pseudotextularia elegans fructicosa	*
Praeglobotruncana citae	*
Biglobigerinella multispina	*
Gavelinella vombensis	
Eponides spp.	
Globigerinelloides asper	
Dentalina spp.	
Gyroidinoides spp.	
Nodosarids	
Polymorphinids	
Saccammina sp.	
Trochamminoides sp.	
Gavelinopsis sp.	
Globotruncana arca	*
Gavelinella sp.	
Rugoglobigerina rugosa rotundata	*
Abathomphalus mayaroensis	*
Praebulimina spp.	
Heterohelix pulchra	
Gyroidina quadrata	
Globotruncana contusa	*
Reussella szajnochae	*
Anomalinoides velascoensis	
Spiroplectammina sp.	
Gaudryina bentonensis	
Bolivinoides draco draco	*
Allomorphina sp.	
Stensioina pommerana	*
Miliolids	
Hormosina sp.	
Gaudryina sp.	

Other fossils

Coscinodiscus sp. 1	
Fish teeth	
Large flattened radiolaria	
Radiolaria	

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BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE 17.2.75. | CHART No. 7 7000' - 8000' | LOCATION Norwegian North Sea Well 33/9-3

FOR Mobil Exploration Norway Inc. | ANALYST JWC. CWH. CND. GLT. JC.

LIMESTONE · SANDSTONE ■ COAL / LIGNITE CMT Cement

DOLOMITE • COARSE SAND

WHITE CHALK O CONGLOMERATE

MARL / GYPSUM/ANHYDRITE

CLAY S SALT

SHALE C CHERT

SILTY/SANDY SHALE P PYRITE

SILTSTONE G GLAUCONITE

DIAGNOSTIC SPECIES

ENVIRONMENT: CONTINENTAL; BRACKISH / DELTAIC / LAGOONAL; LITTORAL; INNER SUBLITTORAL; OUTER SUBLITTORAL; BATHYAL

AGGLUTINATING FORAMINIFERA; CALCAREOUS BENTHONIC FORAMINIFERA; PLANKTONIC FORAMINIFERA

% FORAMINIFERAL ASSEMBLAGES

INTERPRETED LITHOLOGY | DEPTH IN FEET | SYSTEM | STAGE

MIDDLE JURASSIC | LOWER CRETACEOUS | UPPER CRETACEOUS | BARREMIAN | LOWER CAMPANIAN

MICROFOSSILS

Foraminifera

Haplophragmoides spp.
Dorothia bulletta
Rugoglobigerina rugosa rugosa *
Glomospira charoides
Abathomphalus mayaroensis *
Globigerinelloides asper
Gaudryina hentonensis
Rugoglobigerina rugosa rotundata *
Heterohelix globulosa
Recurvoides sp.
Lenticulina spp.
Gavelinopsis spp.
Ammosphaeroidina sp.
Trochammina squamata
Hormosina sp.
Spiroplectammina sp.
Cyclammina sp.
Eggerella sp.
Gavelinella vombensis
Patellina subcretacea *
Fvigerinammina mocsiana *
Marssonella kummi *
Glomospira gordialis
Trochoilina infragranulata *
Autoertus (Spirillina) neocomiana *

Ostracoda

Pontocyprella sp.

Miospores

Araucariacites australis
Bacutatisporites/Osmundacidites group
Bisaccates
Gleichenidites senonicus
Lycopodiumsporites spp.
Cerebropollenites mesozoicus
Dellotidospora spp.

Micro-plankton

Acanthomorph acritarchs

Other fossils

Sponge spicules
Echinoderm debris
Radiolaria (large, white)
Radiolaria

Pelosina complanata
Ammodiscus incertus
Bathysiphon spp.
Rousella szajnocha *
Trochammina spp.
Trochammoides spp.
Eponides spp.
Gaudryina sp.
Saccammina sp.
Haplophragmoides spp.
Dorothia bulletta
Rugoglobigerina rugosa *

