ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. 2763P/A

STATOIL 34/10 - 14 NORWEGIAN NORTH SEA WELL: BIOSTRATIGRAPHY OF THE INTERVAL 1500m – 2646m T.D.

by

P. CONNELL
J. P. G. FENTON
R. FOOTITT
C. W. HASKINS
R. S. W. NEVILLE
D. J. SHIPP

PROJECT NO. RRPS/823/A/10287

Prepared by:

Robertson Research International Limited,
Ty'n-y-Coed,
Llanrhos,
Llandudno,
Gwynedd LL30 1SA,
Wales,
U.K.

Prepared for:

Statoil a.s.,
P.O. Box 300,
Lagardsveien 78,
4001 Stavanger,
Norway.

May, 1982

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

Robertson Research staff involved in this study were:

Paul Connell	- Tertiary Foraminifera
Jim Fenton	- Palynology and Project Co-ordinator
Richard Footitt	- Lithologies
Cyril Haskins	- Ostracoda
Dick Neville	- Palynology
Dave Shipp	- Mesozoic Foraminifera.

INTRODUCTION

This report summarises the results of the micropalaeontological, palynological and stratigraphic analyses which have been carried out on material received from the section 1500m - 2646mT.D. from the Statoil 34/10-14 Norwegian North Sea Well under Project No. RRPS/823/A/10287.

The following analyses were carried out:
Lithology: 318 ditch cuttings, 9 sidewall core and 18 core samples from the entire section.
Micropalaeontology: 317 ditch cuttings, 9 sidewall cores and 3 core samples from the interval 1500m - 2646m T.D.
Palynology: 60 ditch cuttings, 9 sidewall cores and 18 core samples from the interval 1800m - 2646m T.D.

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 4.

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 I whilst those of the core pieces can be seen in Appendix II. All core piece depths quoted are uncorrected.

It should be noted that the lithostratigraphic terminology is taken from Deegan and Scull 1977. The stratigraphic significance of the Rhaetian - Volgian dinocyst zones is summarised in Appendix III.

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

INTRODUCTION

This report summarises the results of the micropalaeontological, palynological and stratigraphic analyses which have been carried out on material received from the section 1500m - 2646mT.D. from the Statoil 34/10-14 Norwegian North Sea Well under Project No. RRPS/823/A/10287.

The following analyses were carried out:
Lithology: 318 ditch cuttings, 9 sidewall core and 18 core samples from the entire section.
Micropalaeontology: 317 ditch cuttings, 9 sidewall cores and 3 core samples from the interval 1500m - 2646m T.D.
Palynology: 60 ditch cuttings, 9 sidewall cores and 18 core samples from the interval 1800m - 2646m T.D.

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 4.

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 I whilst those of the core pieces can be seen in Appendix II. All core piece depths quoted are uncorrected.

It should be noted that the lithostratigraphic terminology is taken from Deegan and Scull 1977. The stratigraphic significance of the Rhaetian - Volgian dinocyst zones is summarised in Appendix III.

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

Robertson Research staff involved in this study were:

Paul Connell	- Tertiary Foraminifera
Jim Fenton	- Palynology and Project Co-ordinator
Richard Footitt	- Lithologies
Cyril Haskins	- Ostracoda
Dick Neville	- Palynology
Dave Shipp	- Mesozoic Foraminifera.

SUCCESSION

Age		Tops
Middle? - Early? Eocene		1500m (top not seen)
---------- ?Unconformity ----------		
Late Palaeocene		1554m
---------- Unconformity ----------		
Late Cretaceous	late Maastrichtian - Campanian	1730m(log)
---------- Unconformity ----------		
Midddle - Early Jurassic	early Bajocian - latest Toarcian	1907m(log)
Early Jurassic	late - middle Toarcian	2106m
	?Fault ----------	
	late Pliensbachian	2159m(log)
	early Pliensbachian - Sinemurian	2229.40m(SWC)
Early Jurassic - Late Triassic		2372m(log) - 2646m T.D.

This breakdown has been achieved by analysis of ditch cuttings, selected sidewall core and core piece samples. Electric log information (GR/ISF/BHC; FDC/CNL) was made available.

