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PHILLIPS 7/11 - 7 NORWEGIAN NORTH SEA WELL: BIOSTRATIGRAPHY OF THE INTERVAL 4570' — 16160' T.D.

by

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INTRODUCTION

This report summarises the results of the micropalaeontological, palynological, nannofossil and stratigraphic analyses which have been carried out on material received from the section 4570'-16160'T.D. from the Phillips 7/11-7 Norwegian North Sea Well under Project No. RRPS/834/A/10034.

The following analyses were carried out:
Lithology: 793 ditch cuttings, 19 sidewall core and 7 core samples from the entire section.
Micropalaeontology: 359 ditch cuttings samples from the interval 4570'-15000'.
Palynology: 22 ditch cuttings, 10 sidewall core and 7 core samples from the interval 14150'-16160'T.D.
Nannofossils: 38 ditch cuttings and 4 sidewall core samples from the interval 11370'-14450'.

The basic breakdown 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 on page 5.

All rock colour references in this report conform to the "Rock-Color Chart" distributed by the Geological Society of America. The lithological descriptions of the sidewall cores can be seen in Appendix 1, whilst those of the core samples occur in Appendix 2.

It should be noted that the lithostratigraphic terminology is taken from Deegan and Scull, 1977. The stratigraphic significance of the Rhaetian - Albian dinocyst zones is summarised in Appendices 3 and 4.

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 Phillips Petroleum with whom we have been associated during the course of this work.

Robertson Research staff involved in this study were:

Mike Charnock : Tertiary micropalaeontology
Paul Frame : Mesozoic micropalaeontology
Alison Merker : Tertiary micropalaeontology
Nick Miles : Palynology and project co-ordinator
Chris Mortimer : Calcareous nannofossils
Jeff Standring : Lithostratigraphy

SUMMARY

1. The youngest sediments analysed were the Middle Miocene sands and clays of the Nordland Group.

2. The Nordland Group ranges in age from Middle Miocene - Late Oligocene.

3. A thick sequence of shales and claystones of Late Oligocene to Middle - Early ?Eocene age is assigned to the Hordaland Group.

4. The Upper Palaeocene Rogaland Group is represented by the tuffaceous claystones of the Balder and Sele Formations and the shales of the Lista Formation.

5. The Montrose Group is represented by an unassigned sand unit of Late Palaeocene age and the Maureen Formation, comprising sands with reworked chalky limestones of Late - Early Palaeocene age.

6. The early part of the Lower Palaeocene consists of chalky limestones of the Chalk Group, Ekofisk Formation.

7. Chalky limestones of the Chalk Group, Tor and Hod Formations, persist below the conformable Tertiary - Cretaceous boundary, ranging from late Maastrichtian to early Coniacian - Turonian in age.

8. Grey calcareous shales of early Coniacian - Turonian age are assigned to the Plenus Marl Formation of the Chalk Group.

9. Argillaceous limestones of Cenomanian to possible latest Albian age are assigned to the Hidra Formation of the Chalk Group.

10. The Lower Cretaceous consists of a sequence of calcareous shales and limestones of the Cromer Knoll Group.

SUCCESSION

Age		Tops
Middle Miocene		4570' (top not seen)
Early Miocene		4720'
Earliest Miocene - ?Late Oligocene		5380'
Late Oligocene		5500'
Early Oligocene		6160'
Late - Middle? Eocene		7030'
Middle - Early? Eocene		9700'
Late Palaeocene		10210'
Early Palaeocene		11110'
Late Cretaceous	latest Maastrichtian	11370'
	late Maastrichtian	11450'
	early Maastrichtian	12810'
	early Maastrichtian - late Campanian	12930'
	early Campanian	13150'
	Santonian	13290'
	Coniacian	13410'
	early Coniacian - Turonian	13650'
	late - middle Cenomanian	13830'
Late - ?Early Cretaceous	early Cenomanian - ?latest Albian	14070'

SUCCESSION continued.....

	(late Albian	14250'(SWC)
	(	
	(-------Unconformity----------	
	(	
Early Cretaceous	(early Barremian - ?Valanginian	14350'
	(	
	(-----?Unconformity----------	
	(	
	(early Valanginian - latest	14450'(SWC)
	(Ryazanian	
Early Cretaceous - Late Jurassic	late Ryazanian - late Volgian	14454'(log)

----------Unconformity----------

?Triassic	14900'
Triassic	14976'(core)
Late Permian	15982'(log)-16160'T.D.

This breakdown is based on the analysis of ditch cuttings, sidewall core and core samples only, with some wireline log information supplied by the client. Wireline logs were not made available.

LITHOSTRATIGRAPHIC SUCCESSION

Unit	Age	Tops
Nordland Group:	Middle Miocene to Late Oligocene	4570' (top not seen)
Hordaland Group:	Late Oligocene to Middle - Early? Eocene	5530'
Rogaland Group:		
Balder and Sele Formations	Late Palaeocene	10210'
Lista Formation	Late Palaeocene	10360'
Montrose Group:		
Unassigned	Late Palaeocene	10510'
Maureen Formation	Late to Early Palaeocene	11000'
Chalk Group:		
Ekofisk Formation	Early Palaeocene	11130'
Tor Formation	latest to late Maastrichtian	11370'
Hod Formation	late Maastrichtian to early Coniacian - Turonian	12770'
Plenus Marl Formation	early Coniacian - Turonian	13820'
Hidra Formation	late - middle Cenomanian to early Cenomanian - ?latest Albian	13830'
Cromer Knoll Group:	late Albian to early Valanginian - latest Ryazanian	14250' (SWC)
Humber Group:		
Kimmeridge Clay Formation	late Ryazanian - late Volgian	14454' (log) ✓

?"Triassic" Group:		
?Smith Bank Formation	?Triassic	14900'
"Triassic" Group:		
Smith Bank Formation	Triassic	14976'(core)
Zechstein Group:	Late Permian	15982'(log)-16160'TD
		16160'T.D.

V

LITHOSTRATIGRAPHY

This section of the report is based upon the analysis of ditch cuttings, sidewall core and selected core samples only. Wireline logs were not made available by the client. The lithostratigraphic terminology is taken from Deegan and Scull, 1977.

LITHOSTRATIGRAPHIC UNITS

NORDLAND GROUP: 4570'-5530'. Age: Middle Miocene to Late Oligocene.

Lithologies within this interval predominantly comprise soft clays and disaggregated sands. The clays are soft, locally indurated and firm, medium grey to light olive grey, faintly micaceous and non-calcareous. They become locally shaly below 4950'. The sands are well-sorted with very fine to fine, angular to subangular, clear to white grains. Firm to moderately hard, medium light grey dolomite in microcrystalline or sucrosic form occurs as a common accessory below 5260', whilst traces of pyrite occur commonly throughout.

HORDALAND GROUP: 5530'-10210'. Age: Late Oligocene to Middle - Early? Eocene. The upper boundary of this group has been placed at 5530' where shales and claystones replace the poorly consolidated clays and sands of the overlying Nordland Group. The Hordaland Group essentially comprises a thick sequence of shales and claystones which are soft to firm, subfissile to weakly fissile, predominantly medium grey to olive grey, generally becoming darker with depth, faintly micromicaceous, locally silty and non-calcareous. They are commonly greenish grey in colour below 8290'. Fissile shales dominate the lower part of the interval below 9730'. They are mainly medium grey to greenish grey in colour but locally greyish red at the base.

Disaggregated sand grains occur only sporadically below 6180', probably representing thin sandstone stringers within this mainly argillaceous sequence. Rare bioclastic fragments occur in association with these sands.

Throughout the interval, traces of carbonate are noted. Limestones and dolomites which are firm to moderately hard, pale yellowish brown to brownish grey and microcrystalline occur probably in the form of thin stringers and nodules. Pyrite is also a common accessory, occurring as finely disseminated crystals or in rod-like form, and as fine, euhedral crystals in the lower part of the interval. Dark green, reniform glauconite and black, brittle carbonaceous material are also noted rarely.

ROGALAND GROUP: 10210'-10510'. Age: Late Palaeocene.

Two separate intervals have been recognised within this group as follows:

Balder and Sele Formations: 10210'-10360'. Age: Late Palaeocene.
In the absence of wireline logs, the Balder and Sele Formations have not been differentiated. The upper boundary has been placed at 10210' on the first positive identification of tuffaceous lithologies typical of the Late Palaeocene in this area. Lithologies consist of tuffaceous claystones which are firm, locally soft, and brittle, blocky, medium grey to medium dark grey with fine, light grey, tuffaceous lenses and laminae and are non-calcareous. Pyrite occurs throughout the interval in the form of fine, euhedral crystals. Minor greyish red shales persist throughout, but these may be caved from the overlying interval.

Lista Formation: 10360'-10510'. Age: Late Palaeocene.
The upper boundary of this formation has been placed at 10360' where shales form the predominant lithology and tuffaceous sediments are absent. The shales are soft to firm, fissile, medium grey to medium dark grey, faintly micromicaceous and non-calcareous. No samples were received from 10460' to the base of the interval at 10510', but rare traces of fine, white sandstone are noted in the ditch cuttings samples at 10450'.

MONTROSE GROUP: 10510'-11130'. Age: Late to Early Palaeocene.

Two distinct lithological units have been recognised within this group as follows:

Interval: 10510'-11000'. Age: Late Palaeocene.
The upper boundary of this interval has been placed directly beneath a sample gap. A marked lithological change is noted at this point, although the boundary may occur above the stated depth. Lithologies comprise sandstones, represented in ditch cuttings samples mainly by disaggregated grains which are moderately sorted, very fine to medium and angular to subangular. Rare, medium to coarse, subrounded grains are noted in the lower part of the interval. In addition, shales similar to those described in the overlying interval, but predominantly medium grey in colour, occur commonly. Brittle, black, carbonaceous material and fine, reniform glauconite grains occur together with pyrite as minor accessories.

Maureen Formation: 11000'-11130'. Age: Late to Early Palaeocene.
This formation has been differentiated from the main part of the Montrose Group because of the presence of significant quantities of reworked chalky limestones. The lithologies continue to be dominated by sandstones similar to those described above but with medium to coarse, subrounded to subangular grains being fairly common, and with inferior sorting. A soft, white, calcareous cement was occasionally noted. Shales persist, but only as a subordinate lithology. The reworked chalky limestones may have originated by a variety of processes including slumping and debris flows. They are firm to hard, platy, white to very light grey, microcrystalline with a slightly chalky texture.

CHALK GROUP: 11130'-14250'(SWC). Age: Early Palaeocene to Late - Early Cretaceous, late - middle Cenomanian to early Cenomanian - ?latest Albian.

Five formations have been recognised within this group as follows:

Ekofisk Formation: 11130'-11370'. Age: Early Palaeocene.
This formation is dominated by firm to moderately hard, blocky, white, microcrystalline, chalky limestones. Below 11220' they become light grey and increasingly argillaceous. They may equate to the so-called 'Ekofisk tight zone' and should be readily recognisable on wireline logs.

Tor Formation: 11370'-12770'. Age: Late Cretaceous, latest Maastrichtian to late Maastrichtian.

The upper boundary of this formation has been placed at 11370' on the first downhole appearance of hard, platy limestones, with accessory chert, which are characteristic of this formation. The limestones are moderately hard to hard, platy, white to very light grey, microcrystalline, locally stylolitic and slightly chalky in part. Hard, brownish grey to translucent chert occurs as a minor accessory, especially in the upper part of the interval. Pyrite is also noted sporadically in finely disseminated form. Trace quantities of soft, dark grey shale are noted within the interval 12260'-12320' forming fine, argillaceous laminae within otherwise pure limestone lithologies.

Hod Formation: 12770'-13820'. Age: Late Cretaceous, late Maastrichtian to early Coniacian - Turonian.

The upper boundary of this formation is considered to lie at 12770' on the first downhole appearance of a conspicuous, red, argillaceous limestone. This boundary must be viewed with caution however, in view of the young age of the sediments at this depth. In a typical chalk sequence, the upper boundary of this formation would be expected to lie within the early Campanian, although it has been recorded within the early Maastrichtian. This particular boundary lies within the late Maastrichtian interval. Although the top of the early Maastrichtian has been taken at 12810' in this report, it may actually coincide with the top of the red limestones in this poorly fossiliferous section.

The limestones are firm, platy, pinkish grey to pale red, microcrystalline and slightly argillaceous. Below 12880' they are replaced by limestones which are moderately hard, brittle, platy, white to very light grey, microcrystalline and very slightly chalky in part. They are also locally argillaceous, especially in the lower part of the interval. Traces of chert, similar to those described in the overlying interval are noted below 13380' and fine, green glauconite grains occur sporadically below 13400'.

Plenus Marl Formation: 13820'-13880'. Age: Late Cretaceous, early Coniacian - Turonian.

Minor quantities of dark grey, calcareous shale in the ditch cuttings samples at 13820' mark the upper boundary of this formation. The shales are soft to firm,

weakly fissile, dark grey to medium grey, micromicaceous and very weakly calcareous. Although this unit occurs within a section defined on biostratigraphic evidence as early Coniacian - Turonian, regional evidence indicates that the Plenus Marl Formation is of early Turonian age.

Hidra Formation: 13830'-14250'(SWC). Age: Late Cretaceous, late - middle Cenomanian to Late - ?Early Cretaceous, early Cenomanian - ?latest Albian. The upper boundary of this formation has been placed mainly on biostratigraphic evidence for the Cenomanian as no marked lithological break is noted. The upper part of the formation comprises argillaceous limestones which are soft to firm, medium light grey to medium grey, microcrystalline and very argillaceous grading locally to calcareous shale. Below 13900', the argillaceous content decreases and limestones become firm, platy, very light grey or light grey in colour. These limestones exhibit a granular texture below 13920' and are locally silty. At and below 14150', the limestones are again notably argillaceous although sample quality throughout this lower section is poor, principally due to the drilling methods employed. Both glauconite and pyrite persist as traces throughout the interval.

CROMER KNOLL GROUP: 14250'(SWC)-14454'(log). Age: Early Cretaceous, late Albian to early Valanginian - latest Ryazanian.

The sediments of this group have not been differentiated in this report. The lithologies consist of calcareous shales which are predominantly medium grey in colour, but are also commonly greyish red within the interval 14300'-14340'. Soft, white to light grey limestones which are argillaceous in part also occur below 14340'. Such limestone developments are typical of the Barremian. Sample quality throughout the entire section is generally poor due to the methods of drilling employed.

HUMBER GROUP: 14454'(log)-14900'. Age: Early Cretaceous - Late Jurassic, late Ryazanian - late Volgian.

Kimmeridge Clay Formation: 14454'(log)-14900'.
The upper boundary of this formation has been placed at 14454' on a wireline log break which was supplied by the client, although the typical dark claystone

lithologies are recorded in ditch cuttings samples at 14450'. The lithologies consist of claystones which are predominantly firm to moderately hard, subfissile, greyish black, slightly silty and non-calcareous, although they are weakly to moderately calcareous in the upper part of the interval. Trace quantities of soft, black, fibrous lignite occur sporadically throughout.

?TRIASSIC GROUP: 14900'-14976'(core). Age: ?Triassic.

?Smith Bank Formation: 14900'-14976'(core).
The upper boundary of this formation has been placed at 14900' where minor quantities of greyish red claystone are noted in ditch cuttings samples. This interval has been assigned only a questionable Triassic age due to poor lithological evidence. Ditch cuttings throughout this interval are dominated by Kimmeridge Clay type lithologies which are considered to be caved.

TRIASSIC GROUP: 14976'(core)-15982'(log). Age: Triassic.

Smith Bank Formation: 14976'(core)-15982'(log).
The first good evidence of Smith Bank Formation is seen in the core samples within the interval 14976'-14993'3", comprising claystones and shales which are soft to firm, subfissile to moderately fissile, greenish grey to medium dark grey, micromicaceous, locally sandy, waxy and non-calcareous. The more characteristic greyish red claystones are noted in the core at 15140'. Below 15160', minor quantities of sandstone are noted in ditch cuttings samples. They are firm to moderately hard, white to yellowish grey, well-sorted with fine, angular to subangular grains with accessory mica in a thin, non-calcareous cement. Traces of medium grey to yellowish grey dolomite occur within the interval 15210'-15280' and claystones which are firm, subfissile to blocky, greyish red to dark reddish brown, micaceous, slightly silty and non-calcareous become common below 15250'.

Sandstones occur below 15280'. They are generally firm to friable, white, locally brownish grey, predominantly well-sorted with very fine to fine, angular to subangular grains in a non-calcareous cement. The sands are predominantly

red-stained below 15580'. Lithologies over the entire section are generalised due to the heavy contamination by cavings which dominate most of the samples.

ZECHSTEIN GROUP: 15982'(log)-16160'T.D. Age: Late Permian.

The upper boundary of this interval has been placed on a wireline log break supplied by the client. Ditch cuttings samples consist mainly of caved Jurassic lithologies, but traces of soft, white, amorphous anhydrite are noted below 16000'.

VI

BIOSTRATIGRAPHY

VI (1) CENOZOIC

INTERVAL 4570'-4720'; MIDDLE MIOCENE (top not seen)

Lithostratigraphic Unit:
Nordland Group (part).

Environment: marine, inner to outer shelf.

The age of this interval is based on the following micropalaeontological criteria:

- the presence of Hoeglundina elegans at 4570'.
- the subsequent appearance of Globorotalia continuosa at 4600' and the development of the Glomospira charoides/Bathysiphon spp./Pseudoclavulina sp. Assemblage at 4600' based on the occurrence of Bathysiphon spp. at 4600' and Glomospira charoides at 4630'.
- the occurrence of Globigerina angustiumbilicata and Globigerina concinna at 4690'.

MICROPALAEONTOLOGY

The occurrence of Hoeglundina elegans in the first sample at 4570' is generally indicative of a Middle Miocene age. This age is supported by the development of the Glomospira charoides/Bathysiphon spp./Pseudoclavulina sp. Assemblage at 4600'. This assemblage is normally dominated by agglutinated foraminifera. Their poor development in the microfauna at the top of the well is most likely due to massive caving of calcareous benthonics. The presence of two of the nominate taxa, namely, Bathysiphon spp. at 4600' and Glomospira charoides at 4630' supports the designation of the assemblage. Pseudoclavulina sp. was first noted at 4930' in the underlying interval. Its relatively low occurrence in this well is presumed to be due to caving. The planktonic foraminifera Globorotalia continuosa, was recorded from 4600' to 4690' and supports a Middle Miocene age.

At 4690' Globigerina angustiumbilicata, one of the nominate taxa for the Globorotalia scitula/Globigerina angustiumbilicata Assemblage, occurs and indicates an early Middle Miocene age.

INTERVAL 4720'-5380'; EARLY MIOCENE

Lithostratigraphic Unit:
Nordland Group (part).

Environment: marine, inner to outer shelf.

The age and upper limit of this interval are based on the following micropalaeontological criteria:

- the presence of Globigerinoides triloba at 4720'.
- the subsequent occurrence of Sphaeroidinellopsis seminulum at 5050', Globigerina apertura and Orbulina universa at 5200', Globigerina ciperoensis at 5230', Globorotalia siakensis at 5350' and Pseudarcella spp. at 4780'.

MICROPALAEONTOLOGY

The upper limit and age of this interval are based on the first occurrence of Globigerinoides triloba at 4720'. This species has a more restricted range in the North Sea than the rest of the world and suggests by its occurrence at 4720' an Early Miocene age.

The age assigned is supported by the subsequent appearance of a number of planktonic foraminifera including Sphaeroidinellopsis seminulum (5050'), Globigerina apertura (5200'), Orbulina universa (5200'), Globigerina ciperoensis (5230') Globorotalia siakensis (5350') and species of the problematic protist genus Pseudarcella spp. at 4780'.

The microfaunas of this interval are dominated by agglutinated foraminifera, most of which are presumed to be caved from the overlying interval. Calcareous benthonic and planktonic foraminifera occur in lesser numbers.

INTERVAL 5380'-5500'; EARLIEST MIOCENE - ?LATE OLIGOCENE

Lithostratigraphic Unit:
Nordland Group (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the appearance of Globigerina woodi and Globorotalia zealandica at 5380'.
- the occurrence of Bolboforma spinosa (5410') and Bolboforma armata at 5440'.