ROBERTSON RESEARCH INTERNATIONAL LTD.
BIOSTRATIGRAPHICAL ANALYSIS CHART
DATE 19.2.75
CHART No. 8 8000'-9000'
LOCATION Norwegian North Sea Well 33/9-3
FOR Mobil Exploration Norway Inc.
ANALYST JWC, RSWN, JU, GAB, CWH.
LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE
SPHAEROSDERITE
IRONSTONE
DIAGNOSTIC SPECIES *
REWORKED SPECIES R
MICROFOSSILS
ENVIRONMENT
CONTINENTAL
BRACKISH / DELTAIC / LAGOONAL
LITTORAL
INNER SUBLITTORAL
OUTER SUBLITTORAL
BATHYAL
AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
% FORAMINIFERAL ASSEMBLAGES
INTERPRETED LITHOLOGY
DEPTH IN FEET
SYSTEM
STAGE
MIDDLE JURASSIC
LOWER JURASSIC
UPPER TOARCIAN
TOARCIAN
DOMERIAN
Foraminifera
Ostracoda
Miospores
Microplankton
Bathysiphon spp.
Trochammina spp.
Haplophragmoides cf. cushmani
Trochammina globigeriniformis
Haplophragmoides spp.
Ammobaculites agglutinans
100
200
300
400
500
600
700
800
900
1000

ROBERTSON RESEARCH INTERNATIONAL LTD.

BIOSTRATIGRAPHICAL ANALYSIS CHART

DATE	CHART No.	LOCATION
24.2.75.	9000' - 9800'	Norwegian North Sea Well 33/9-3

FOR	ANALYST
Mobil Exploration Norway Inc.	JU. GAB. JWC. CWII. RSWN.

LIMESTONE · DOLOMITE · WHITE CHALK · MARL · CLAY · SHALE · SILTY/SANDY SHALE · SILTSTONE

SANDSTONE · COARSE SAND · CONGLOMERATE · GYPSUM/ANHYDRITE · SALT · CHERT · PYRITE · GLAUCONITE

COAL / LIGNITE · Oolitic beds · Calcareous sandstone

DIAGNOSTIC SPECIES *

REWORKED SPECIES R

ENVIRONMENT: CONTINENTAL · BRACKISH / DELTAIC / LAGOONAL · LITTORAL · INNER SUBLITTORAL · OUTER SUBLITTORAL · BATHYAL

AGGLUTINATING FORAMINIFERA · CALCAREOUS BENTHONIC FORAMINIFERA · PLANKTONIC FORAMINIFERA

% FORAMINIFERAL ASSEMBLAGES

INTERPRETED LITHOLOGY · DEPTH IN FEET · SYSTEM · STAGE

DOMERIAN

CARIXIAN - UPPER SINEMURIAN

LOWER JURASSIC

100 · 200 · 300 · 400 · 500 · 600 · 700 · 800 · 900 · 1000

MICROFOSSILS

Foraminifera · Ostracoda · Miospores · Micro-plankton · Other fossils

- Amadiscus asper
- Bathysiphon sp.
- Protoonina sp.
- Trochammina globigeriniformis
- Haplophragmoides spp.
- Haplophragmoides cf. cushmani
- Verneuilinoides mauritii
- Reophax sp.
- Trochammina squamata
- Ammobaculites agglutinans
- Ammobaculites sp.
- Trochammina topagorukensis
- Saracenaria sublaevis
- Lenticulina varians
- Verneuilinoides sp. 1
- Planularia cf. inaequistriata
- ?Dentalina rotatina
- Trochammina grovei
- Trochammina nitida
- Marginulina praepupa
- Hungarella Nr. 4 (KLINGLER)
- Hungarella sp.
- Hungarella arpaltheri
- Hungarella cf. contractula
- Healdia kouthensis
- Bisaccates
- Perinopollenites elatoides
- Deltoidospora spp.
- "Circumpolles" group
- Chasmatosporites hians
- Klukisporites spp.
- Lycopodiumsporites spp.
- Araucariacites australis
- Baculatisporites/Osmundacidites group
- Lycopodiacidites spp.
- Cerebropollenites mesozoicus
- Staplinisporites caminus
- Tsugaepollenites dampieri
- Duplexisporites problematicus
- Classopollis torosus
- Leptolepidites spp.
- Convolucosisporites spp.
- Cycadopites spp.
- Brachysaccus microsaccus
- Striatoabieites sp.
- Chasmatosporites apertus
- Cyclotriletes sp.
- Cycadopites subgranulosus
- Nannoceratopsis gracilis
- Acanthomorph acritarchs
- Microforaminifera
- Botryococcus
- Echinoderm debris