LITHOSTRATIGRAPHY

Wireline logs (GR, ISF, FDC, CNL, BHC and MSFL), were provided for the study of this well and all but one of the lithostratigraphic unit boundaries are based on log breaks. Interpretation of the lithologies is based on ditch cuttings, sidewall cores and selected core piece evidence and is adapted to the wireline log accordingly. The lithostratigraphic terminology is taken from Deegan and Scull (1977).

LITHOSTRATIGRAPHIC UNITS

HORDALAND GROUP: 1500m - 1554m; Age: Middle? - Early? Eocene.

This group is dominated by moderately fissile, dark greenish grey, often pyritic shales which contain stringers or concretions of light olive grey, granular limestones. There are also fragments of white, fine grained sandstones in the ditch cuttings samples at 1509m and 1548m,but these may be caved. Lost circulation material is present in the samples from 1509m to the base of the interval.

ROGALAND GROUP: 1554m - 1730m(log); Age: Late Palaeocene.

This group is represented by two formations.

Balder Formation: 1554m - 1621m(log);
In conjunction with the micropalaeontological evidence, the top of this formation is taken on the incoming of dark grey to dark greenish grey shales which are rarely speckled white and may be tuffaceous. More positively identified tuffs and tuffaceous shales are seen, however, at and below 1557m. They are 'rubbly', olive grey to medium dark grey and light olive grey to greenish grey, mottled white. Pyrite is abundant throughout and hard, cryptocrystalline, dark grey limestone is noted in the ditch cuttings samples at 1587m. The latter may, however, be an altered volcanic. Traces of fine

grained, angular sand are noted at 1617m.

Lista Formation: 1621m(log) - 1730m(log);
This formation comprises moderately fissile, light olive grey to greenish grey shales which contain thin, scattered interbeds of white, fine to coarse grained, angular sand and stringers or concretions of light olive grey to olive grey limestones. From 1689m to 1887m lost circulation material dominates the ditch cuttings samples.

SHETLAND GROUP: 1730m(log) - 1907m(log); Age: late Maastrichtian - Campanian.

This group is domianted by light grey to light olive grey and olive grey variably calcareous shales which are interbedded with white, yellowish grey and light grey limestones. Towards the base of the interval, at and below 1845m, the shales become darker in colour being olive grey, to dark greenish grey and dark grey to olive black. At the base of the interval the shales contain thin lenses of friable, dusky yellowish brown, silty to fine grained sandstone. Lost circulation material again dominates the samples throughout.

BRENT GROUP: 1907m(log) - 2074m(log); Age: early Bajocian.

This group is represented by only three formations with the Tarbert Formation being absent and the Broom Formation being transitional (see below). Most of this group has been cored and the lithologies are therefore deduced from selected core pieces and wireline log evidence.

Ness Formation: 1907m(log) - 1977m(log); Age: early Bajocian.
This formation is typically characterised by an interbedded sequence of shales, sandstones and coals. The shales are fissile, light olive grey to olive grey and dark yellowish brown, carbonaceous, pyritic and often silty, whilst sandstones are friable, light olive grey to olive grey, very fine grained, subangular, micaceous, argillaceous and carbonaceous. The coals are firm, black to greyish brown, brittle, subvitreous to earthy.

Etive Formation: 1977m(log) - 2003m(log); Age: early Bajocian.
Unfortunately, no core pieces were provided over this interval, but wireline log evidence, showing the typical response for this formation, suggests variably argillaceous sandstone is the in situ lithology.

Rannoch Formation: 2003m(log) - 2074m(log); Age: early Bajocian.
Friable light grey to light olive grey, very fine to fine grained, angular, micromicaceous, often argillaceous and calcareous sandstone is the typical lithology for this formation.

BRENT GROUP/DUNLIN GROUP: 2074m(log) - 2086m(log); Age: early Bajocian - latest Toarcian.

Broom Formation/Drake Formation:
The occurrence of friable, white, fine to very coarse grained, angular to subrounded sandstones would normally indicate the presence of the Broom Formation of the Brent Group. However, the presence of interbedded olive grey claystones typical of the Drake Formation of the Dunlin Group, suggests that this interval represents a transition between the two formations. This transition is clearly indicated by a gradual upward decrease in the gamma ray response on the wireline log.