MICROPALAEONTOLOGY

The microfaunas of this interval are dominated by planktonic foraminifera of the Globigerina woodi Assemblage. Its upper limit is based on the first appearance of the nominate taxon at 5380'. This assemblage is normally developed towards the base of the Early Miocene. It is uncertain whether this assemblage ranges into the Oligocene and, therefore, a questionable Late Oligocene age has been assigned. The Globigerina woodi Assemblage has been incorporated into the more long ranging Globigerina ciperoensis Assemblage in the RRI Southern Offshore Norway Phase II Study.

The presence of the planktonic foraminifera Globorotalia zealandica (5380') and Praeorbulina glomerosa at 5410', and also the problematical algal cysts Bolboforma spinosa (5410') and Bolboforma armata (5440') generally support the age assigned.

INTERVAL 5500'-6160'; LATE OLIGOCENE

Lithostratigraphic Units:
Nordland Group (part): 5500'-5530';
Hordaland Group (part): 5530'-6160'.

Environment: marine, outer shelf to upper bathyal.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the presence at 5500' of Globorotalia opima nana.
- the subsequent appearance of Sigmoilina schlumbergeri (5530'), of Litheliid sp. A (5680'), Globigerina galavisi (5800'), Globigerina officinalis and Globigerina ampliapertura at 5920' and Asterigerina guerichi at 6010'.

MICROPALAEONTOLOGY

The upper limit of this interval is based on the appearance of Globorotalia opima nana at 5500'. This species tops at mid zone P.22 according to Blow (1979), immediately below the Oligocene/Miocene boundary. The nominate taxon for the Sigmoilina schlumbergeri Assemblage makes its first downhole appearance at 5530'. The occurrences of the following planktonic foraminifera support a Late Oligocene age: Globigerina galavisi and Globigerina officinalis at 5500' and Globigerina ampliapertura at 5920'. Litheliid sp. A at 5680' and Asterigerina guerichi at 6010' also support a Late Oligocene age.

An increase in calcareous benthonic and planktonic foraminifera midway through this interval indicates a slight shallowing of the basin, but the largely agglutinated microfauna shows the influence of an outer shelf to upper bathyal environment of deposition.

INTERVAL 6160'-7030'; EARLY OLIGOCENE

Lithostratigraphic Unit:
Hordaland Group (part).

Environment: marine, outer shelf to upper bathyal.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the presence at 6160' of Globigerina angiporoides.
- the subsequent occurrences of Globigerina gortanii at 6370' and Globigerina corpulenta at 6580'.

MICROPALAEONTOLOGY

The presence of Globigerina angiporoides at 6160' indicates sediments no younger than Early Oligocene age have been penetrated. The supportive evidence of Globigerina gortanii at 6370', Globigerina corpulenta at 6580', Dorothia sp. 6 at 6220' and Karreriella apicularis at 6790' confirms the age assigned. Diatoms characteristic of the Oligocene are present in low numbers throughout this interval, but occur in the underlying interval, where they are considered to be caved.

At 6460' and 6880' specimens of siliceous Coscinodiscus sp. 1 normally typical of the Late Palaeocene are considered to be reworked, as are Danian planktonic foraminifera at 6550' and 6610'.

The microfaunas are dominated by agglutinated foraminifera indicative of an outer shelf to upper bathyal regime.

INTERVAL 7030'-9700'; LATE - MIDDLE? EOCENE

Lithostratigraphic Unit:
Hordaland Group (part).

Environment: marine, outer shelf to upper bathyal.

The upper limit and age of the interval are based on the following micropalaeontological criteria:

- the presence of Globigerina linaperta s.s. at 7030'.
- the subsequent records of Globigerina pseudovenezuelana (8380'), Trochammina globigeriniformis (7150'), Cystammina spp. (7180'), Trochammina altiformis (7510'), Cyclammina amplectens (7720') and Trochammina sp. X at 8350'.

MICROPALAEONTOLOGY

The planktonic foraminifer Globigerina linaperta s.s. does not range into the Oligocene, according to Blow (1979), and its presence at 7030' therefore indicates an age no younger than Late Eocene. This age is supported by the appearance of Globigerina pseudovenezuelana at 8380'. The nominate taxa for the Trochammina globigeriniformis/Trochammina sp. X/Cystammina spp. Assemblage are found at 7150', 8350' and 7180' respectively. In the North Sea region this assemblage ranges from Early Oligocene to Middle Eocene and therefore broadly confirms the age assigned.

The following species support the age assigned to the interval, namely Trochammina altiformis found at 7510' and Cyclammina amplectens at 7720'. The latter species becomes common at 7780'. The green staining of the microfaunas at 7720' is characteristic of Eocene faunas and the composition, almost exclusively agglutinated, indicates an outer shelf to upper bathyal environment.

INTERVAL 9700'-10210'; MIDDLE TO EARLY? EOCENE

Lithostratigraphic Unit:
Hordaland Group (part).

Environment: marine, outer shelf to upper bathyal.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the presence at 9700' of Ammobaculites sp. 1
- the subsequent occurrence of Spiroplectammina spectabilis at 9970'.

MICROPALAEONTOLOGY

The appearance of two of the nominate taxa for the Ammobaculites sp. 1/Spiroplectammina spectabilis/Verneuilina subeocana Assemblage, namely, Ammobaculites sp. 1 at 9700' and Spiroplectammina spectabilis at 9970' indicates sediments of Middle Eocene age have been penetrated. An Early Eocene interval is usually defined by a marked influx of members of the Globigerina linaperta group and corresponds in part to the basal Hordaland Group red shale. This red shale horizon occurs at 10130' but unfortunately members of this group are absent. Abundant members of the Globigerina linaperta group occur at 10270' in the underlying interval and are presumed to be caved. The occurrence of Spirosigmoilinella sp. 1 at 10060' is thought to be the result of reworking from the Late Palaeocene.

The assemblages are dominated by agglutinated foraminifera and were deposited in an outer shelf to upper bathyal environment.

INTERVAL 10210'-11110'; LATE PALAEOCENE

Lithostratigraphic Units:

Rogaland Group;

Balder and Sele Formations: 10210'-10360';

Lista Formation: 10360'-10510';

Montrose Group (part);

Unassigned Unit: 10510'-11000';

Maureen Formation (part): 11000'-11110'.

Environment: marine, outer shelf to upper bathyal.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the appearance of Coscinodiscus sp. 1 and sp. 2 at 10210'.
- the subsequent occurrence of Spirosigmoilinella sp. 1 (10330'), Labrospira pacifica (10660') and the development of the Spongodiscid Radiolaria Assemblage at 10930'.

MICROPALAEONTOLOGY

The top of the Late Palaeocene interval is based on the first appearance of Coscinodiscus sp. 1 and sp. 2 at 10210'. This defines the upper limit of the Coscinodiscus sp. 1 Assemblage and its base is defined on the last downhole occurrence of the nominate taxon at 10360'. At the base of this assemblage, the diatoms have a siliceous rather than pyritised type of preservation.

The first in situ occurrence of Spirosigmoilinella sp. 1 at 10330', and Labrospira pacifica at 10660' confirm the age assigned, as does the persistent occurrence of Spiroplectammina spectabilis at and below 10660'. The Spongodiscid Radiolaria Assemblage is developed below 10930', based on the appearance of the nominate taxon and is typical of sediments of earliest Late Palaeocene age. The occurrence of Globigerina trivialis (11020') and Globorotalia compressa at 11080' are possibly reworked from the Early Palaeocene.

The microfaunas of this interval are generally dominated by agglutinated foraminifera and are believed to indicate an outer shelf to upper bathyal environment.

INTERVAL 11110'-11370'; EARLY PALAEOCENE

Lithostratigraphic Units:

Montrose Group (part);

Maureen Formation (part): 11110'-11130';

Chalk Group (part);

Ekofisk Formation: 11130'-11370'.

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following micropalaeontological criteria:

- the occurrence of Globorotalia cf. compressa, Globigerina trivialis, Globigerina triloculinoides, Globorotalia pseudobulloides and Gavelinella vombensis at 11110'.
- the subsequent appearance of Anomalinoides velascoensis at 11140'.

MICROPALAEONTOLOGY

The presence of Globorotalia cf. compressa and Globigerina trivialis at 11110' is indicative of an age no younger than the Early Palaeocene P2 Zone as defined by Blow (1979). An Early Palaeocene age is supported by the presence of other planktonic foraminifera including Globorotalia pseudobulloides and Globigerina triloculinoides in the same sample, although, according to Blow, these species may range into the younger P3 Zone. The appearance of the calcareous benthonic foraminifera Gavelinella vombensis (11110') and Anomalinoides velascoensis at 11140' also support the age assigned.

The general nature of the microfaunas, dominated by planktonic and calcareous benthonic foraminifera, indicates an outer shelf environment.

VI (2) CRETACEOUS

INTERVAL 11370'-11450'; LATE CRETACEOUS, LATEST MAASTRICHTIAN

Lithostratigraphic Unit:
Chalk Group (part);
Tor Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following lithological and nannofloral criteria:

- the appearance of lithologies typical of the Tor Formation at 11370'.
- the presence of Arkhangelskiella cymbiformis at 11370'.
- the occurrence of Nephrolithus frequens and Lithraphidites quadratus at 11450'.
- the relative stratigraphic position.

MICROPALAEONTOLOGY

The samples analysed from this interval were barren of in situ foraminifera and no age determination was possible.

CALCAREOUS NANNOFOSSILS

The three ditch cuttings samples analysed from this interval yielded nannofloral assemblages which were considerably modified by caving from the overlying Early Palaeocene interval. The appearance of Arkhangelskiella cymbiformis at 11370' indicates that sediments assigned to the Arkhangelskiella cymbiformis NK1 Zone of Maastrichtian age are present at this depth. The subsequent appearance of Kamptnerius magnificus and Micula staurophora at 11380' and Cribrosphaera ehrenbergi, Prediscosphaera cretacea, Lucinorhabdus cayeuxii and Eiffellithus turriseiffeli at 11430' provides confirmation that sediments of a general Maastrichtian age are present over this interval.

However, the occurrence of the latest Maastrichtian marker species Nephrolithus frequens and Lithraphidites quadratus at 11450' (which are presumed to be caved) suggests that sediments of latest Maastrichtian age are present in the well. In

view of this, and the fact that the first evidence for the penetration of late Maastrichtian is provided at 11450', a latest Maastrichtian age (Subzone 1B-1A) has been assigned to the interval 11370' to 11450' based on both nannofloral evidence and relative stratigraphic position.

INTERVAL 11450'-12810'; LATE CRETACEOUS, LATE MAASTRICHTIAN

Lithostratigraphic Unit:
Chalk Group (part);
Tor Formation (part) 11450'-12770';
Hod Formation (part) 12770'-12810'.

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral criteria:

- the appearance of Reinhardtites levis at 11450'.
- the subsequent appearance of Gartnerago obliquum 11490'.

MICROPALAEONTOLOGY

The majority of the samples analysed in this interval were barren of in situ foraminifera. From the remaining samples only poor microfaunas were recovered. The presence of rare Inoceramus debris and an occurrence of the Rugoglobigerina/Archaeoglobigerina complex (12730') only support the broad Late Cretaceous age. No more restricted age determination is possible on micropalaeontological evidence.

CALCAREOUS NANNOFOSSILS

Poor to moderately preserved nannofloral assemblages were noted from the ditch cuttings samples examined from this interval. The appearance of Reinhardtites levis at 11450' indicates that sediments of late Maastrichtian age assigned to the Reinhardtites levis Subzone 1C have been penetrated at this depth. The subsequent appearance of Gartnerago obliquum at 11490' confirms that sediments of a late Maastrichtian age have been reached, and allows the recognition of the Gartnerago obliquum Subzone 1D.

The subsequent occurrence of Helicolithus aff. trabeculatus at 11730', Dodekapodorhabdus cf. noeli at 11850', Monomarginatus quaternarius at 11970', Prediscosphaera stoveri at 12210' and Zygodiscus sp. A at 12750' provides further evidence for a general Maastrichtian age for sediments at these depths.

Late Cretaceous and Early Palaeocene caving was noted throughout the interval.

INTERVAL 12810'-12930'; LATE CRETACEOUS, EARLY MAASTRICHTIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral criterion:

- the appearance of Reinhardtites biperforatus at 12810'.

MICROPALAEONTOLOGY

Samples in this interval were either barren or poorly fossiliferous. Although the Rugoglobigerina/Archaeoglobigerina complex was recovered from these samples, it does not display the abundances normally associated with its occurrence in the early Maastrichtian due to the poor faunal recovery in this well. Consequently, no positive age determination can be assigned on micropalaeontological evidence.

Some pink staining of the microfaunas was recorded in the upper part of this interval.

CALCAREOUS NANNOFOSSILS

The ditch cuttings samples yielded poor to moderately preserved nannofloral assemblages. The appearance of Reinhardtites biperforatus at 12810' indicates that sediments assigned to the Reinhardtites biperforatus Subzone 1F of early Maastrichtian age have been penetrated at this depth.

INTERVAL 12930'-13150'; LATE CRETACEOUS, EARLY MAASTRICHTIAN - LATE CAMPANIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral and micropalaeontological criteria:

- the appearance of Broinsonia parca at 12930'.
- the subsequent appearance of Orastrum campanensis at 13050'.
- the occurrence of ?Globotruncana marginata at 12970'.
- the incoming of common Globotruncana marginata at 13060'.

MICROPALAEONTOLOGY

Poor microfaunas of little diversity were recovered from this interval.

The broad early Maastrichtian to late Campanian age of the interval is based primarily on nannofossil criteria. Micropalaeontological evidence for an early Maastrichtian age is absent. However, the occurrence of a tentatively identified specimen of Globotruncana marginata at 12970' may suggest a late Campanian age from that depth. Also, at 13060' common Globotruncana marginata specimens were recovered indicating an age, in view of the possible higher occurrence of this marker species (at 12970'), within the late Campanian. Due to the difficulties of identifying any early Maastrichtian sediments in this interval and the poor identification of G. marginata at 12970', no good age boundary has been delimited and a broad early Maastrichtian to late Campanian age is assigned. This is in agreement with that determined from the nannofossil analyses (see below).

CALCAREOUS NANNOFOSSILS

Rich, diverse and moderately preserved nannofloral assemblages were noted from the ditch cuttings samples analysed from this interval.

The appearance of Broinsonia parca at 12930' indicates the penetration of sediments assigned to the Broinsonia parca Subzone 1G of early Maastrichtian age. However, the subsequent appearance of Orastrum campanensis at 13050' suggests that the Orastrum campanensis Subzone 2A of late Campanian age has been encountered. In view of this and the micropalaeontological evidence, a general early Maastrichtian to late Campanian age has been assigned to the interval.

INTERVAL 13150'-13290'; LATE CRETACEOUS, EARLY CAMPANIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following micropalaeontological and nannofloral criteria:

- the incoming of Tritaxia dubia at 13150'.
- the continued occurrence of Broinsonia parca, Orastrum campanensis and Monomarginatus quaternarius at 13170' and 13230'.

MICROPALAEONTOLOGY

As in the overlying section only poor microfaunas with little diversity were recovered from this interval.

The incoming of Tritaxia dubia at 13150' allows the recognition of the Tritaxia dubia Assemblage. This indicates an early Campanian age for the interval.

CALCAREOUS NANNOFOSSILS

Quite rich but poorly preserved nannofloral assemblages were recorded from the two ditch cuttings samples examined from this interval.

The continued occurrence of Orastrum campanensis, Broinsonia parca, Monomarginatus quaternarius at 13170' and 13230' suggests that sediments of a general Campanian age are present at these respective depths.

INTERVAL 13290'-13410'; LATE CRETACEOUS, SANTONIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral and micropalaeontological criteria:

- the occurrence of abundant Watznaueria barnesae.
- the appearance of Broinsonia enormis and Eiffellithus eximius at 13290'.
- the occurrence of Stensioina cf. praeexsculpta at 13300'.

MICROPALAEONTOLOGY

Poor, low diversity microfaunas were recovered from this section. The top of the interval is placed at 13290' on nannofossil criteria. The first micropalaeontological evidence for the age occurs at 13300' with the incoming of Stensioina cf. praeexsculpta indicating a Santonian age. The interval is also assigned to the Stensioina Assemblage.

CALCAREOUS NANNOFOSSILS

Quite rich but poorly preserved nannofloral assemblages were recorded from the ditch cuttings samples analysed from this interval.

The appearance of Broinsonia enormis and Eiffellithus eximius at 13290' indicates that sediments are no younger than the Broinsonia enormis Subzone 2C of early Campanian age at this depth. However, the appearance of abundant Watznaueria barnesae in association with the continued occurrence of Lucinorhabdus cayeuxii and Orastrum campanensis at the same horizon suggests that sediments of an older Santonian age are present at this level, assigned to the unnamed NK3 Zone.

Late Cretaceous caving has considerably modified the nannofloral assemblages noted over this interval.

INTERVAL 13410'-13650'; LATE CRETACEOUS, CONIACIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral and micropalaeontological criterion:

- the appearance of relatively common Eiffellithus eximius, Tranolithus orionatus and Gartnerago obliquum in association with abundant Watznaueria barnesae at 13410'.

MICROPALAEONTOLOGY

The microfaunas in this interval remain basically the same as those of the overlying section. No age diagnostic species were recovered, however, the presence of the Globotruncana cf. linneiana group from 13600' is consistent with a Coniacian age.

CALCAREOUS NANNOFOSSILS

Relatively rich, moderately preserved nannofloral assemblages were recorded from the ditch cuttings samples analysed from this interval.

The appearance of relatively common Eiffellithus eximius, Tranolithus orionatus and Gartnerago obliquum in association with abundant Watznaueria barnesae at 13410' indicates that sediments assigned to the Watznaueria barnesae/ Eiffellithus eximius Zone NK4 of Coniacian age are present at this horizon.

Some Late Cretaceous caving was also noted over this interval.

INTERVAL 13650'-13830'; LATE CRETACEOUS, EARLY CONIACIAN - TURONIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hod Formation (part): 13650'-13820';
Plenus Marl Formation: 13820'-13830'.

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofossil criteria:

- the appearance of Helicolithus cf. trabeculatus at 13650'.
- the continued occurrence of Eiffellithus eximius, Kamptnerius magnificus and Quadrum gartneri down to 13770'.

MICROPALAEONTOLOGY

The samples analysed from this interval are barren or poorly fossiliferous. No age diagnostic species were recovered although the occurrence of Globotruncana linneiana cf. tricarinata at 13770' is consistent with the age assigned on nannofossil evidence.

CALCAREOUS NANNOFOSSILS

The ditch cuttings examined from this interval contained poorly preserved nannofloral assemblages dominated by Watznaueria barnesae.

The appearance of Helicolithus cf. trabeculatus at 13650' indicates that sediments are no younger than early Coniacian in age at this depth. The continued occurrence of Eiffellithus eximius, Kamptnerius magnificus and Quadrum gartneri down to 13770' (if in situ) suggests that the sediments are probably no older than Turonian at these respective depths, and may be assigned to the Watznaueria barnesae/Eiffellithus eximius Zone NK4 to Helicolithus cf. trabeculatus Zone NK5 of a general Coniacian to Turonian age.

INTERVAL 13830'-14070'; LATE CRETACEOUS, LATE - MIDDLE CENOMANIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hidra Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral criteria:

- the appearance of Parhabdolithus asper at 13830'.
- the subsequent appearance of Parhabdolithus achlyostaurion at 13890' and Cribrosphaera primitiva at 13950'.

MICROPALAEONTOLOGY

Samples from this interval are either barren or poorly fossiliferous. No Cenomanian marker species were recovered.

CALCAREOUS NANNOFOSSILS

The four ditch cuttings samples analysed from this interval yielded poor to moderately preserved nannofloral assemblages characterised by abundant Watznaueria barnesae.

The appearance of Parhabdolithus asper in association with common Tranolithus orionatus and Broinsonia cf. enormis at 13830' suggests that sediments assigned to the Parhabdolithus achlyostaurion Zone NK6 of Cenomanian age are present at this horizon. The subsequent appearance of Parhabdolithus achlyostaurion at 13890' and Cribrosphaera primitiva at 13950' provides confirmation for the penetration of Cenomanian age sediments at these respective depths, and allows the recognition of the Parhabdolithus asper Subzone 6C to the Parhabdolithus achlyostaurion Subzone 6A of late - middle Cenomanian age over the interval 13830' to 14070'.

INTERVAL 14070'-14250'(SWC); LATE CRETACEOUS - ?EARLY CRETACEOUS; EARLY CENOMANIAN - ?LATEST ALBIAN

Lithostratigraphic Unit:
Chalk Group (part);
Hidra Formation (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral, palynological and micropalaeontological criteria:

- the appearance of Gartnerago nanum at 14070'.
- the subsequent appearance of Zygodiscus theta and Gartnerago sp. at 14130'.
- the occurrence of Ovoidinium scabrosum at 14200'.
- the occurrence of ?Gavelinella cf. baltica at 14230'.

MICROPALAEONTOLOGY

From 14070' to 14150' the samples analysed were principally barren of foraminifera. Below 14150', only poor microfaunas were recorded. The age of this interval is based on nannofossil criteria only; no definitive age diagnostic foraminifera were recovered. However, the occurrence of a poorly preserved ?Gavelinella cf. baltica at 14230' would support the broad early Cenomanian to ?latest Albian age assigned to the interval.

CALCAREOUS NANNOFOSSILS

The ditch cuttings samples examined from this interval yielded poorly preserved but quite rich nannofloral assemblages.

The appearance of Gartnerago nanum at 14070' indicates that sediments assigned to the Gartnerago nanum Subzone 6D of early Cenomanian age are present at this horizon. The subsequent appearance of Zygodiscus theta and Gartnerago sp. at 14130' is consistent with an early Cenomanian age determination. However, the occurrence of abundant Biscutum ellipticum, also at 14130', is of interest since this feature is often associated with late Albian age sediments.

PALYNOLOGY

Two ditch cuttings samples were analysed from this interval. The palynofloras recovered were dominated by dinocysts, particularly elements of the Spiniferites ramosus group, with rare bisaccate pollen being the only miospore recorded.

The presence of Litosphaeridium siphoniphorum at 14150' indicates an age no younger than Cenomanian. The subsequent occurrence of Ovoidinium verrucosum (at 14200'), a dinocyst that ranges no younger than earliest Cenomanian, supports the age assigned to this interval on nannofossil evidence.

It is considered possible that sediments of a latest Albian age are present within this interval in view of the fact that the underlying interval is dated as no younger than the Apteodinium grande Subzone (OIIB), with no sediments of the latest Albian O. verrucosum Subzone (OIIA) age being identified.

INTERVAL 14250'(SWC)-14350'; EARLY CRETACEOUS, LATE ALBIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part).

Environment: marine, inner to outer shelf.

The upper limit and age of this interval are based on the following nannofloral and palynological criteria:

- the occurrence of Apteodinium grande at 14250'(SWC).
- the occurrence of Tetrapodorhabdus captensis at 14250'(SWC).
- the subsequent occurrence of Litosphaeridium conispinum at 14300'.

MICROPALAEONTOLOGY

Only poor microfaunas of little diversity were recovered from this interval. No positive late Albian markers were recovered.

CALCAREOUS NANNOFOSSILS

The single sample, a sidewall core, analysed from this interval yielded a relatively rich but poorly preserved nannofloral assemblage, dominated by Watznaueria barnesae and to a lesser extent Tranolithus orionatus.

The appearance of Tetrapodorhabdus captensis at 14250'(SWC) indicates that sediments assigned to the Tetrapodorhabdus captensis Subzone 7A of late Albian age are present at this depth. The continued occurrence of Eiffellithus turriseiffeli and Prediscosphaera spinosa at the same horizon provides further supporting evidence for the late Albian age determination.

PALYNOLOGY

One sidewall core sample and one ditch cuttings sample were analysed from this interval.

The palynoflora recovered from 14250'(SWC) was low in numbers and diversity, and dominated by microplankton, including specimens of Apteodinium grande, a dinocyst restricted to the late Albian, A. grande Subzone (OIIB).

The ditch cuttings sample at 14300' yielded a palynoflora dominated by elements of the Spiniferites ramosus group. The occurrence of Litosphaeridium conispinum at this depth supports the age assigned, this dinocyst ranging no younger than the A. grande Subzone (OIIB).

No evidence of early Albian to "mid" Barremian age sediments was recorded, consequently, this interval is considered to rest unconformably on the underlying early Barremian - ?Valanginian age sediments.

INTERVAL 14350'-14450'(SWC); EARLY CRETACEOUS, EARLY BARREMIAN - ?VALANGINIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part).

Environment: marine, inner shelf.

The upper limit and age of this interval are based on the following palynological, nannofloral and micropalaeontological criteria:

- the appearance of Kleithriasphaeridium corrugatum at 14350'.
- the occurrence of Nannoconus abundans at 14362'(SWC).
- the appearance of Conusphaera mexicana at 14400'.
- the occurrence of consistent Lenticulina spp. from 14350', polymorphinids from 14390' and ostracods from 14410'.

MICROPALAEONTOLOGY

Foraminifera were moderately common in this interval. The consistent occurrence of Lenticulina spp. and polymorphinids from 14350' and 14390' respectively, and the subsequent occurrence, from 14410', of common and consistently occurring ostracods allow the recognition of the Calcareous Benthonics/Ostracods Assemblage in this interval. This suggests a broad Barremian to Neocomian age which is in agreement with the more restricted early Barremian to ?Valanginian age assigned from palynological and nannofossil analyses.

CALCAREOUS NANNOFOSSILS

The two sidewall cores examined from this interval yielded moderately preserved nannofloral assemblages dominated by Watznaueria barnesae and Parhabdolithus asper.

The appearance of Nannoconus abundans at 14362'(SWC) indicates the penetration of the Nannoconus abundans NK9 Zone of Barremian age at this depth. However, the subsequent appearance of Conusphaera mexicana and to a lesser extent common Micrantholithus holschulzi and Nannoconus steinmanni at 14400' indicate that

sediments assigned to the Conusphaera mexicana Subzone 9C of a more restricted early Barremian age are present at this level.

PALYNOLOGY

Microplankton continue to dominate the palynofloras recovered from the upper part of this interval, although an increase in numbers and diversity of miospores is apparent.

At 14350' the palynoflora is characterised by the common occurrence of elements of the Spiniferites ramosus group and bisaccate pollen with numerous specimens of Kleithriasphaeridium corrugatum and Pseudoceratium pelliferum. The presence at this level of Cassiculosphaeridia magna, Sirmiodinium grossii and P. pelliferum indicates the penetration of Barremian age sediments, whilst the appearance of the subzonal index taxon indicates an age no younger than the early Barremian K. corrugatum Subzone (IC).

The sidewall core sample at 14400' yielded an impoverished palynoflora characterised by the presence of low numbers of bisaccates and Cicatricosisporites spp. The presence of a specimen of Odontochitina operculata indicates an age no older than the Barremian Sirmiodinium grossii Zone (I).

No evidence of Hauterivian to Valanginian aged sediments was recorded within this interval. It is considered probable that an unconformity separates this interval from the underlying early Valanginian to latest Ryazanian, although the presence of a condensed sequence representing some or all of the Hauterivian to late Valanginian cannot be discounted.

INTERVAL 14450'(SWC)-14454'(log); EARLY CRETACEOUS, EARLY VALANGINIAN - LATEST RYAZANIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part).

Environment: marine, inner shelf.

The upper limit and age of this interval are based on the following palynological and nannofloral criteria:

- the occurrence of Occisucysta cf. evittii and Endoscrinium pharo at 14450'(SWC).
- the appearance of Micrantholithus speetonensis at 14450'(SWC).
- the occurrence of common Parhabdolithus embergeri in association with Ethmorhabdus sp. at 14450'(SWC).

MICROPALAEONTOLOGY

The microfaunas recovered from this interval remain the same as those of the overlying section. The continued presence of the nominate forms of the Calcareous Benthonic/Ostracods Assemblage still suggests a broad Barremian to Neocomian age. This supports the more restricted early Valanginian to latest Ryazanian age assigned to the interval from palynological and nannofossil analyses.

CALCAREOUS NANNOFOSSILS

The sidewall core analysed at 14450' yields a very rich, moderately well preserved nannofloral assemblage characterised by abundant Watznaueria barnesae.

The appearance of Micrantholithus speetonensis at 14450'(SWC) indicates that sediments assigned to the Micrantholithus speetonensis Subzone 11B, of early Valanginian age, are present at this depth. Further support for this age determination is provided by the appearance of Ethmorhabdus sp. and common Parhabdolithus embergeri, together with the continued occurrence of Corollithion silivaridian, Bukrylithus ambiguus, Sollanites horticus and Cruciplacolithus salebrosus (relatively common) at the same depth.

PALYNOLOGY

The sidewall core sample at 14450' yielded a moderately diverse palynoflora dominated by dinocysts. Characteristic elements of the palynoflora comprise common Oligosphaeridium diluculum and numerous specimens of Cyclonephelium hystrix and Hystrichodinium pulchrum. The appearance of Occisucysta cf. evittii and the subzonal index taxon indicates the penetration of sediments no younger than the early Valanginian Endoscrinium pharo Subzone (IVC).

Although no positive indication of late Ryazanian age sediments was recorded within this interval, it is considered probable that they are present; regional knowledge indicates that the oldest Cromer Knoll Group sediments are of latest Ryazanian age.

VI (3) CRETACEOUS - JURASSIC

INTERVAL 14454'(log)-14900'; EARLY CRETACEOUS - LATE JURASSIC, LATE RYAZANIAN - LATE VOLGIAN

Lithostratigraphic Unit:
Humber Group;
Kimmeridge Clay Formation.

Environment: marine, inner shelf.

The top of this interval is based on a log break at 14454'. The age is based on the following stratigraphic, palynological and micropalaeontological criteria:

- the regionally recognised age for the top of the Kimmeridge Clay Formation.
- the influx of prasinophycean algae at 14600'.
- the occurrence of Rhaxella perforata, Lithostrobus sp. and incoming of Cenosphaera sp. at 14730'.

MICROPALAEONTOLOGY

From 14530' to 14710' only poor microfaunas were recovered. Below 14710', the samples were barren of in situ foraminifera. The presence of Rhaxella perforata, the radiolaria Lithostrobus sp. and incoming of Cenosphaera sp. in the interval indicate the presence of the Kimmeridge Clay Formation of late Ryazanian or older age. This supports the late Ryazanian to late Volgian age assigned to the interval on palynological and stratigraphic criteria. The radiolaria and Rhaxella perforata are particularly common below 14710'.

PALYNOLOGY

The ditch cuttings sample at 14550' yielded an impoverished palynoflora with rare in situ dinocysts and miospores. The presence of Egmontodinium torynum at this level indicates an age no younger than the late Ryazanian Dingodinium spinosum Zone (V).

Ditch cuttings samples analysed from 14600' to 14750' yielded palynofloras dominated by numerous to common specimens of the prasinophycean algae Pterospermella spp. Assemblages of this type are characteristically encountered within the late Ryazanian to late Volgian of the North Sea area, being associated with the "hot" shale of the Kimmeridge Clay

Formation. Regionally, the top of the Kimmeridge Clay Formation (14454'log) is known to be within the late Ryazanian stenomphalus ammonite zone.

The ditch cuttings sample at 14800' and the sidewall core samples at 14838' and 14852' yielded very impoverished palynofloras, with rare microplankton. No evidence of the penetration of sediments any older than late Ryazanian to late Volgian was recovered; consequently, this interval is considered to rest unconformably on the underlying ?Triassic age sediments.

VI (4) ?TRIASSIC

INTERVAL 14900'-14976'(core); ?TRIASSIC

Lithostratigraphic Unit:
?"Triassic" Group;
?Smith Bank Formation.

Environment: terrestrial, lacustrine/fluviatile.

The upper limit and age assigned to this interval are based on the following lithostratigraphic and stratigraphic criteria:

- the presence of rare red claystones at 14900'.
- the presence of well dated Triassic in the underlying interval.

MICROPALAEONTOLOGY

The samples analysed from this interval were barren of any in situ foraminifera.

PALYNOLOGY

The ditch cuttings sample at 14900' yielded an assemblage comprising rare specimens of prasinophycean algae and bisaccate pollen, considered to be caved from the overlying interval.

The core sample at 14940' yielded no palynomorphs.

The ?Triassic age is assigned in view of the poor quality of the ditch cuttings samples available for lithological analysis and the absence of in situ Jurassic palynomorphs.

VI (5) TRIASSIC

INTERVAL 14976'(core)-15982'(log); TRIASSIC

Lithostratigraphic Unit:
"Triassic" Group;
Smith Bank Formation.

Environment: terrestrial, fluviatile/lacustrine.

The upper limit and age assigned to this interval are based on the following lithostratigraphic and palynological criteria:

- the presence of greenish grey lithologies in the core at 14976'.
- the presence of ?Triadispora sp., cf. Plicatipollenites sp. and Chasmatosporites sp. at 15620'.

MICROPALAEONTOLOGY

From 14976'(core) to 15000' samples analysed were barren of in situ foraminifera. No micropalaeontological analysis was carried out below 15000'.

PALYNOLOGY

The analysis of core, sidewall core and ditch cuttings samples from 14976'(core) to 15539'(SWC) yielded only rare occurrences of non-age diagnostic bisaccate pollen in a dark state of preservation typical of the Triassic.

At 15620' the presence of ?Triadispora sp., cf. Plicatipollenites sp. and Chasmatosporites sp. suggests a Triassic age.

No age diagnostic forms were recorded from 15703.8'(SWC) to 15930'(SWC).

VI (6) LATE PERMIAN

INTERVAL 15982'(log)-16160'T.D.; LATE PERMIAN

Lithostratigraphic Unit:
Zechstein Group.

Environment: marginal marine, hypersaline.

The upper limit of this interval is based on wireline log information supplied by the client.

The age assigned to this interval is based on the following lithostratigraphic and palynological criteria:

- the presence of rare anhydrite lithologies at and below 16000'.
- the appearance of Lueckisporites virkkiae at 16100'.
- the subsequent appearance of numerous L. virkkiae with Vittatina hiltonensis and Perisaccus granulosus at 16160'(T.D.).

PALYNOLOGY

Ditch cuttings samples analysed from 16020' to 16160'(T.D.) yielded rare to numerous bisaccate and striate bisaccate pollen.

At 16100' the appearance of Lueckisporites virkkiae indicates an age no younger than Late Permian. This age is supported by the subsequent occurrence of numerous L. virkkiae with Perisaccus granulosus and Vittatina hiltonensis.

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APPENDIX 1

LITHOLOGICAL DESCRIPTIONS OF SIDEWALL CORES

Depth (feet)	Core No.	Run No.	Recovery (mm)	Quality	Type of Analysis	Lithology
14250	45	2	Frgs.	Exc.	N P	LIMESTONE: firm to moderately hard, light grey to very light grey, microcrystalline, slightly argillaceous.
14362	44	2	Frgs.	Exc.	N P	CALCAREOUS SHALE: firm to moderately hard, weakly to moderately fissile, dark grey, faintly micromicaceous, moderately to strongly calcareous.
14400	43	2	Frgs.	Exc.	N P	LIMESTONE: firm to moderately hard, light brownish grey to brownish grey, microcrystalline.
14450	42	2	Frgs.	Exc.	N P	LIMESTONE: firm, light grey to medium grey, microcrystalline, slightly argillaceous, very pyritic with common, fine, euhedral crystals.
14838	38	2	Frgs.	Exc.	P	SILTY SHALE: soft to firm, locally moderately hard, dark grey, very micaceous and silty, very weakly calcareous.
14852	37	2	Frgs.	Exc.	P	SILTY SHALE: as 14838'.
15250	33	2	Frgs.	Exc.	P	SILTY CLAYSTONE: soft to firm, blocky to subfissile, greyish red to pale red, micaceous and very silty, non-calcareous.

15283	32	2	Frgs.	Exc.		SANDSTONE: soft, friable, very light grey to brownish grey, well-sorted with very fine, angular to subangular grains grading to coarse silt, micaceous, non-calcareous.
15539	30	2	Frgs.	Exc.	P	ARENACEOUS CLAYSTONE: soft to firm, blocky, greyish red to moderate reddish brown, very silty, sandy and micaceous grading locally to argillaceous sandstone, non-calcareous.
15631.80	24	2	Frgs.	Exc.		SANDSTONE: firm to friable, very light grey to light olive grey, well-sorted with very fine to medium, angular to subangular grains, occasionally stained red, in a non-calcareous cement.
15703.80	22	1	Frgs.	Exc.	P	SANDSTONE: firm to friable, pale red to light brownish grey, well-sorted, with very fine angular to subangular grains, grading locally to silt, micaceous, non-calcareous.
15754.80	20	1	20	Exc.		ARENACEOUS CLAYSTONE: grading to ARGILLACEOUS SANDSTONE: as 15539'.
15830.80	16	1	16	Exc.		SANDSTONE: firm to friable, greyish red to moderate, reddish brown, well-sorted with very fine to fine, angular grains, commonly stained red, micaceous, argillaceous, non-calcareous.

15900	28	2	Frgs.	Exc.		SANDSTONE: firm to friable, pale red to pale reddish brown, well-sorted, fine to silty, angular grains, commonly stained red, very micaceous, argillaceous, non-calcareous.
15919.80	11	1	Frgs.	Exc.		SANDSTONE: as 15900'.
15930	27	2	Frgs.	Exc.	P	SANDSTONE: as 15900'.
15946.80	8	1	Frgs.	Exc.		SANDSTONE: as 15900', but pinkish grey to pale red in colour, and slightly argillaceous.
15960	26	2	Frgs.	Exc.		ARGILLACEOUS SILTSTONE: soft to firm, platy to blocky, greyish red to moderate reddish brown, micaceous, very argillaceous, non-calcareous.
15967.20	5	1	Frgs.			ARENACEOUS CLAYSTONE: grading to ARGILLACEOUS SANDSTONE: as 15539'.

KEY

Frags. = Fragments
Exc. = Excellent
N = Calcareous Nannofossils
P = Palynology

APPENDIX 2

LITHOLOGICAL DESCRIPTIONS OF CORE PIECES

Depth (feet)	Core No.	Type of Analysis	
14940		P	ARGILLACEOUS SANDSTONE: moderately hard, medium grey to brownish grey, well-sorted with fine to medium, angular to subangular grains in an argillaceous, non-calcareous matrix.
14976	3	P	CLAYSTONE: soft to firm, subfissile, greenish grey to medium grey, micromicaceous, locally slightly waxy, non-calcareous.
14979.50	3	P	CLAYSTONE: soft to firm, locally brittle, non-fissile, medium dark grey to olive grey, micromicaceous, waxy, irregular fracture, non-calcareous. (Drill mud penetrates entire sample).
14993	3	P	SHALE: firm, weakly to moderately fissile, greenish grey, micromicaceous, arenaceous with fine subrounded to subangular grains and coarse mica flakes, non-calcareous.
14995	3	P	CLAYSTONE: soft to firm, non-fissile, medium grey to medium dark grey, waxy, slightly silty, very micaceous, non-calcareous.
15056	4	P	ARENACEOUS CLAYSTONE: firm to moderately hard, non-fissile, greyish green, very micaceous, locally waxy, sandy with common, fine, angular quartz grains, grading locally to ARGILLACEOUS SANDSTONE: locally dolomitic, non-calcareous.
15140	6	P	CLAYSTONE: firm, subfissile, greyish red to very dusky red, slightly silty and micaceous, locally waxy, non-calcareous.

KEY

P = Palynology

Appendix 3

RYAZANIAN–ALBIAN DINOCYST ZONATION

GEOLOGICAL AGE			STANDARD AMMONITE ZONES	DINOCYST ZONATION	
				ZONES	SUBZONES
EARLY CRETACEOUS	Albian	late	*dispar*	*Ovoidinium scabrosum* OII	*Ovoidinium verrucosum* OIIA
			inflatum		*Apteodinium grande* OIIB
			cristatum		*Systematophora cretacea* OIIC
		middle	*lautus*		
			loricatus		
			dentatus		
		early	*mamillatum*		*Cauca parva* OIID
			tardefurcata		
	Aptian	late	*jacobi*	*Dingodinium albertii* OI	*Aptea polymorpha* OIA
			nutfieldensis		*Cyclonephelium tabulatum* OIB
			martinioides		
		early	*bowerbanki*		
			deshayesi		
			forbesi		
			fissicostatus		
	Barremian	late	*bidentatum*	*Sirmiodinium grossii* I	*"Astrocysta" cretacea* IA
		early–mid.	*rude-fissicostatum*		*Doidyx anaphrissa* IB
			rarocinctum		*Kleithriasphaeridium corrugatum* IC
	Hauterivian	late	*variabilis*	*Subtilisphaera terrula* II	*Adnatosphaeridium vetusculum* IIA
			marginatus		*Canningia* cf. *reticulata* IIB
			gottschei	*"Oligosphaeridium" nannum* III	*Chlamydophorella trabeculosa* IIIA
			speetonensis		
		early	*inversus*		*Kleithriasphaeridium simplicispinum* IIIB
			regale		
			noricum		
			amblygonium		
	Valanginian	late	unnamed	*Phoberocysta neocomica* IV	*Muderongia extensiva* IVA
			pitrei		
			dichotomites		
		early	*polyptychites*		*Tubotuberella apatela* IVB
			paratollia		*Endoscrinium pharo* IVC
	Ryazanian	late	*albidum*	*Dingodinium spinosum* V	*"? Prolixosphaeridium" torynum* VA
			stenomphalus		*Dichadogonyaulax* sp. VB
			icenii		
		early	*kochi*		*Cannosphaeropsis* sp. A VC
			runctoni		

* The Barremian/Hauterivian boundary should now be placed at the top of the *marginatus* Zone (Rawson, in press).