DUNLIN GROUP: 2086m(log) - 2372m(log) Age: early Bajocian - latest Toarcian to early Pliensbachian - Sinemurian.

The group is represented by only three formations. It is considered that the Cook Formation is probably faulted out.

Drake Formation: 2086m(log) - 2159m(log); Age: early Bajocian - latest Toarcian to late - middle Toarcian.
Whilst olive grey to dark grey, micaceous, occasionally slightly silty claystones are not seen until 2103m in the ditch cuttings samples, the whole interval is considered to be dominated by this lithology.

Burton Formation: 2159m(log) - 2203m(log); Age: late Pliensbachian.
The top of this formation is taken on a distinctive gamma ray log break with an upward increase. The lithologies comprise firm, olive grey to medium dark grey, micaceous, silty claystones which occasionally contain friable, white siltstone lenses.

Amundsen Formation: 2203m(log) - 2372m(log); Age: late Pliensbachian to early Pliensbachian - Sinemurian.
From the top of this interval down to 2231m the ditch cuttings samples are dominated by light olive grey to olive grey, micaceous, often highly silty claystones which contain interbeds of medium dark grey, micaceous, argillaceous siltstones. From 2231m to 2319m the claystones become dark grey to olive grey, micromicaceous, they are only occasionally slightly silty and rarely contain siltstone interbeds. From 2319m to the base of the interval the ditch cuttings samples are dominated by very fine grained, angular sand. From the gamma ray log this sand would appear to be highly argillaceous and probably micaceous. Only rare fragments of olive grey to medium grey micaceous claystones occur in the samples. In addition, at and below 2355m, the sand is coarser, being generally fine to medium (but some coarse) grained. This basal coarser grained seciton may possibly represent reworking of the underlying Nansen Member of the Statfjord Formation.

Statfjord Formation: 2372m(log) - 2646mT.D. Age: Early Jurassic - Late Triassic.
This formation is represented by three members.
Nansen Member: 2372m(log) - 2397m(log);
This member is characterised by unconsolidated, white, sandstone which has translucent to opaque, fine to very coarse, angular grains. Several medium grey to olive grey micaceous claystones occur as interbeds.

Eirikson Member: 2397m(log) - 2457m(log);
The distinctive log pattern suggests the presence of this member. The ditch cuttings samples throughout this interval are dominated by white, fine to coarse grained, angular sand which is highly angular at and below 2433m. In addition some carbonaceous debris is noted at 2397m and 2403m - a feature which is often characteristic of this member. No shales were seen in the ditch cuttings samples but wireline log evidence suggests that interbeds are present.

Raude Member: 2457m(log) - 2646m T.D.;

This member comprises an interbedded sequence of fine to coarse grained, angular sand and waxy, dark grey to olive grey, sandy claystones. The claystones become variegated at and below 2559m being olive grey to dark grey, very dark red to purple, greenish grey to dark greenish grey and light olive brown.

V

BIOSTRATIGRAPHY

V(1) TERTIARY

INTERVAL 1500m - 1554m; MIDDLE? - EARLY? EOCENE (top not seen)

Lithostratigraphic Unit:
Hordaland Group.

Environment: marine, outer shelf to upper bathyal.

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

- the occurrence of abundant spongodiscid and actinommid radiolaria at 1506m and below.
- the occurrence of Cyclammina amplectens at 1506m and below.
- regional stratigraphic considerations.

MICROPALAEONTOLOGY

The microfauna of this interval is dominated by long-ranging agglutinated foraminifera including species of Cyclammina, Haplophragmoides and Bathysiphon, together with spongodiscid and actinommid radiolaria. Cyclammina amplectens is considered by Gradstein and Berggren (1981) to be confined to the Eocene and to be particularly characteristic of the Middle Eocene. Its occurrence suggests that the age of this interval is no younger than the Eocene.

In the absence of diagnostic Early Eocene microfossils it is possible that there is an unconformity separating this interval from the underlying sediments of Late Palaeocene age.