Appendix 4

RHAETIAN–VOLGIAN DINOCYST ZONATION

GEOLOGICAL AGE			STANDARD AMMONITE ZONES	DINOCYST ZONATION	
				ZONES	SUBZONES
LATE JURASSIC	Volgian	late	*lamplughi*	*"Imbatodinium" villosum* VI	*Egmontodinium* sp. A VIA
			preplicomphalus		*Kleithriasphaeridium* sp. A VIB
			primitivus		*Systematophora* spp. VIC
			opprassus		
		middle	*giganteus*	*Muderongia* sp. A VII	*Dichadogonyaulax pannea* VIIA
			gorei		*Dichadogonyaulax culmula* VIIB
			albani		
			Epipallasiceras sp.		*Glossodinium dimorphum* VIIC
			rotunda		
			pallasioides	*Pareodinia mutabilis* VIII	*Gonyaulacysta pennata* VIIIA
			Pavlovia sp.		*Gonyaulacysta jurassica* VIIIB
		early	*pectinatus*	*Gonyaulacysta longicornis* IX	*Egmontodinium polypiacophorum* IXA
			hudlestoni		
			wheatleyensis		
			scitulus		
			elegans		*Scriniodinium luridum* IXB
	Kimmeridgian		*autissiodorensis*		
			eudoxus	*Gonyaulacysta cladophora* X	
			mutabilis		
			cymodoce		
			beylei	*Scriniodinium crystallinum* XI	*Leptodinium egemenii* XIA
	Oxfordian	late	*pseudocordata*		*Stephanelytron radcliffense* XIB
			decipiens	*Scriniodinium galeritum* XII	*Scriniodinium oxfordianum* XIIA
			cautisnigrae		*Compositosphaeridium costatum* XIIB
		middle	*transversarium*		
			plicatilis	*Acanthaulax spinosissima* XIII	
		early	*cordatum*	*Wanaea digitata* XIV	*Gonyaulacysta areolata* XIVA
			mariae		*Wanaea fimbriata* XIVB
	Callovian	late	*lamberti*		*Mendicodinium groenlandicum* XIVC
			athleta		
		middle	*coronatum*	*Polystephanephorus paracalathus* XV	*Kalyptea stegasta* XVA
			jason		*Nannoceratopsis pellucida* XVB
		early	*calloviense*	*Pareodinia ceratophora* XVI	
			macrocephalus		*Dichadogonyaulax gochtii* XVIA
MIDDLE JURASSIC	Bathonian	late	*discus*		*Wanaea acollaris* XVIB
			aspidoides		
			retrocostatum		
		middle	*morrisi*		*Gonyaulacysta filapicata* XVIC
			subcontractus		
			progracilis		
		early	*zigzag*		
	Bajocian	late	*parkinsoni*	*Nannoceratopsis spiculata* XVII	
			garantiana		
			subfurcatum		
		middle	*humphriesianum*	*Nannoceratopsis gracilis* XVIII	*Polysphaeridium deflandrei* XVIIIA
			sauzii		
			laeviuscula		
			discites		
		early	*concavum*		
			murchisonae		
			opalinum		
EARLY JURASSIC	Toarcian	late	*levesquei*		*Mancodinium semitabulatum* XVIIIB
			thouarsense		
		middle	*variabilis*		
			bifrons		"Sphaeromorphs" XVIIIC
		early	*falciferum*		
			tenuicostatum		
	Pliensbachian	late	*spinatum*		*Luehndea spinosa* XVIIID
			margaritatus		
		early	*davoei*	*Polysphaeridium langii* XIX	Unnamed subzone XIXA
			ibex		
			jamesoni		
	Sinemurian	late	*raricostatum*		*Liasidium variabile* XIXB
			oxynotum		
			obtusum		
		early	*turneri*		Unnamed subzone XIXC
			semicostatum		
			bucklandi		
	Hettangian		*angulata*		*Dapcodinium priscum* XIXD
			liasicus		
			planorbis		
LATE TRIASSIC	Rhaetian			*Rhaetogonyaulax rhaetica* XX	

LITHOLOGIES

Clay

Shale/mudstone

Siltstone

Sand/sandstone, very fine to medium grained

Sand/sandstone, coarse grained to granules

Conglomerate (with sand matrix)

Conglomerate (without sand matrix)

Coal/lignite

Breccia

Limestone (undifferentiated)

Chalky limestone

Dolomitic limestone

Calcareous dolomite

Dolomite

Chert

Anhydrite/gypsum

Salt (halite)

Potassium salts

Concretions/nodules

Igneous rocks, undifferentiated

Basement, undifferentiated

Granite

Qualifiers

Argillaceous

Silty/sandy

Pebbly

Carbonaceous

Calcareous

Dolomitic

Red sediments

Accessories

Calcite C

Ironstone/ferruginous deposits ..... Fe

Glauconite ..... Gl

Kaolinite ..... K

Phosphate ..... Ph

Pyrite ..... Py

Siderite/sphaerosiderite ..... S

Silica ..... Si

GRAIN TYPES

Oolith

Fossils in general

Bioclastic debris

Mudflakes

BIOSTRATIGRAPHIC SYMBOLS

Fossil Abundances

- Present ..... ○
- Common ..... ●
- Abundant ..... ■

Diagnostic forms ..... *

Caved forms C

Reworked forms ..... R

Incoming of

Outgoing of

Unconformity/stratigraphic hiatus

Faulted boundary ..... F — F

Late ..... LT., lt.

Middle ..... M., m.

Early ..... EY., ey.

Other symbols

Sample gap

Lost circulation material ..... lcm

Cement ..... cmt

Turbo drilling or diamond bit drilling ..... tu
(Samples unsuitable for good stratigraphic analysis)

Casing point

Core

Sidewall core

Sidewall core (analysed for biostratigraphy) ..... *

Sidewall core (no recovery)

FIGURE 1 – Legend (edited from Robertson Research Standard Legend).

FIGURE 2

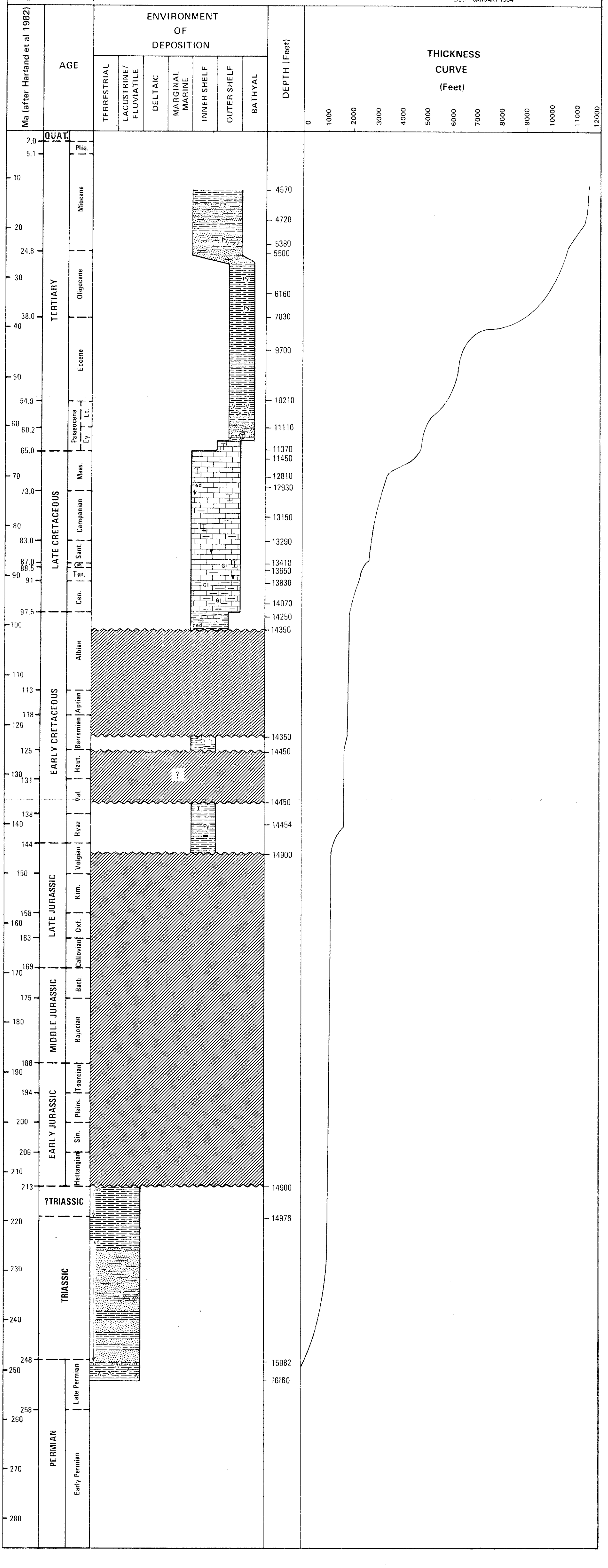
DEPOSITIONAL HISTORY

ROBERTSON RESEARCH INTERNATIONAL LIMITED

PHILLIPS 7/11-7

Drg. No. 030P/10034/5614

Date: JANUARY 1984



STRATIGRAPHY

AGE

EARLY MIOCENE | MIDDLE MIOCENE

MICROFAUNAL ASSEMBLAGE

Globorotalia scitula group / *Globigerina angustiumbilicata*

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (NO LOGS AVAILABLE)

NORDLAND GROUP

GENERALISED LITHOLOGY

Nonaspira chloroides / *Bathysiphon* spp / *Pseudoclavulina* spp

cmt cmt cmt cmt cmt

Py Py Py Py Py

DEPTH (feet)

4570
4600
4700
4800
4900
5000

COMMENTS

H. elegans
T. continuosa, *Bathysiphon* spp
N. chloroides
G. angustiumbilicata
G. concinna (N8)
G. trilobo (N7)
Pseudarcella spp
Pseudoclavulina spp.

Mixed foraminiferal association dominated by Calcareous Benthonics

Influx of planktonic foraminifera

Microfauna dominated by agglutinated foraminifera

ENVIRONMENT

CONTINENTAL
- TERRESTRIAL
- LACUSTRINE / FLUVIATILE

TRANSITIONAL
- MARGINAL MARINE

MARINE
- INNER SHELF
- OUTER SHELF
- BATHYAL

COMMENTS ON KEROGENS (< 20%)

FORAMINIFERAL ASSOCIATION
- AGGLUTINATED
- CALCAREOUS
- BENTHONIC
- PLANKTONIC

FORAMINIFERA

1. *Hoeglundina elegans*
2. *Cibicides* cf. *lobatulus*
3. *Quinqueloculina seminulum*
4. *Sigmoilina celata*
5. *Pullenia bulloides*
6. *Cassidulina laevigata*
7. *Cassidulina subglobosa*
8. *Fissurina marginata*
9. *Cibicides lobatulus*
10. *Robulus* sp.
11. *Globigerina atlantica*
12. *Globigerina bulloides*
13. *Globigerina* spp.
14. *Bathysiphon* spp.
15. *Lenticulina* spp.
16. *Cibicides* spp
17. *Astrolia beccari*
18. *Nonion affine*
19. *Globorotalia humerosa*
20. *Globigerina pachyderma*
21. *Globorotalia continuosa*
22. *Pyrgo* aff. *depressa*
23. *Cibicides weuglorstorfi*
24. *Fissurina obliqnyana*
25. *Glomospira charoides*
26. *Robulus* spp.
27. *Dentalina* sp.
28. *Cibicides dutemplei*
29. *Chilostomellina fimbriata*
30. *Globigerina angustiumbilicata*
31. *Quinqueloculina* sp.
32. *Globigerina concinna*
33. *Globigerina* aff. *ciperoensis*
34. *Globigerinoides trilobo*
35. *Valvulineria* spp.
36. *Alveolophragmium*/*Cyclammina* spp
37. *Praeglobobulimina ovata*
38. *Bulimina* spp.
39. *Recurvoides* spp.
40. *Cyclammina* spp.
41. *Cyclammina rotundidorsata*
42. *Ammodiscus* spp.
43. *Cyclammina placenta*
44. *Haplophragmoides* spp.
45. *Pseudoclavulina* sp.
46. *Eggerella* spp.
47. *Haplophragmoides carinatum*
48. *Hormosina* sp.

OTHER MICROFOSSILS

- Echinoderm debris
- Ostracod spp.
- Gastropod/Pteropod debris
- *Pseudarcella* spp.
- *Pseudarcella arenata*
- *Costacodacus* spp.
- Bivalve fragments

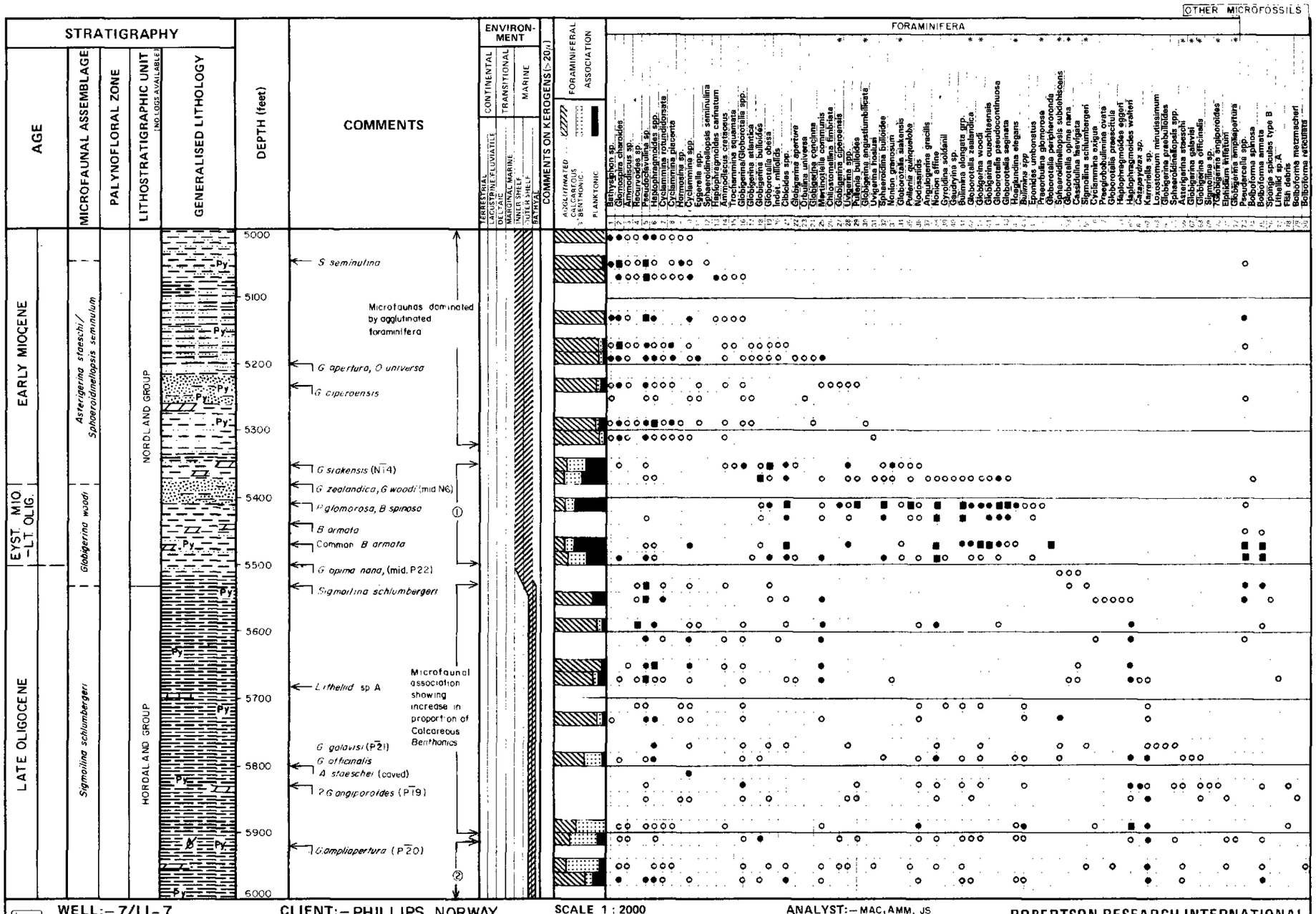
WELL:– 7/11 - 7
CHART:– 1 of 13
FIGURE:– 3

CLIENT:– PHILLIPS NORWAY
DEPTH:– 4570'- 5000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

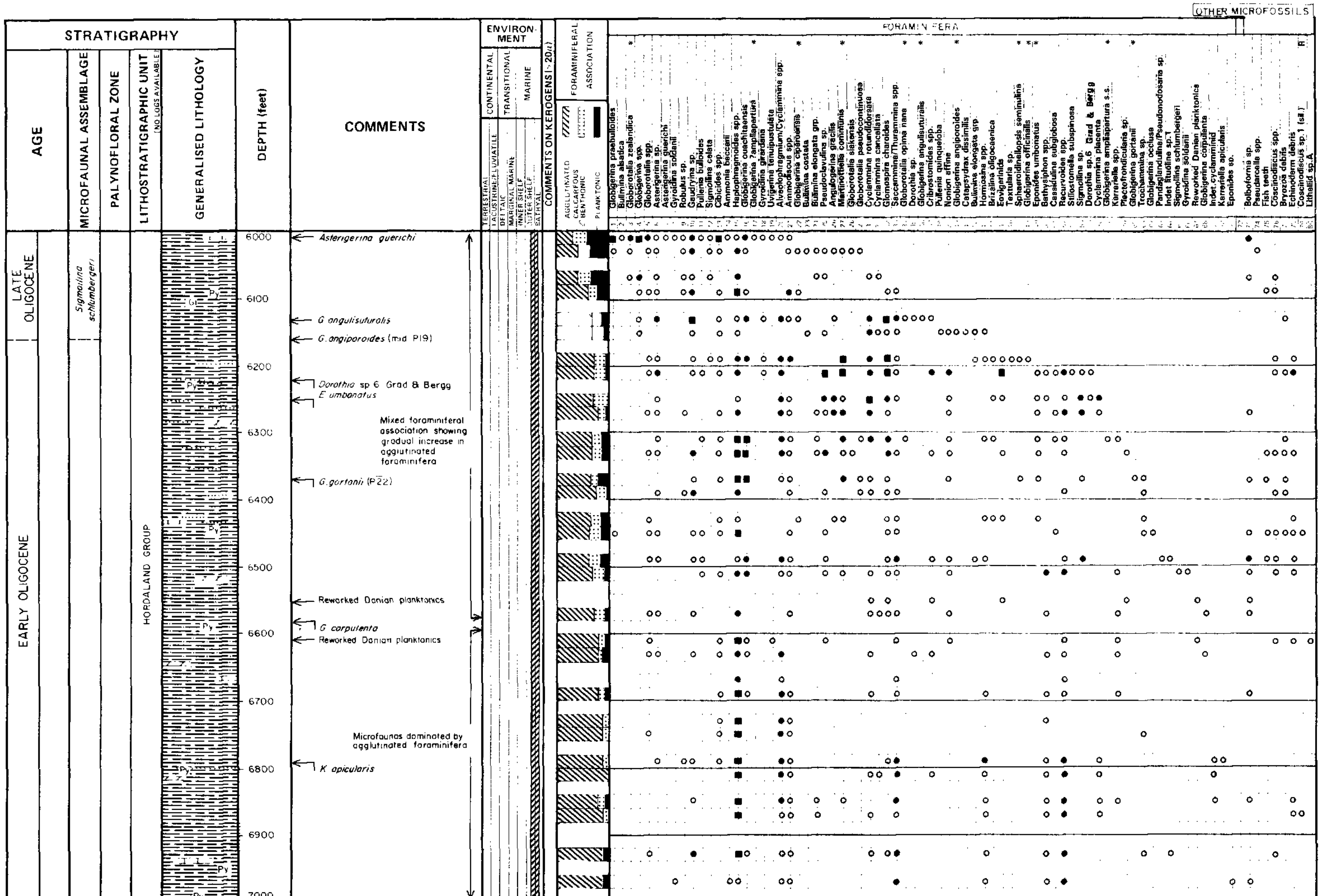
ANALYST:– MAC, AMM, JS
DRAWING NO.:– 0308/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



① Mircofaunal associations contain abundant planktonic foraminifera

② Mixed foraminiferal association showing gradual increase in agglutinated foraminifera



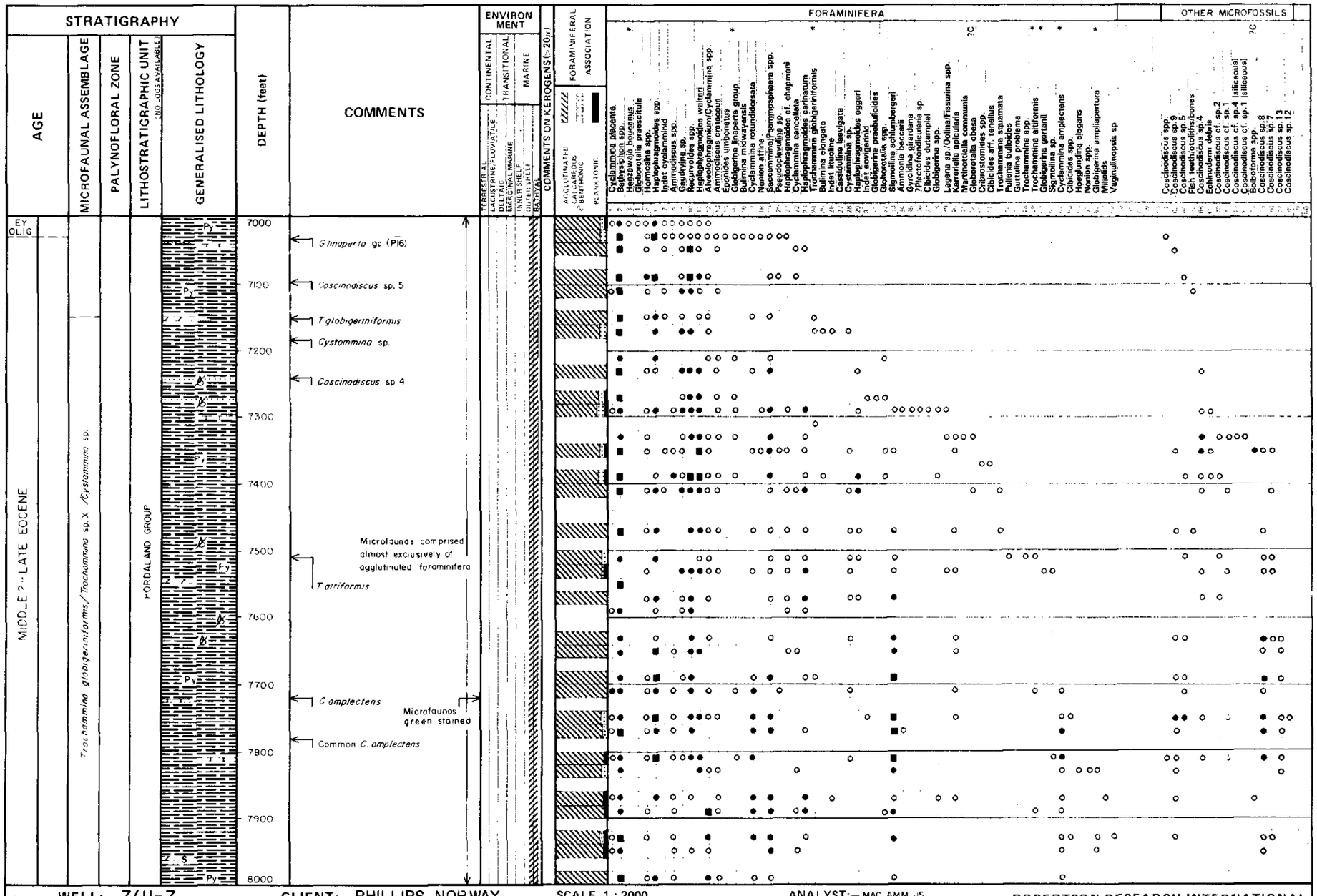
WELL:– 7/11-7
CHART:– 3 of 13
FIGURE:– 5

CLIENT:– PHILLIPS NORWAY
DEPTH:– 6000' - 7000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– MAC, AMM, JS
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



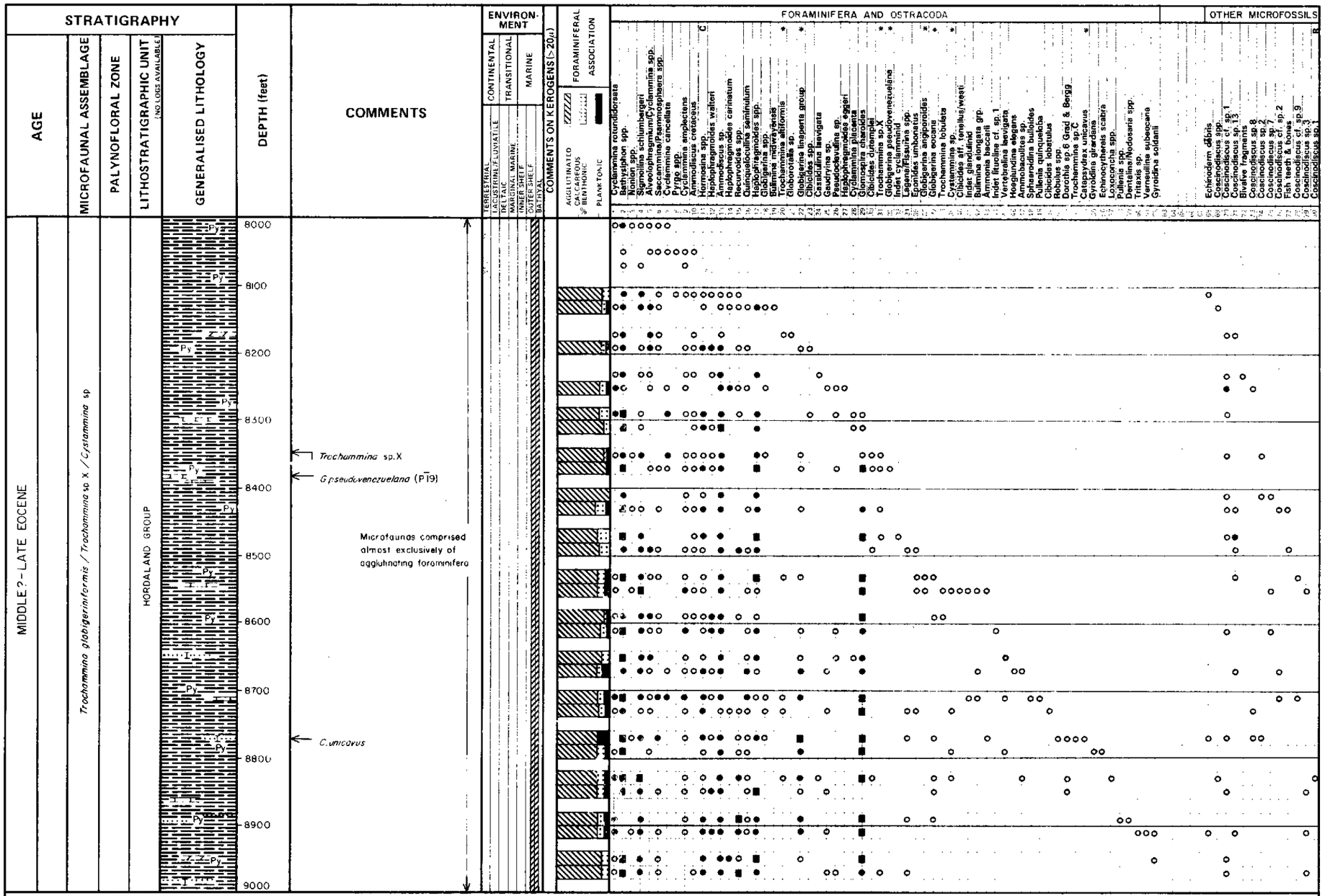
WELL:– 7/11-7
CHART:– 4 of 13
FIGURE:– 6

CLIENT:– PHILLIPS NORWAY
DEPTH:– 7000'-8000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– MAC, AMM, JS
DRAWING NO.:– 0309/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



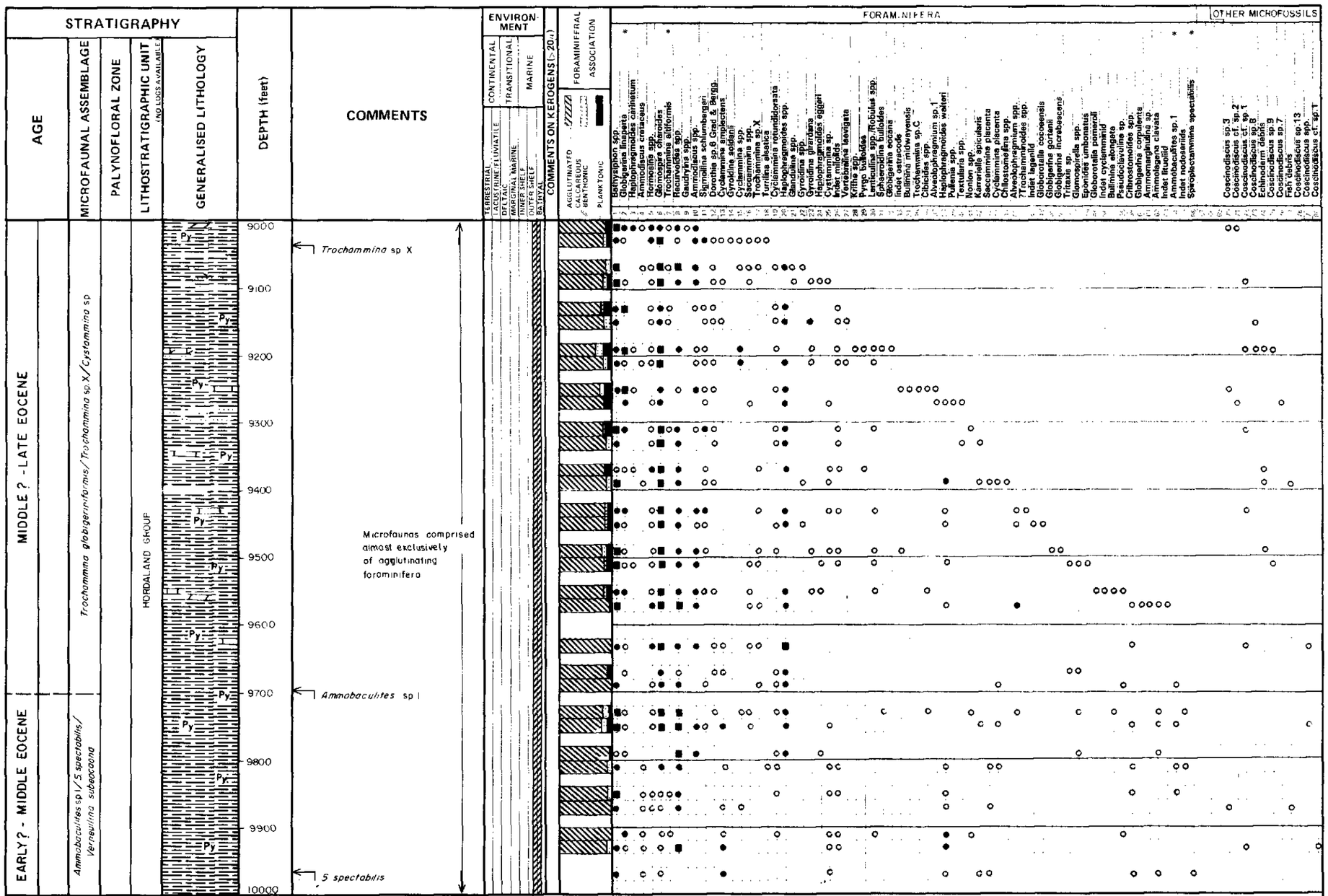
WELL:– 7/11–7
CHART:– 5 of 13
FIGURE:– 7

CLIENT:– PHILLIPS NORWAY
DEPTH:– 8000' – 9000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– MAC, AMM, JS
DRAWING NO.:– 0309/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



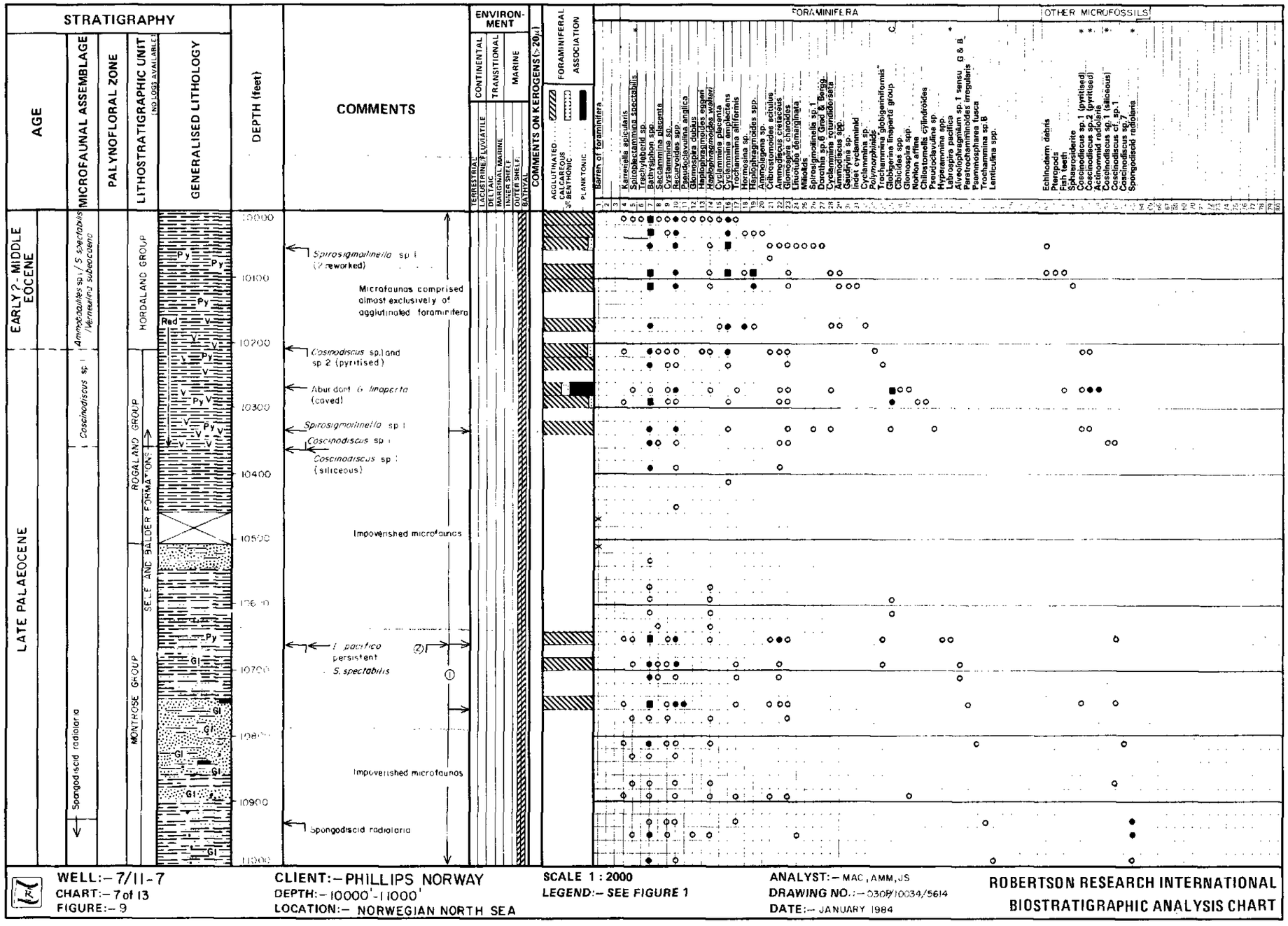
WELL:– 7/11-7
CHART:– 6 of 13
FIGURE:– 8

CLIENT:–PHILLIPS NORWAY
DEPTH:– 9000'-10000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– MAC, AMM, JS
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



WELL:– 7/11-7
CHART:– 7 of 13
FIGURE:– 9

CLIENT:– PHILLIPS NORWAY
DEPTH:– 10000'-11000'
LOCATION:– NORWEGIAN NORTH SEA

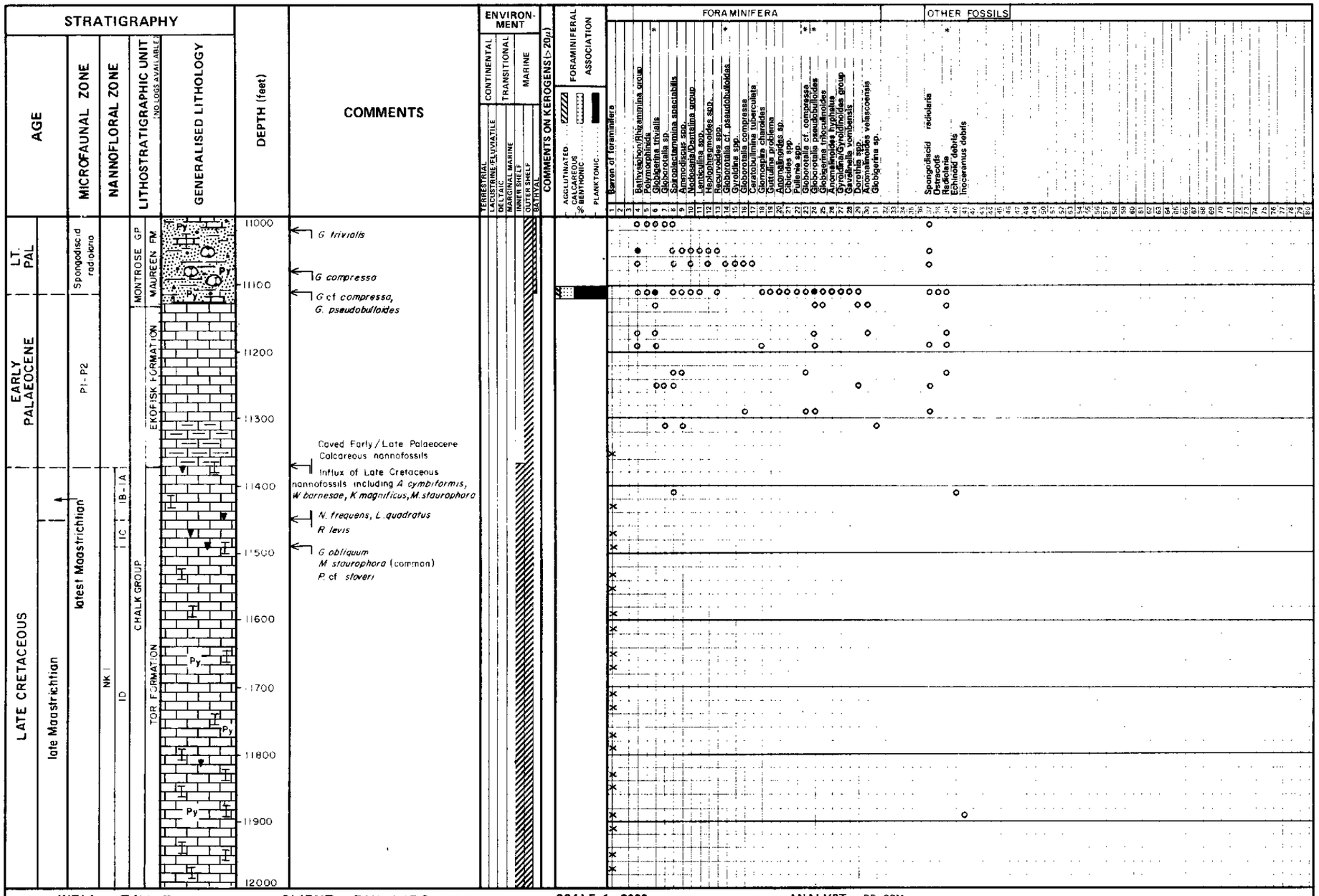
SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– MAC, AMM, JS
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① Microfaunas comprised exclusively of agglutinated foraminifera