INTERVAL 1554m - 1730m(log); LATE PALAEOCENE

Lithostratigraphic Units:
Rogaland Group (part):
Balder Formation: 1554m - 1621m(log);
Lista Formation: 1621m(log) - 1730m(log).

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 at 1554m.
- the occurrence of Trochammina sp. A, at 1623m and below.

MICROPALAEONTOLOGY

A Late Palaeocene age is indicated by the first appearance at 1554m of the pyritised diatom Coscinodiscus sp. 1. **The microfauna is particularly sparse** in the interval 1572m to 1611m where volcanoclastic sediments comprise the dominant lithotype.

A rich, well diversified microfauna of agglutinating foraminifera, including the index form Trochammina sp. A, appears at 1623m. **This fauna is dominated** by species of Haplophragmoides, Bathysiphon, Cribrostomoides, and Glomospira with rare occurrences of Cyclammina spp..

The absence of diagnostic Early Palaeocene microfossils suggests that the Palaeocene is separated from the Late Cretaceous by an unconformity.

INTERVAL 1730m(log) - 1907m(log); LATE CRETACEOUS, LATE MAASTRICHTIAN - CAMPANIAN.

Lithostratigraphic Unit:
Shetland Group.

Environment: marine, outer shelf.

The upper limit of this interval is based on a log break at 1730m, marking the unconformity between the Late Palaeocene and Cretaceous.

The age of this interval is based on the following micropalaeontological and palynological criteria.

- the appearance of abundant specimens of Pseudotextularia elegans fructicosa, P. elegans elegans and Globigerinelloides asper in the cuttings sample from 1725m.
- the presence of common Globotruncana contusa and representatives of the Rugoglobigerina/Archaeoglobigerina complex at the same depth.
- the presence within the interval of forms such as Reussella szajnochae szajnochae and Abathomphalus mayaroensis.
- the occurrence of increased numbers of agglutinating foraminifera towards the base of the interval.
- the appearance of Odontochitinia operculata at 1800m.
- the subsequent appearance of Raphidodinium fucatum and Palaeohystrichophora infusorioides at 1890.80m(core).
- the overall dinocyst content.

MICROPALAEONTOLOGY

The appearance of Late Cretaceous foraminifera in the cuttings sample at 1725m is thought to reflect the log breaks at 1730m, there apparently being a log to cuttings depth discrepancy as previously noted at the top of the Palaeocene.

The presence of abundant specimens of Pseudotextularia elegans fructicosa and P. elegans elegans together with common Globotruncana contusa indicates that the youngest Late Cretaceous sediments are of late Maastrichtian age.

The occurrence of Reussella szajnochae szajnochae from 1761m is of note as this is an early Maastrichtian to Campanian form. In addition the increase in agglutinating foraminifera noted towards the base of the interval may indicate the presence of the early Campanian, Tritaxia dubia Assemblage, although this species is absent. As a result of the above evidence a late Maastrichtian to Campanian age range has been assigned to this interval.

The microfaunas are rich, and in the upper part of this interval are dominated by typical Late Cretaceous planktonic foraminifera such as Globigerinelloides asper, Heterohelix globulosa and the Rugoglobigerina/Archaeoglobigerina complex. The increase in agglutinaging forms noted near the base of the interval is represented by Bathysiphon spp. and Recurvoides spp.. It should be noted, however, that some of the specimens recorded may be caved from the Tertiary.

A major unconformity separates this interval from the underlying Jurassic deposits with much of the Late Cretaceous, the Early Cretaceous, the Late Jurassic and part of the Middle Jurassic being unrepresented.

PALYNOLOGY

Rich microplankton dominated palynofloras were recorded from the ditch cuttings and core piece samples in this interval. Assemblages from the ditch cuttings samples between 1800m and 1884m are characterised by common to abundant specimens of Palaeoperidinium pyrophorum, Ceratiopsis diebelii and undifferentiated bisaccates. Core piece samples between 1890.80m and 1911.46m contain palynofloras with common to abundant specimens of P. pyrophorum, Chatangiella spp. and undifferentiated bisaccates. A depths discrepancy is apparent between the core pieces and log depths.