② Microfossils white stained


STRATIGRAPHY
AGE
MICROFAUNAL ZONE
NANNOFLORAL ZONE
LITHOSTRATIGRAPHIC UNIT (NO LOGS AVAILABLE)
GENERALISED LITHOLOGY
DEPTH (feet)
COMMENTS
ENVIRON-MENT
CONTINENTAL
TRANSITIONAL
MARINE
FORAMINIFERAL ASSOCIATION
FORAMINIFERA
OTHER FOSSILS
EARLY PALAEOCENE
LT. PAL
P1-P2
Spongodiscid radiolaria
MONTROSE GP
MAUREEN FM
EKOFISK FORMATION
LATE CRETACEOUS
late Maastrichtian
latest Maastrichtian
NK I
ID
IC
IB-IA
CHALK GROUP
TOR FORMATION
Py
11000
11100
11200
11300
11400
11500
11600
11700
11800
11900
12000
G. triviolis
G compresso
G cf compressa, G. pseudobulloides
Caved Early/Late Palaeocene Calcareous nannofossils
Influx of Late Cretaceous nannofossils including A cymbiformis, W barnesae, K magnificus, M staurophora
N. frequens, L. quadratus
R levis
G obliquum
M staurophora (common)
P cf stoveri
COMMENTS ON KEROGENS (>20µ)
TERRESTRIAL
LACUSTRINE/FLUVIATILE
DELTAIC
MARGINAL MARINE
INNER SHELF
OUTER SHELF
BATHYAL
AGGLUTINATED
CALCAREOUS & BENTHONIC
PLANKTONIC
Barren of foraminifera
Bathysiphon/Rhizammina group
Psammosphaera
Globigerina trivialis
Globorotalia sp.
Spiroplectammina spectabilis
Ammodiscus spp.
Nodosaria/Dentalina group
Lenticulina spp.
Haplophragmoides spp.
Reophax spp.
Globorotalia cf. pseudobulloides
Gyroidina spp.
Globorotalia compressa
Ceratobulimina tuberculata
Glomospira charoides
Spiroplectammina spectabilis
Cibicidoides spp.
Cibicidoides sp.
Pullenia spp.
Globorotalia cf. compressa
Globorotalia pseudobulloides
Globigerina triloculinoides
Anomalinoides? hyphalus
Gyroidinoides/Gyroidinoides group
Gyroidinoides nitidus
Dorothia spp.
Anomalinoides velascoensis
Globigerina sp.
Spongodiscid radiolaria
Ostracods
Radiolaria
Echinoid debris
Inoceramus debris
WELL:- 7/11-7
CHART:-8a of 13
FIGURE:- 10
CLIENT:- PHILLIPS NORWAY
DEPTH:- 11000'-12000'
LOCATION:- NORWEGIAN NORTH SEA
SCALE 1 : 2000
LEGEND:- SEE FIGURE 1
ANALYST:- PF, CPM
DRAWING NO.:- 030P/10034/5614
DATE:- JANUARY 1984
ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

DEPTH (feet) (NO LOGS AVAILABLE)

NANNOFLORAL ZONE

COMMENTS

COMMENTS ON KEROGENS(>20µ)

CALCAREOUS NANNOFOSSILS

1	Neochiastozygus perfectus	C	
2	Ericsonia sp.	C	
3	Thoracosphaera operculata	C	
4	Prinsius sp.	C	
5	Thoracosphaera sp.	C	
6	Prinsius dimorphosus	C	
7	Chiasmolithus bidens	C	
8	Markalius inversus		
9	Markalius Biscutum sp.		
10	Prinsius rosenkrantzii	C	
11	Cruciplacolithus tenuis	C	
12	Neocrepidolithus dirimosus	C	
13	Neocrepidolithus cruciatus	C	*
14	Arkhangelskiella cymbiformis		
15	Watznaueria barnesae	C	
16	Chiasmolithus danicus		
17	Placozygus sigmoides		
18	Micula staurophora		
19	Kamptnerius magnificus		
20	Cribrosphaera ehrenbergii		
21	Lucinorhabdus cayeuxii		
22	Zygodiscus sp.		
23	Heliolithus riveae		
24	Prediscosphaera cretacea		
25	Eiffellithus turriseiffelii		
26	Cretarhabdus conicus		
27	Biscutum sp.		
28	Prediscosphaera cf. stoveri		
29	Prediscosphaera horridi		*
30	Ahmuellerella regularis		*
31	Crantarhabdus ?coronatus		
32	Lithraphidites quadratus		*
33	Nephrolithus frequens		*
34	Reticulofenestra cf. spinosa		
35	Reinhardtites levis		*
36	Prediscosphaera cf. spinosa		
37	Gartnerago obliquum		*
38	Helicolithus trabeculatus (small)		
39	Neocrepidolithus sp.		
40	Micula concava		
41	Helicolithus cf. trabeculatus		
42	?Chiasphaera danica		
43	Discorhabdus ignotus		
44	Dodekapodorhabdus cf. noeli		
45	Ahmuellerella octoradiata		
46	Monomarginatus quaternarius		
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11100
11200
11300
11400
11500
11600
11700
11800
11900
12000

NK1
IE? – 1D
1C
1B – 1A

Caved Early/Late Palaeocene Calcareous nannofossils

Influx of Late Cretaceous nannofossils including *A cymbiformis*, *W barnesae*, *K magnificus*, *M staurophora*

N frequens, *L quadratus*

R levis

G obliquum
M staurophora (common)
P cf. stoveri

H trabeculatus (Small)

D cf noeli

M quaternarius

WELL:– 7/11–7
CHART:– 8b of 13
FIGURE:– 11

CLIENT:– PHILLIPS NORWAY
DEPTH:– 11000' – 12000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– CPM
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: LATE CRETACEOUS; late Maastrichtian; ey. Maas.; late Campanian-early Maastrichtian

MICROFAUNAL ASSEMBLAGE

NANNOFLORAL ZONE: NK; IO; IE - IF; IG

LITHOSTRATIGRAPHIC UNIT (NO LOGS AVAILABLE): CHALK GROUP; TOR FORMATION; HOD FORMATION

GENERALISED LITHOLOGY

DEPTH (feet): 12000; 12100; 12200; 12300; 12400; 2500; 12600; 12700; 12800; 12900; 13000

COMMENTS

- P. obscurus
- P. stoveri
- ? Globotruncana sp.
- Rugoglobigerina / Archaeoglobigerina complex
- Zygodiscus sp A
- R. biperforatus
- Pink staining
- B. parca
- Tertiary caving
- ?G. marginata
- Red
- Py

ENVIRONMENT: TERRESTRIAL; LACUSTRINE/FLUVIATILE; DELTAIC; MARGINAL MARINE; INNER SHELF; OUTER SHELF; BATHYAL; CONTINENTAL; TRANSITIONAL; MARINE

COMMENTS ON KEROGENS (>20µ)

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS; % BENTHONIC; PLANKTONIC

FORAMINIFERA

1 Barren of in situ foraminifera
3 Cibicidoides vombensis
4 Anomalinoides spissicostatus C
6 Glenomgura sp. *
7 ?Globotruncana sp.
8 Gyroidinia/Gyroidinoides group *
9 Rugoglob/Archaeoglob complex
10 Osangularia spp.
11 Globogerinelloides asper
12 Globogerinelloides sp.
13 Heterohelix sp.
15 Dorothia sp.
16 Globotruncana ?marginata
17 ?Praeglobotruncana sp.
18
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CALCAREOUS NANNOFOSSILS

22 Arkhangelskiella cymbiformis *
24 Kamptnerius magnificus
25 Biscutum sp.
26 Watznaueria barnesae
27 Prediscosphaera cretacea
28 Prediscosphaera cf. stoveri
29 Eiffellithus turriseiffelii
30 Chiastozygus amphipons
31 Micula staurophora
32 Lithraphidites carniolensis
33 Gartnerago obliquum
34 Reticapsa crenulata
35 Helicolithus anceps
36 Cretarhabdus conicus
37 Ahmuellerella octoradiata
38 Retecapsa ?crenulata
39 Phanulithus obscurus
40 Helicolithus trabeculatus
41 Zygodiscus sp.
42 Nephrolithus frequens
43 Prediscosphaera stoveri
44 Monomarginatus quaternarius
45 Podorhabdus ?hayi sp.
46 Lucianorhabdus cayeuxii
47 Neocrepidolithus sp.
48 Prediscosphaera grandis
50 Discorhabdus sp.
51 Markalius inversus
52 Granturhabdus coradventis
53 Microrhabdulus decoratus
54 Chiastozygus cuniculus C
56 Octolithus multiplus C
57 Biscutum sp.2
58 Eiffellithus eximius R
59 Prediscosphaera spinosa
60 Discolithina sp.
61 Discorhabdus sp.
62 Markalius/Biscutum sp. *
63 Tranolithus sp. *
64 Reinhardtites sp.
65 Broinsonia parca *
66 Eiffellithus cf. turriseiffelii
67 Helicolithus aff. trabeculatus
68 Reinhardtites sp.
69 Reinhardtites anthophorus
70 *
71
72
73
74
75
76 Inoceramus debris
77 Radiolaria
78
79
80

OTHER FOSSILS

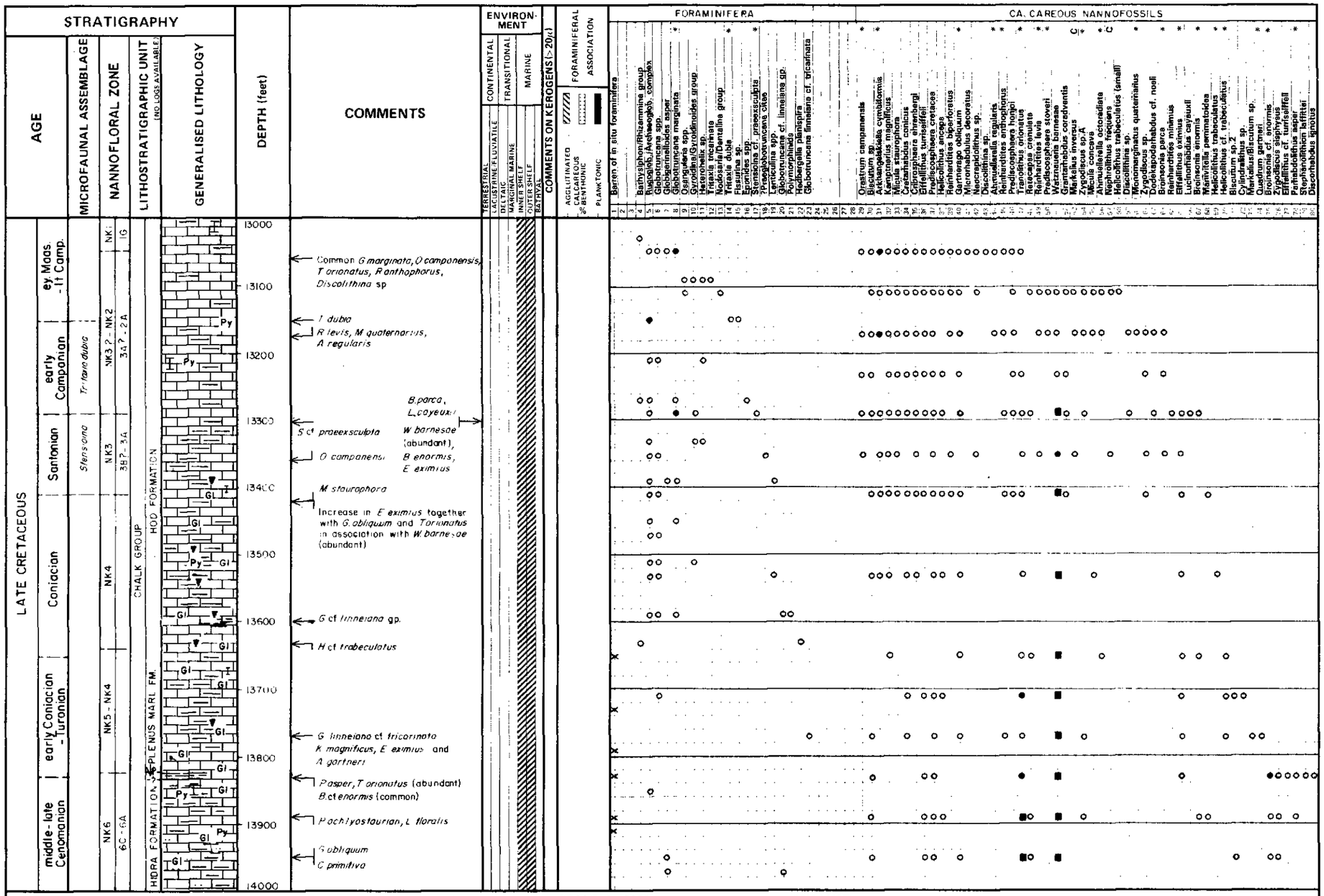
WELL:– 7/11-7
CHART:– 9 of 13
FIGURE:– 12

CLIENT:– PHILLIPS NORWAY
DEPTH:– 12000' - 13000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– PF, JS, CPM
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



WELL:– 7/11-7
CHART:– 10a of 13
FIGURE:– 13

CLIENT:– PHILLIPS NORWAY
DEPTH:– 13000'-14000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– PF, CPM, JS
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

DEPTH (feet)
(NO LOGS AVAILABLE)

NANNOFLORAL ZONE

COMMENTS

CALCAREOUS NANNOFOSSILS

OTHER FOSSILS

COMMENTS ON KEROGENS (> 20μ)

1 Lithastrinus floralis
2 Parhabdolithus achlyostaurion
3 Retecapsa angustiforata
4 Cribrosphaera primitiva
5 Biscutum ellipticum
6
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9 Radiolaria
10 Ostracods
11 Actinommid radiolaria
12 Inoceramus debris
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DEPTH (feet)	NANNOFLORAL ZONE			
13000	NK3	NK1	3A? – 2A	1G
13100		NK3? – NK2		
13200				
13300				
13400			3B? – 3A	
13500		NK4		
13600				
13700		NK5 – NK4		
13800				
13900	NK6		6A – 6C	← P. achlyostaurion, L. floralis
14000				← C. primitiva

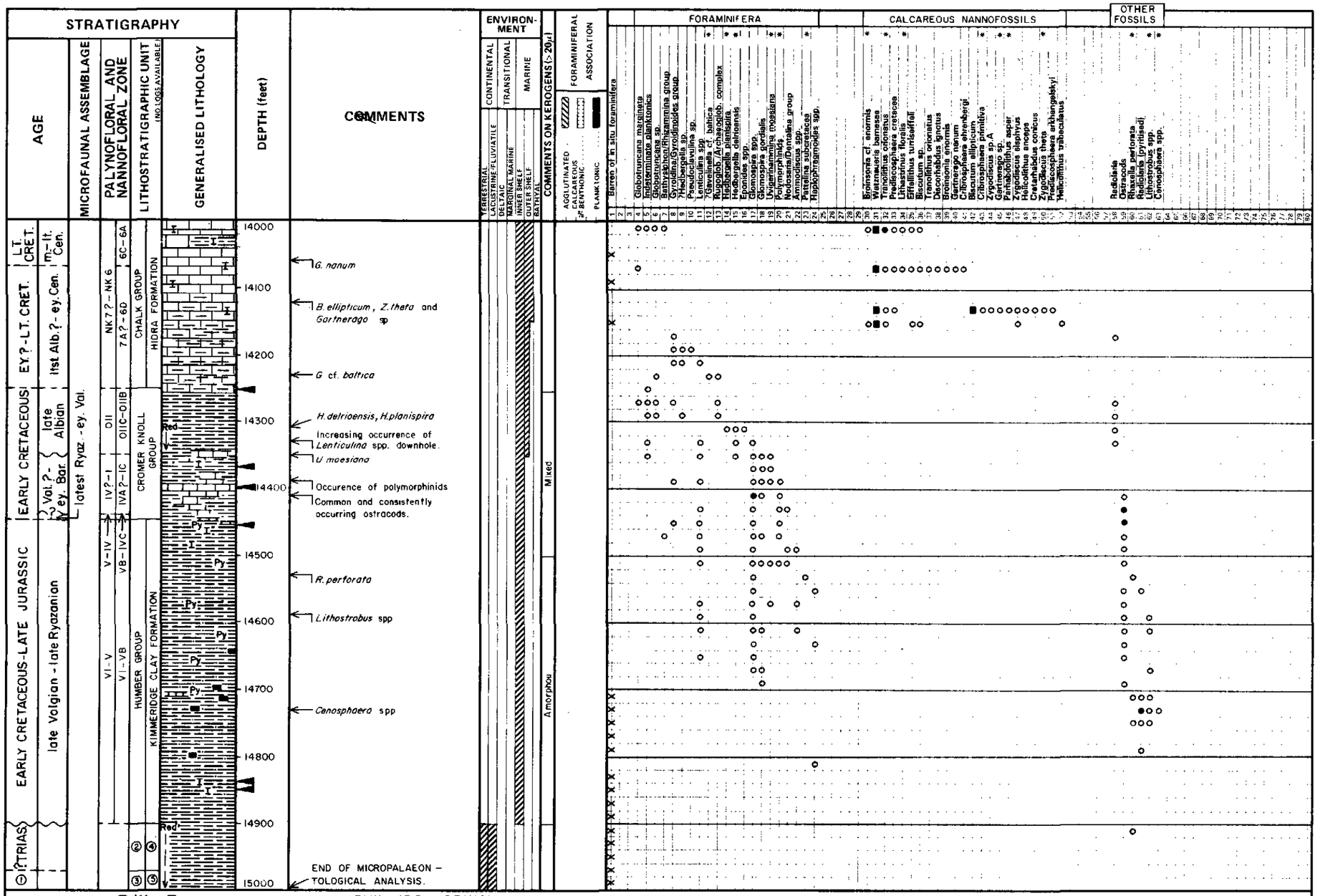
WELL:– 7/11-7
CHART:– 10b of 13
FIGURE:– 14

CLIENT:– PHILLIPS NORWAY
DEPTH:– 13000'-14000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– CPM, PF
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



WELL:- 7/11-7
CHART:- IIa of 13
FIGURE:- 15

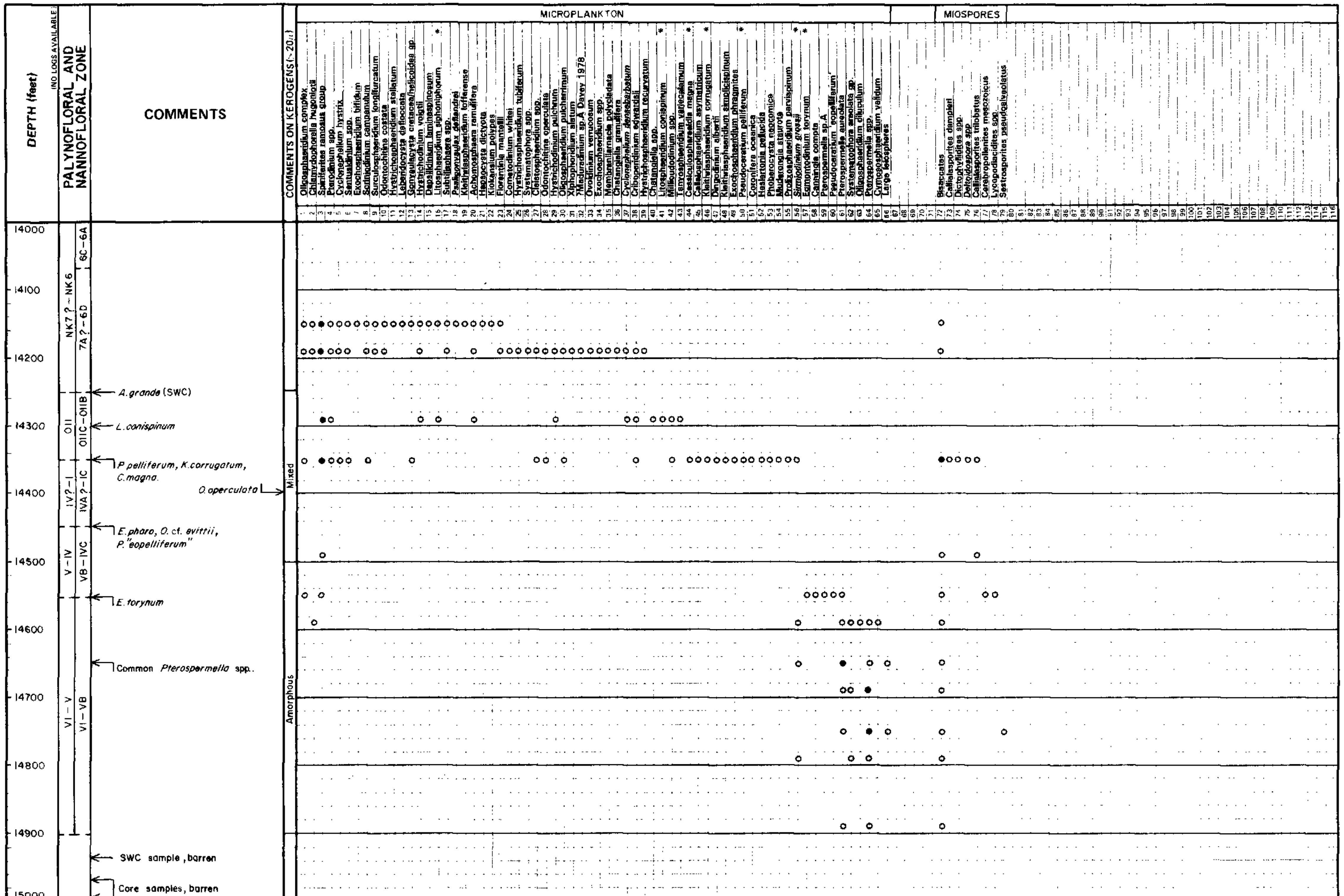
CLIENT:- PHILLIPS NORWAY
DEPTH:- 14000' - 15000'
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:- PF, CPM.
DRAWING NO.:- 030P/10034/5614
DATE:- JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① TRIASSIC
② ? "TRIASSIC GROUP"
③ " TRIASSIC GROUP"
④ ? SMITH BANK FORMATION
⑤ SMITH BANK FORMATION



WELL:– 7/11–7
CHART:– IIb of 13
FIGURE:– 16

CLIENT:– PHILLIPS NORWAY
DEPTH:– 14000' – 15000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– NHM
DRAWING NO.:– 030P/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE

MICROFAUNAL ASSEMBLAGE

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (NO LOGS AVAILABLE)

GENERALISED LITHOLOGY

DEPTH (feet)

COMMENTS

ENVIRON-MENT

CONTINENTAL

TRANSITIONAL

MARINE

TERRESTRIAL

LACUSTRINE/FLUVIATILE

DELTAIC

MARGINAL MARINE

INNER SHELF

OUTER SHELF

BATHYAL

COMMENTS ON KEROGENS (>20µ)

FORAMINIFERAL ASSOCIATION

AGGLUTINATED

CALCAREOUS

% BENTHONIC

PLANKTONIC

MIOSPORES

Barren of in situ palynomorphs

Bisaccates

Chasmatosporites sp.

cf. *Alisporites* sp.

Striatoabieites sp.

? *Triadispora* sp.

Not Representative

TRIASSIC

PERMIAN

"TRIASSIC" GROUP

SMITH BANK FORMATION

ZECHSTEIN GROUP

Rad

15000

15100

15200

15300

15400

15500

15600

15700

15800

15900

16000

← Bisaccates

← *Chasmatosporites* sp.
cf. *Plicatipollenites* sp.
? *Triadispora* sp.

← Bisaccates

WELL:– 7/11-7
CHART:– 12 of 13
FIGURE:– 17

CLIENT:–PHILLIPS NORWAY
DEPTH:– 15000'-16000'
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– JS, NHM
DRAWING NO.:– 030P/0034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: PERMIAN

MICROFAUNAL ASSEMBLAGE

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (NO LOGS AVAILABLE)

GENERALISED LITHOLOGY: ZECHSTEIN GROUP

DEPTH (feet): 16000 · 16100 · 16160 TD

COMMENTS:
- ← *Protohaploxypinus* sp
- ← *L. virkkiae*
- ← *P. granulosus* *V. hiltonensis*

ENVIRON-MENT: CONTINENTAL (TERRESTRIAL, LACUSTRINE/FLUVIATILE, DELTAIL); TRANSITIONAL (MARGINAL MARINE); MARINE (INNER SHELF, OUTER SHELF, BATHYAL)

COMMENTS ON KEROGENS (>20µ): Not representative

FORAMINIFERAL ASSOCIATION: AGGLUTINATED, CALCAREOUS BENTHONIC, PLANKTONIC

MIOSPORES

1 Bisaccates
2 *Picea* (*Abiespollenites*)
3 *Striatiti* (*Striatopodocarpites*)
4 *Lueckisporites virkkiae*
5 *Ellipsovelatisporites rugulatus*
6 *Vittatina hiltonensis*
7 *Limitisporites* spp.
8 *Lunatisporites labdacus*
9 *Lunatisporites* spp.
10 *Klausipollenites schaubergeri*
11 *Pelasecus granulosus*

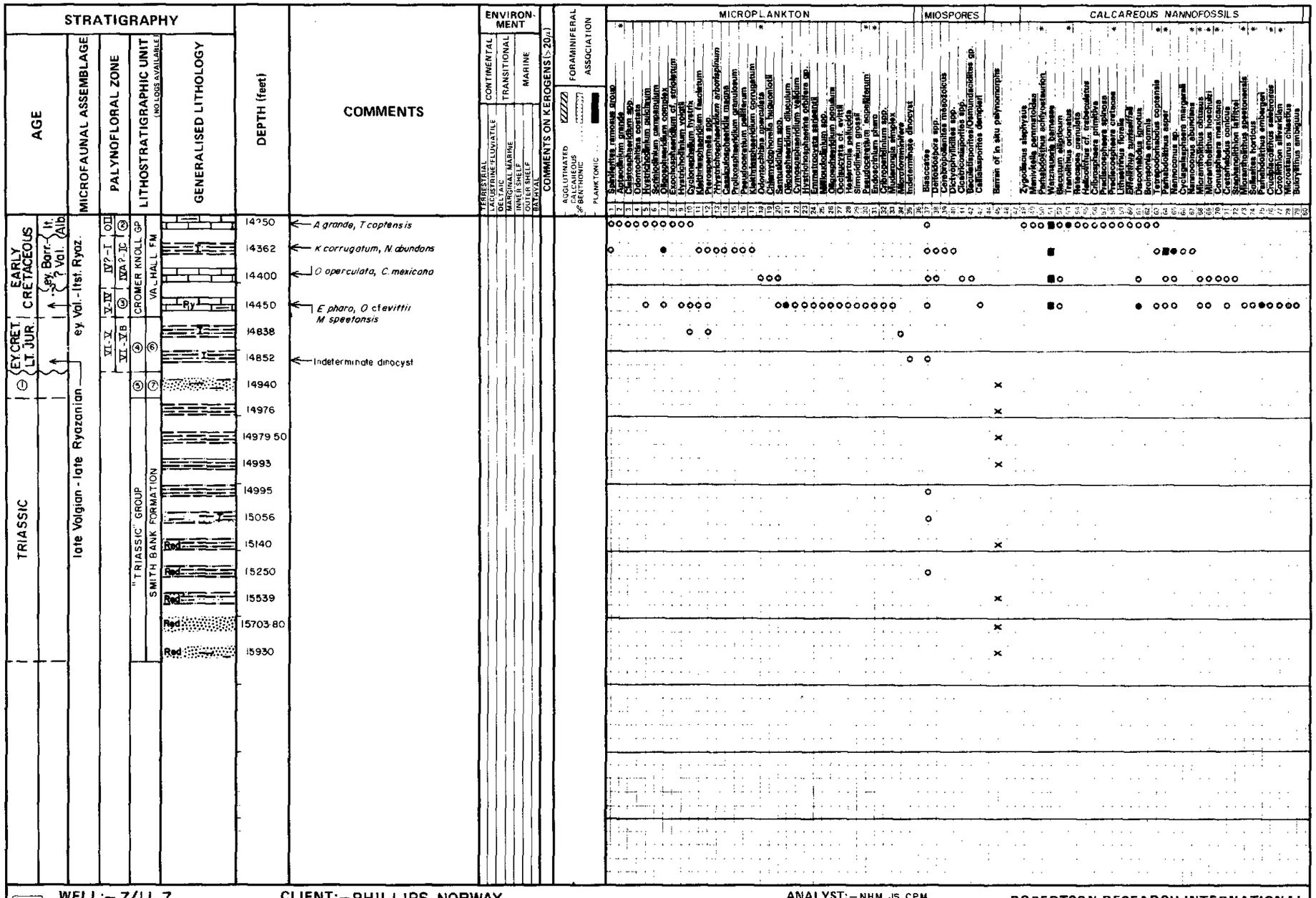
WELL:– 7/11-7
CHART:– 13 of 13
FIGURE:– 18

CLIENT:– PHILLIPS NORWAY
DEPTH:– 16000' - 16160' T.D
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– JS, NHM
DRAWING NO.:– 0308/10034/5614
DATE:– JANUARY 1984

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



① ? TRIASSIC
② OIIB - OIIC
③ IVC - VB
④ HUMBER GROUP
⑤ KIMMERIDGE CLAY FORMATION
⑥ ? "TRIASSIC" GROUP
⑦ ? SMITH BANK FORMATION

ENCLOSURE 1

ROBERTSON RESEARCH INTERNATIONAL

SUMMARY LOG
PHILLIPS 7/11 - 7

SCALE 1: 500

GEOLOGY FILE

AREA: NORWEGIAN NORTH SEA

SPUD DATE: 29th December 1982

COMPANY: PHILLIPS PETROLEUM

COMPLETION DATE:

INTERVAL STUDIED: 4570' - 16160'

T.D.: 16160'

Drawing No 030P/10034/5614

ANALYST MAC, PF, AMM, NHM, CPM, JS.

Date JANUARY 1984

Cored Interval

Casing Shoe

Sidewall Core

Sidewall Core (no recovery)

Sidewall Core analysed for biostratigraphy *

AGE	STRATIGRAPHIC INTERVAL TOPS LITHOSTRATIGRAPHIC (FEET)	LITHOSTRATIGRAPHIC UNITS (NO LOGS AVAILABLE)	LITHOLOGICAL COMMENTS	LITHOLOGY	DEPTHS, CASING AND CORING DETAILS (FEET)	MICROPALAEONTOLOGICAL COMMENTS	MICROFAUNAL ASSEMBLAGE/ZONE	DINOCYST ZONE	NANNOFLORAL AND PALYNOLOGICAL COMMENTS	ENVIRONMENT OF DEPOSITION
MIDDLE MIOCENE	4720		CLAY: soft, locally indurated and firm, blocky, medium grey to light olive grey, faintly micaceous, non-calcareous; in association with SAND: disaggregated, well sorted, very fine to fine, angular to subangular, clear to white grains. Traces of pyrite occur commonly, occasionally in rod-like form.	cmf cmf cmf Py Py Py	4570 4600 4650 4700 4750 4800 4850	*Hoeglundina elegans*; *Globorotalia continuosa* (N16), *Bathysiphon* spp.; *Glomospira charoides*; Mixed foraminiferal associations dominated by calcareous benthonics.; *Globigerina angustiumbilicata*, *Globigerina concinna* (N8); Influx of planktonic foraminifera.; *Globigerinoides triloba* (N7); *Pseudercella* spp.	*Glomospira charoides*/ *Bathysiphon* spp./ *Pseudoclavulina* spp.; *Globigerina angustiumbilicata* spp./ *Globorotalia scitula*			TERRESTRIAL; LACUSTRINE/FLUVIATILE; DELTAIC; MARGINAL MARINE; INNER SHELF; OUTER SHELF; BATHYAL

MIOCENE

EARLY MIOCENE

NORDLAND GROUP

CLAY: as described above is locally shaly and is predominantly medium grey to olive grey in colour.

Rare echinoid spines.

DOLOMITE: firm to moderately hard, medium light grey, microcrystalline, sucrosic in part; occurs as a common accessory in the lower part of the interval.

OLIGOCENE? - MIOCENE

EARLIEST MIOCENE - ?LATE OLIGOCENE

5380

5500

5530

SHALE: soft to firm, subfissile to weakly fissile, predominantly medium grey to olive grey, faintly micromicaceous, non-calcareous.
Pyrite in fine crystalline

4900

4950

5000

5050

5100

5150

5200

5250

5300

5350

5400

5450

5500

5550

Common *Pseudoclavulina* sp.

Microfaunas dominated by agglutinated foraminifera.

Sphaeroidinellopsis seminulum

Globigerina apertura, *Orbulina universa*

Globigerina ciperoensis

Globigerina angustiumbilicata

Globorotalia siakensis (N14)

Globorotalia zealandica, *Globigerina woodi* (mid N6)

Praeorbulina glomerosa, *Bolboforma spinosa*

Bolboforma armata

Microfaunal associations contain abundant planktonic foraminifera

Common *Bolboforma armata*

Globorotalia opima nana (N22)

Sigmoilina schlumbergeri

Asterigerina steeschi : *Sphaeroidinellopsis seminulum*

Globigerina woodi

OLIGOCENE

LATE OLIGOCENE

HORDALAND GROUP

form occurs sporadically.

LIMESTONE and DOLOMITE: firm to moderately hard, pale yellowish brown to brownish gray, microcrystalline; occurs probably in the form of thin stringers or nodules within the shale.

Dark green glauconite occurs rarely.

SAND; disaggregated, well sorted, very fine to fine, angular to subangular grains; occur in trace quantities.

5600

5650

5700

5750

5800

5850

5900

5950

6000

6050

6100

6150

6200

6160

Lithelid sp.A

Microfaunas dominated by agglutinated foraminifera

Globigerina officinalis, *Globigerina galevisi* (P21), *Asterigerina staeschi* (caved)

?*Globigerina angiporoides*

Globigerina ampliapertura (P20)

Asterigerina guerichi

Mixed foraminiferal associations showing gradual increase in agglutinated foraminifera

Sigmoilina schlumbergeri

Globigerina angulisuturalis

Globigerina angiporoides (mid P19)

Dorothia sp.6, *Eponides umbonatus*

OLIGOCENE

HORDALAND GROUP

EARLY OLIGOCENE

OLIGOCENE

CLAYSTONE: soft to firm, blocky to subfissile, medium grey to medium dark grey, faintly micromicaceous, slightly silty in part, non-calcareous; forms the predominant lithology.

Pyrite persists in trace quantities throughout the interval.

Py

6250

Cyclammina placenta

6300

6350

Globigerina gortanii

6400

6450

Reworked Late Palaeocene microfossils

6500

6550

Reworked Early Palaeocene planktonic foraminifera

Globigerina corpulenta?

6600

Sigmoilina schlumbergeri

Reworked Early Palaeocene planktonic foraminifera

6650

6700

Microfaunas dominated by agglutinated foraminifera.

6750

Karreriella apicularis

6800

EOCENE

MIDDLE? - LATE EOCENE

7030

HORDALAND GROUP

HORDALAND GROUP

Carbonaceous material, brittle, black, vitreous; occurs very rarely.

Trace quantities of bioclastic debris, including bivalves and echinoid fragments occur intermittently.

CLAYSTONE: medium grey to medium dark grey in colour, persists as the predominant lithology.

6850

6900

6950

7000

7050

7100

7150

7200

7250

7300

7350

7400

7450

7500

Reworked Late Palaeocene microfossils

Globigerina linaperta group (PFG)

Coscinodiscus sp.5

Microfaunas composed almost exclusively of agglutinated foraminifera

Trochammina globigeriniformis

Cystammina sp.

Coscinodiscus sp.4

Reworked Late Palaeocene microfossils

Trochammina globigeriniformis/Trochammina sp.X/ *Cystammina* sp.

Trochammina altiformis

EOCENE

MIDDLE? - LATE EOCENE

HORDALAND GROUP

Thin stringers and lenses of carbonate persist and rarely include: sideritic dolomite, hard, dusky yellowish brown, microcrystalline.

7550
7600
7650
7700
7750
7800
7850
7900
7950
8000
8050
8100
8150

Cyclammina amplectens Selectively green stained microfaunas

Common *Cyclammina amplectens*

EOCENE

EOCENE

MIDDLE? - LATE EOCENE

HORDALAND GROUP

CLAYSTONE: soft to firm, subfissile, medium grey to medium light grey and locally greenish grey, faintly micromicaceous non-calcareous.
Thin stringers and nodules of limestone and dolomite persist and pyrite continues to occur as a minor accessory.

SANDSTONE: soft, white, very fine grained, moderately calcareous; occurs sporadically as traces. Traces of green glauconite occur rarely.

8200
8250
8300
8350
8400
8450
8500
8550
8600
8650
8700
8750
8800

Trochammina sp.X

Globigerina pseudovenezuelana (P19)

Microfaunas composed almost exclusively of agglutinated foraminifera.

Catapsydrax unicavus

Trochammina globigeriniformis / Trochammina sp.X / Cystammina sp.

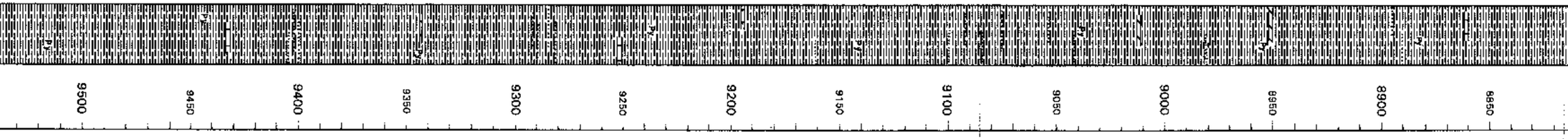
EOCENE

MIDDLE? - LATE EOCENE

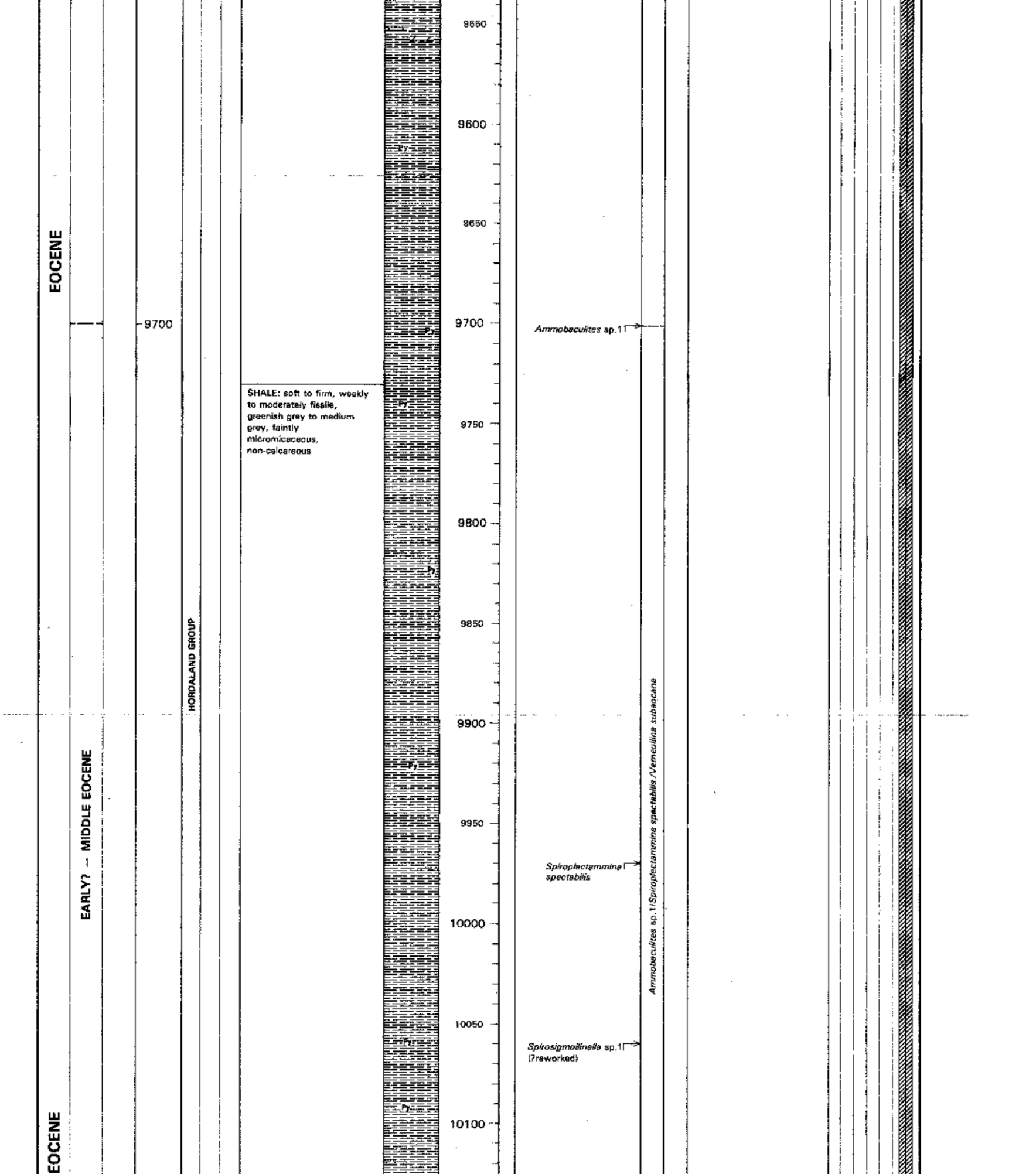
MIDDLE? - LATE EOCENE

HORDALAND GROUP

HORDALAND GROUP



Trochammina globigeriniformis/Trochammina sp.X/ *Cystammina* sp.