An age no younger than Campanian is indicated at 1800m by the appearance of Odontochitina operculata. This age assignment is substantiated by the appearances of Adnatosphaeridium sp. sensu McIntyre, Hystrichosphaeridium sp. 2 sensu McIntyre (1824m), Raphidodinium fucatum and Palaeohystrichophora infusorioides (1890.80m(core)). In addition, the presence of very abundant specimens of P. pyrophorum also suggests a general Maastrichtian - Campanian age. An age no older than the upper part of the Campanian is indicated at

1895.45m(core) by the last downhole occurrence of Spongodinium delitiense. The appearance of Callaiosphaeridium asymmetricum at 1911.46m(core) tentatively suggests an age no younger than the early part of the Campanian.

No positive palynological evidence has been encountered to indicate the presence of Cretaceous sediments of pre-Campanian age.

A specimen of Heslertonia heslertonensis (1908.70m(core)) indicates recycling of Barremian - Hauterivian deposits, whilst some miospores encountered within the interval suggest reworking of Middle and Early Jurassic sediments.

V(3) JURASSIC

INTERVAL 1907m(log) - 2106m; MIDDLE - EARLY JURASSIC, EARLY BAJOCIAN - LATEST TOARCIAN.

Lithostratigraphic Units:

Brent Group: 1907m (log) - 2074m (log);

Ness Formation: 1907m(log) - 1977m(log);

Etive Formation: 1977m(log) - 2003m(log);

Rannoch Formation: 2003m(log) - 2074m(log).

Brent Group/Dunlin Group: 2074m(log) - 2086m(log);

Broom Formation/Drake Formation: 2074m(log) - 2086m(log).

Dunlin Group (part): 2086m(log) - 2106m(log);

Drake Formation (part): 2086m(log) - 2106m(log).

Environment: initially inner shelf marginal marine with strong terrestrial influences, with increasing deltaic influences uphole, culminating in marginal marine/non-marine deltaic environments.

The top of this interval is based on a log break at 1907m. The age is based on the following palynological criteria:

- the appearance of Nannoceratopsis gracilis, N. senex and N. triceras at 1916.70m(core).
- the overall palynofloral content.
- regional considerations.

MICROPALAEONTOLOGY

The samples examined from this interval contain no in situ microfauna.

PALYNOLOGY

Rich and diverse miospore dominated palynofloras were recovered from the ditch cuttings samples and the majority of the core pieces examined in this interval. Core pieces between 1991.48m and 2036.90m, however, yielded impoverished assemblages. The interval is characterised by the occurrence of common to

abundant specimens of undifferentiated bisaccates, Deltoidospora spp., the Baculatisporites/Osmundacidites group, Klukisporites variegatus, Perinopollenites elatoides, Classopollis spp., Converrucosisporites spp., Botryococcus spp., Nannoceratopsis gracilis and N. senex.

Whilst the appearance of species of Nannoceratopsis (e.g. N. gracilis and N. senex) usually indicate, on regional considerations, an age no younger than middle Bajocian, N. gracilis Zone (XVIII), an age no younger than early Bajocian is indicated at 1916.70m(core) by the simultaneous appearance of Nannoceratopsis triceras. The first downhole appearance of this age-diagnostic taxon is of proven correlative value within the Brent Province in the lower part of the Ness Formation. An early Bajocian age is confirmed by the subsequent occurrence of Nannoceratopsis cf. spiculata, a dinocyst considered to be restricted to sediments of early Bajocian age in onshore sections in the U.K.

Marginal marine palynofloras were recovered from the core pieces between 1916.70m and 1963.49m, except for the coal at 1926.05m.

A feature of potential correlative value is the appearance and consistent occurrence of abundant to common specimens of Nannoceratopsis gracilis and N. senex at and below 2094m. This palynoevent is often first encountered downhole within the basal part of the Rannoch Formation or more commonly within the Broom Formation. Although this event is first encountered within the Drake Formation in the ditch cuttings, the possibility exists that there is a difference of approximately 17m between loggers and drillers depths near the Broom/Drake (see Summary Log). Although positive evidence is lacking, regional and local considerations suggest that the Bajocian/Toarcian boundary probably lies between 2074m(log) and 2106m.

Reworking of Carboniferous and Permo-Triassic sediments is indicated at 1916.70m(core) and 1918.50m(core) respectively.

INTERVAL 2106m - 2159m(log); EARLY JURASSIC, LATE - MIDDLE TOARCIAN

Lithostratigraphic Unit:
Dunlin Group (part);
Drake Formation (part).

Environment: marine, inner shelf to marginal marine.

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

- an influx of agglutinating foraminifera from 2106m.
- the appearance of the ostracod Kinkelinella cf. perisica also at 2106m.
- the occurrence of Phallocysta eumekes at 2106m.
- the subsequent presence of the ostracods Camptocythere toarciana and Macrocypris cf. liassica at 2118m.
- the overall palynofloral and kerogen content.

This interval is considered to have a faulted contact with the underlying late Pliensbachian interval, the fault occurring somewhere between 2155.50m(SWC) and 2165m(SWC), and thought to be represented by the log break at 2159m.

MICROPALAEONTOLOGY

The occurrence of common agglutinating foraminifera from 2106m suggests that the Toarcian, Trochammina Assemblage is present in this interval. This is confirmed by the presence of the diagnostic Toarcian ostracods Kinkelinella cf. perisica (2106m), Camptocythere toarciana (2118m) and Macrocypris liassica (2118m). The Trochammina Assemblage does not occur in early Toarcian sediments and the fact that it occurs throughout this interval, being recorded in the sidewall core at 2155.5m, suggests that the interval does not include any early Toarcian deposits.

PALYNOLOGY

Miospore dominated palynofloras were recovered from this interval, assemblages being characterised by the occurrence of common to abundant specimens of undifferentiated bisaccates, Chasmatosporites spp., Deltoidospora spp. and Nannoceratopsis senex.

Few age-diagnostic taxa were recorded from this interval, although overall content suggests a late - middle Toarcian age. Of interest is the occurrence of Phallocysta eumekes at 2106m, a dinocyst which has a total range of middle Toarcian - early Bajocian, but is most commonly encountered in sediments of late - middle Toarcian age. Regional considerations suggest that specimens of Eyachia prisca and Fromea elongata at 2166m are caved from the upper part of this interval, as both dinocyst normally characterise sediments of late Toarcian age.

Although no age indicative dinocysts were recorded from the sidewall core at 2155.50m, the overall palynofloral content and kerogen suggest derivation from the Drake Formation of late - middle Toarcian age. The assemblage is considered to equate to the Mancodinium semitabulatum Subzone (XVIIIB).

In view of the late Pliensbachian age assigned to the sidewall core at 2165m, the absence of characteristic early Toarcian palynofloras and the apparent absence of the Cook Formation, regional considerations suggest a faulted contact between the Toarcian and Pliensbachian.

Reworked specimens of striate bisaccates and Ricciisporites tuberculatus are seen at 2106m, suggesting recycling of sediments of Late Triassic age. Reworked miospores are frequently encountered within the upper part of the Drake Formation in the Brent Province.

INTERVAL 2159m(log) - 2229.40m(SWC); EARLY JURASSIC, LATE PLIENSBACHIAN

Lithostratigraphic Units:
Dunlin Group (part);
Burton Formation: 2159m(log) - 2203m(log);
Amundsen Formation (part): 2203m(log) - 2229.40m (SWC).

Environment: marine, inner shelf to marginal marine.

The upper limit of this interval is based on a log break at 2159m, believed to mark a faulted contact between the late - middle Toarcian and the late Pliensbachian.

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

- the presence of Marginulina prima prima in the sidewall core at 2165m.
- the subsequent occurrence of Dentalina matutina and the ostracods Trachycythere tubulosa and Healdia amalthei at 2172m; Hungarella sp. B, (2190m); and Gramannella apostolescui (2199m).
- the appearance of numerous specimens of Luehndea spinosa at 2165m(SWC).
- the last downhole occurrences of L. spinosa, Nannoceratopsis gracilis and N. triceras at 2225.00m(core).