EOCENE
EARLY? – MIDDLE EOCENE
EOCENE
9700
HORDALAND GROUP
SHALE: soft to firm, weakly to moderately fissile, greenish grey to medium grey, faintly micromiceaceous, non-calcareous
9550
9600
9650
9700
9750
9800
9850
9900
9950
10000
10050
10100
Ammobaculites sp.1
Spiroplectammina spectabilis
Spirosigmoilinella sp.1 (?reworked)
Ammobaculites sp.1/Spiroplectammina spectabilis/Verneuilina subaocana

LATE PALAEOCENE

ROGALAND GROUP

SELE AND BALDER FORMATIONS

LISTA FORMATION

10210

10360

10510

SHALE: locally greyish red in colour in the lower part of the interval.
Pyrite occurs in the form of coarse, euhedral crystals.
Rare ?Tuffaceous shales, medium grey in colour occur below 10160'

TUFFACEOUS CLAYSTONE: firm, locally soft and brittle, blocky, medium grey to medium dark grey, with fine, light grey tuffaceous lenses and laminae, non calcareous.

SHALE: soft to firm, fissile, medium grey to medium dark grey, faintly micromicaceous, non-calcareous.

Rare stringers of fine white sandstone near the base of the interval

SANDSTONE: represented in ditch cuttings samples mainly by disaggregated grains which are moderately sorted, very fine to medium, angular to subangular.
SHALE: similar to that described in the overlying interval, but predominantly medium grey in colour, is also common throughout the interval.

red

Py

V

10150

10200

10250

10300

10350

10400

10450

10500

10550

10600

10650

10700

Coscinodiscus sp.1
Coscinodiscus sp.2
(pyritised)

Globigerina linaperta
(caved)

Spirosigmoilinella sp.1

Coscinodiscus sp.1

Coscinodiscus sp.1
(siliceous)

Impoverished microfaunas

Labrospira pacifica

Microfossils white stained

Persistent *Spiroplectammina spectabilis*

Microfaunas composed exclusively of agglutinated foraminifera

Coscinodiscus sp.1

PALAEOCENE

EARLY PALAEOCENE

MONTROSE GROUP

CHALK GROUP

MAUREEN FORMATION

EKOFISK FORMATION

11000

11110

11130

Carbonaceous material brittle, black, sub-vitreous; as traces throughout the interval.
Fine, reniform glauconite is a common accessory

SANDSTONE: contains rare medium to coarse subrounded grains in the lower part of the interval

SANDSTONE: soft and friable, commonly represented in ditch cuttings samples by disaggregated, very fine to fine subangular grains with scattered medium to coarse subrounded to subangular grains, occasionally with a soft, white, calcareous cement.
CHALKY LIMESTONE: firm to hard, platy, white to very light grey, microcrystalline, slightly chalky texture; occurs in subordinate quantities throughout the interval and represents reworking of the underlying Chalk Group lithologies.
SHALE: similar to that described in the overlying interval persists

CHALKY LIMESTONE: firm to moderately hard, blocky, white, microcrystalline, chalky texture

ARGILLACEOUS LIMESTONE: firm, blocky, light grey, microcrystalline, weakly to moderately argillaceous, occurs in trace quantities; becoming common towards the base of the interval

10750

10800

10850

10900

10950

11000

11050

11100

11150

11200

11250

11300

Impoverished microfauna

Spongodiscid radiolaria

Globigerina trivialis

Globorotalia compressa

Globorotalia cf. *compressa*, *G. pseudobulloides*

Spongodiscid radiolaria

Zones P1 - P2

CRETACEOUS	LATE CRETACEOUS	LATEST MAASTRICHTIAN	CHALK GROUP	TOR FORMATION	CHALKY LIMESTONE: moderately hard to hard, platy, white to very light grey, microcrystalline, texture slightly chalky in part; dominates the entire interval. Chert: hard, brownish grey to translucent, occurs as a minor accessory, especially in the upper part of the interval	11370 11400 11450 11500	NANNOFLORAL ZONES *Nephrolithus frequens* Subzone 1B - Subzone 1A *Reinhardtites levis* Subzone 1C	Caved? Early/Late Palaeocene calcareous nannofossils including *Prinsius dimorphosus*, *Cruciplacolithus tenuis*, *Thoracosphaera operculata* (common), *Neochiastozygus perfectus*, *Chiasmolithus bidens* and *Prinsius rosenkrantzii* *Arkhangelskiella cymbiformis*, *Watznaueria barnesae* *Kamptnerius magnificus*, *Micula staurophora* Marked increase in numbers of Late Cretaceous calcareous nannofossils recorded at this horizon including abundant *Arkhangelskiella cymbiformis* together with *Lucinorhabdus cayeuxii*, *Cribrosphaera ehrenbergi* and *Prediscosphaera cretacea* *Neprolithus frequens*, *Lithraphidites quadratus* *Reinhardtites levis*, *Prediscosphaera honjoi*
					CHALKY LIMESTONE: as described above is occasionally stylolitic	11550 11600		*Gartnerago obliquum*, *Micula staurophora*, (common) *Prediscosphaera* cf. *stoveri*, *Prediscosphaera arkhangelskyi* *Kamptnerius magnificus* (common)
					Pyrite occurs sporadically in finely disseminated form within the limestones	11650 11700		
					CHALKY LIMESTONE: as described above but occasionally very light grey or very pale orange in colour and more commonly slightly chalky in texture.	11750 11800 11850 11900 11950 12000		*Helicolithus trabeculatus* (small), *Helicolithus* aff. *trabeculatus* *Dodekapodorhabdus* cf. *noeli* *Monomerginatus quaternarius*

CRETACEOUS

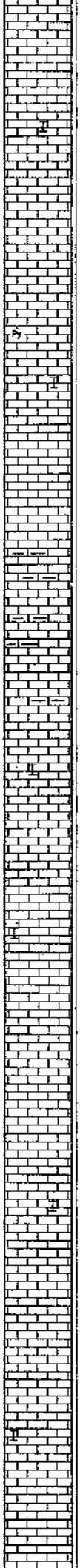
LATE CRETACEOUS

LATE MAASTRICHTIAN

CHALK GROUP

TOR FORMATION

SHALE: soft to firm, fissile, dark grey, faintly micromicaceous, non-calcareous; forms fine 'partings' within the limestone.



12050

12100

12150

12200

12250

12300

12350

12400

12450

12500

12550

12600

12650

Samples are either barren or poorly fossiliferous throughout this interval

?Globotruncana sp.

Arkhangelskiella cymbiformis Zone NK1

Gartnerago obliquum Subzone ID

Phanulithus obscurus

Prediscosphaera stoveri

Prediscosphaera grandis

Poorly preserved but relatively rich nannofloral assemblages

Biscutum sp.2

TOR FORMATION

CRETACEOUS

LATE CRETACEOUS

CHALK GROUP

12770

LIMESTONE: firm, platy, pinkish grey to pale red, microcrystalline, slightly argillaceous

12810

EARLY MAASTRICHTIAN

LIMESTONE: moderately hard, brittle, platy, white to very light grey, microcrystalline, texture is very slightly chalky in part

12930

LATE CAMPANIAN - EARLY MAASTRICHTIAN

HOD FORMATION

13150

CRETACEOUS

LATE CRETACEOUS

CHALK GROUP

EARLY CAMPANIAN

13290

SANTONIAN

12700

12750

12800

12850

12900

12950

13000

13050

13100

13150

13200

13250

13300

13350

Rugoglobigerina/ Archaeoglobigerina complex.

Some pink staining of the microfaunas

Tertiary caving

Globotruncana marginata?

Common *Globotruncana marginata*

Tritaxia dubia

Samples are either barren or poorly fossiliferous throughout this interval.

Stensioina cf. *praeexsculpta*

Reinhardtites biperforatus Subzone 1F - *Trenolithus orionatus* Subzone 1E

Reinhardtites biperforatus Subzone 1F

Broinsonia parca Subzone 1G

Zone NK2 - *Orastrum campanensis* Subzone 2A

Zone NK3? - *Orastrum campanensis* Subzone 3A? - *Orastrum campanensis*

Zone NK3 Subzone 3B? - Subzone 3A

Zygodiscus sp.A

Reinhardtites biperforatus

Broinsonia parca

Arkhangelskiella cymbiformis (abundant)

Orastrum campanensis, Discolithus sp., *Trenolithus orionatus, Reinhardtites anthophorus*

Late Cretaceous caving noted over this interval.

Reinhardtites levis, Monomerginatus, quaternarius Ahmuellerella regularis

Broinsonia parca, Orastrum campanensis, Lucinorhabdus cayeuxii

Watznaueria barnesea (abundant), *Broinsonia enormis, Eiffellithus eximius*

CRETACEOUS

LATE CRETACEOUS

CONIACIAN

TURONIAN - EARLY CONIACIAN

MIDDLE - LATE CENOMANIAN

13410

13650

13830

14070

CHALK GROUP

HOD FORMATION

PLENUS MARL FORMATION

HIDRA FORMATION

Glauconite: fine, dark green, occurs commonly in trace quantities within the limestone.

CALCAREOUS SHALE: soft to firm, weakly fissile, dark grey, micromicaceous, very weakly calcareous.

ARGILLACEOUS LIMESTONE: soft to firm, medium light grey to medium grey, microcrystalline, very argillaceous, grading locally to CALCAREOUS SHALE.

LIMESTONE: firm, platy, very light grey, occasionally light grey microcrystalline

The Limestones have a granular texture below 13920' and are locally silty. Glauconite and pyrite persist as traces.

13400

13450

13500

13550

13600

13650

13700

13750

13800

13850

13900

13950

14000

14050

Globotruncana cf. linneiana gp.

Globotruncana linneiana cf. tricarinata

Watznaueria barnesae/Eiffellithus eximius Zone NK4

Helicolithus cf. trabeculatus Zone NK5 - W. barnesae / E. eximius Zone NK4

Parhabdolithus achlyostaurion Zone NK6

Parhabdolithus asper Subzone 6C - Parhabdolithus achlyostaurion Subzone 6A

Micula staurophora

Increase in *Eiffellithus eximius* together with *Gartnerago obliquum* and *Tranolithus orionatus* in association with abundant *Watznaueria barnesae*.

Helicolithus cf. trabeculatus

Kamptnerius magnificus Eiffellithus eximius, Quadrum gartneri

Parhabdolithus asper, Tranolithus orionatus (abundant), Broinsonia cf. enormis, (common)

Parhabdolithus achlyostaurion, Lithastrinus floralis

Gartnerago obliquum

Cribosphaera primitiva

Gartnerago nanum

CRETACEOUS

EARLY? - LATE CRETACEOUS

LATEST ALBIAN? - EARLY CENOMANIAN

CHALK GROUP

ARGILLACEOUS LIMESTONE: soft to firm, medium light grey to light grey, very argillaceous, grading locally to CALCAREOUS SHALE. Sample quality throughout this interval is poor mainly because of the drilling methods employed.

14100

14150

Gartnerago nanum Subzone

Biscutum ellipticum, (abundant), *Zygodiscus theta*, *Gartnerago* sp.

Palaeoperidinium cretaceum, *Litosphaeridium siphoniphorum*

Tetrapodorhabdus coptensis Zone NK7? - *Parhabdolithus achylosteurion* Zone NK6

Poorly preserved nannofloral assemblage recorded at this horizon.

14200

Ovoidinium verrucosum

?*Gavelinella* cf. *beltica*

Tranolithus orionatus, *Eiffellithus turriseiffeli*, *Prediscosphaera cretacea* (SWC)

14250 (SWC)

14250

Apteodinium grande, *Tetrapodorhabdus coptensis* (SWC)

EARLY CRETACEOUS

LATE ALBIAN

CALCAREOUS SHALE: predominantly medium grey, but also commonly greyish red within the interval 14300' - 14340'.

Tetrapodorhabdus coptensis Zone NK7 - *Tetrapodorhabdus coptensis* Subzone 7A

OII

OIIC - OIIB

14300

Litosphaeridium conispinium

Hedbergella delrioensis, *H. planispira*.

Increasing occurrance of *Lenticulina* spp.

Kleithriasphaeridium corrugatum, *Pseudoceratium pelliferum*, *Cassiculosphaeridia magna*, *Sirmiodinium grossii*

LIMESTONE: soft, locally firm, white to light grey, argillaceous in part; common.

14350

14350

Uvigerinammine moeslana

Parhabdolithus asper (abundant), *Nannoconus abundans*, *Nannoconus* sp., (common), (SWC)

Odontochitina operculata (SWC)

EARLY BARREMIAN ?VALANGIAN

LATEST RYAZANIAN - EARLY VALANGINIAN

Incoming of polymorphinids

14400

P. neocomica Zone (IV)? - *S. grossii* Zone (I)

IVA? - IC

Consistently occurring and occasionally common ostracods.

Nannoconus steinmanni, *Micrantholithus obtusus*, *Micrantholithus holschulzi*, (common), *Conusphaera mexicana*, (SWC)

Parhabdolithus embergerii, (common), *Cretarhabdus conicus*, *Calculites obscurus*, *Cretarhabdus crenulatus*, *Eiffellithus eximius*, *Lithraphidites carniolensis*, *Micrantholithus hoblynii*, *Nannoconus bucherensis*, *Nannoconus circellus*, *Nannoconus dolomitensis*, *Nannoconus globulus*, *Nannoconus kamptneri*, *Nannoconus multiplicatus*, *Nannoconus quadratus*, *Nannoconus truncatus*, *Nannoconus wassallensis*, *Nannoconus wimanii*, *Nannoconus* sp. (common), *Parhabdolithus asper*, *Parhabdolithus embergerii*, *Rhagodiscus splendens*, *Rhagodiscus asperus*, *Tranolithus orionatus*, *Zeugrhabdotus embergeri*, *Zeugrhabdotus sigmoides*, *Zeugrhabdotus trivetabulatus*, *Zeugrhabdotus* sp. (SWC)

14450 (SWC)

14454 (log)

14450

Parhabdolithus embergerii, (common), *Carolilithions silvaridion* *Biscutum* sp. (Kothe), *Cruciplacolithus salebrosus*, *Ethmorhabdus* sp., *Bukrylithus ambiguus*, *Micrantholithus speetonensis*, *Endoscrinium phero*, *Occisucysta* cf. *evittii*, *Pseduoceratium* "*eopelliferum*", common *Oligosphaeridium diluculum* (SWC)

End of calcareous nannofossil analysis

CALCAREOUS CLAYSTONE: soft to firm, blocky, greyish black, faintly micromicaceous, very weakly to moderately calcareous.

Zone NK II - Subzone IIB - V - IV - VB - IVC

Micrantholithus speetonensis

14500

Rhaxella perforata

14550

Egmontodinium torynum, rare *Pterospermella* spp.

Lithostrobus sp.

14600

Numerous *Pterospermella* spp.

CLAYSTONE: firm to moderately hard, subfissile, greyish black, slightly silty, non calcareous forms the predominant lithology throughout the remainder of the interval.

Carbonaceous material: soft, brittle, black, fibrous, sub-vitreous to vitreous.

14650

Common *Pterospermella* spp.

JURASSIC - CRETACEOUS

LATE JURASSIC — EARLY CRETACEOUS

LATE VOLGIAN — LATE RYAZANIAN

HUMBER GROUP

KIMMERIDGE CLAY FORMATION

14700

Cenosphaera sp.

"*Imbatodinium*" *villosum* Zone (VI) - *Dingodinium spinosum* Zone (V)

"*Imbatodinium*" *villosum* Zone (VI) - *Dichadogonyaulax* spp. Subzone (VB)

14750

14800

?TRIASSIC

14900

14976 (core)

?" TRIASSIC GROUP"

?SMITH BANK FM.

CLAYSTONE: soft to firm, moderate reddish brown, silty, micaceous, non-calcareous; occurs in trace quantities in ditch cuttings samples.
Kimmeridge Clay lithologies predominate but may be caved.

CLAYSTSONE AND SHALE: soft to firm, subfissile to moderately fissile, greenish grey to medium dark grey, micromicaceous, locally sandy, waxy, non-calcareous; noted in core. Ditch cuttings are dominated by caved Kimmeridge Clay lithologies as previously described.

CLAYSTONE is greyish red in colour at 15140' (core)

SANDSTONE: firm to moderately hard, white to yellowish grey, well-sorted with fine, angular to subangular grains and mica in a thin, non-calcareous cement; occurs as traces.

Samples contaminated by lost circulation material.
DOLOMITE: firm to moderately hard, microcrystalline or sucrosic, medium grey to yellowish grey; occurs as traces in lower part of the interval.
CLAYSTONE: firm, subfissile to blocky, greyish red to dark reddish brown, micaceous, slightly silty, non-calcareous becomes common.

SANDSTONE: firm to friable, white, locally brownish grey, predominantly well-sorted with very fine to fine, angular to subangular grains in a non-calcareous cement.
CLAYSTONE: as described above persists, but mainly as a subordinate lithology.

Cavings continue to dominate the ditch cuttings samples throughout most of the interval.

red

14850

Samples were barren of in situ foraminifera over this interval

14900

14950

15000'
End of micropalaeontological analyses

15000

15050

15100

15150

15200

15250

15300

15350

15400

Numerous microforaminiferal test linings. (SWC)

Rare indeterminate microplankton (SWC)

Numerous *Pterospermella* spp.

Core sample, barren

Core samples, barren

Rare bisaccate pollen (core)

Rare bisaccate pollen (core)

Core sample, barren

Rare bisaccate pollen (SWC)

TRIASSIC

"TRIASSIC GROUP"

SMITH BANK FORMATION

15450

Rare bisaccate pollen

15500

Sidewall core sample, barren

15550

Sand grains are more commonly stained red.

15600

Chasmatosporites sp., cf. *Plicatipollenites* sp. *?Triadispora* sp.

15650

15700

15750

Rare bisaccate pollen

15800

15850

CLAYSTONE; firm, blocky to subfissile, greyish red to dark reddish brown and locally mottled greenish grey, faintly micaceous, silty, waxy, non-calcareous, occurs commonly in the lower part of the interval, although sandstones persist in ditch cuttings and sidewall core samples.

15900

Sidewall core sample, barren

15950

15982 (log)

The upper boundary of this interval has been placed on a wireline log break supplied by the client. Samples consist mainly of caved Jurassic lithologies but with traces of ANHYDRITE: soft, white to very light grey, amorphous

16000

Protohaploxypinus sp.

PERMIAN

LATE PERMIAN

ZECHSTEIN GROUP

16050

HYPERSALINE

16100

Lueckisporites virkkiae

Vittatina hiltonensis, Lunatisporites labdacus, Perisaccus granulosus, numerous *L. virkkiae* and *Protohaploxypinus* spp.

16150

T.D.16160'