MICROPALAEONTOLOGY

The appearance of Marginulina prima prima in the sidewall core at 2165m indicates that late Pliensbachian deposits have been penetrated at this depth. This is confirmed by the appearance in the cuttings sample at 2172m of Dentalina matutina together with M. prima prima.

Several ostracods representative of the late Pliensbachian, Hungarella Assemblage are encountered in this interval including Trachycythere tubulosa (2172m), Healdia amalthei (2172m), Hungarella sp. B. (2190m) and Gramannella apostolescui (2199m). The latter species is usually first encountered downhole slightly above the base of the late Pliensbachian. The presence of the ostracod Healdia mouhersensis from 2184m is, however, somewhat anomalous as this form had been believed to be confined to early Pliensbachian or older deposits. Its presence may be due to reworking, but this seems somewhat

unlikely.

Numbers are generally less than in the overlying interval,although calcareous benthonic foraminifera and ostracods are more prominent.

PALYNOLOGY

Miospore domianted assemblages were recovered throughout this interval, characterised by common to abundant specimens of undifferentiated bisaccates, Chasmatosporites spp., the Baculatisporites/Osmundacidites group and Deltoidospora spp. Microplankton assemblages are characterised by comon to abundant specimens of Nannoceratopsis gracilis, N. senex and Botryococcus spp..

The appearance of numerous specimens of Luehndea spinosa at 2165m(SWC) suggests an age no younger than the late Pliensbachian, L. spinosa Subzone (XVIIID). Although this taxon extends into the early Toarcian, it is only numerically significant within the late Pliensbachian. The remainder of the microplankton encountered within this interval suggest a late Pliensbachian age. Confirmation of penetration of late Pliensbachian deposits is tentatively suggested at 2190m(SWC) by the appearance of Cerebropollenites cf. thiergartii. This taxon has a total range of Bajocian - Rhaetian, but is most commonly encountered within late Pliensbachian or older sediments.

Whilst the last downhole occurrences of L. spinosa and N. gracilis at 2225.00m(core) indicate an age no older than late Pliensbachian, the simultaneous occurrence of N. triceras suggests an age no older than the upper part of the late Pliensbachian.

Reworked miospores encountered within the interval indicate recycling of sediments of Permo-Triassic, especially Late Permian sediments.

INTERVAL 2229.40m(SWC) - 2372m(log); EARLY JURASSIC, EARLY PLIENSBACHIAN - SINEMURIAN.

Lithostratigraphic Unit:
Dunlin Group (part):
Amundsen Formation (part).

Environment: marine, inner shelf to marginal marine.

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

- the appearance of Dentalina terquemi and common Lenticulina varians in the sidewall core at 2229.40m.
- the occurrence of abundant Lenticulina varians in the cuttings at 2235m.
- the subsequent occurrences of the ostracods Klinglerella cf. triebeli (2304m), and Isobythocypris unispinata (2310m).
- the overall palynofloral content.

MICROPALAEONTOLOGY

The appearance of common Lenticulina varians in the sidewall core at 2229.40m and abundant specimens in the cuttings at 2235m indicates the presence of the L. varians Assemblage of early Pliensbachian to late Sinemurian age. The presence of Dentalina terquemi in the sidewall core at 2229.40m confirms that early Pliensbachian deposits have been penetrated at this depth.

The ostracods Wicherella semiora, first seen at 2241m and Hungarella etaulensis, first seen at 2265m are late - early Pliensbachian forms. Klinglerella cf. triebeli (2304m) and Isobythocypris unispinata (2310m) are, however, not seen above the early Pliensbachian, the former ranging down into the Sinemurian.

In view of the evidence outlined above an early Pliensbachian - Sinemurian age range has been assigned to this interval.

Calcareous benthonic foraminifera represented mainly by Lenticulina varians dominate the microfaunas, although ostracods continue to be prominent. Of additional note is the presence of common echinoderm fragments and gastropods,

especially at the top of the interval, this being a feature often seen at this stratigraphic level.

PALYNOLOGY

Assemblages recovered from this interval are dominated by miospores, with common to abundant specimens of undifferentiated bisaccates and Cerebropollenites mesozoicus. Microplankton are dominated by common sepcimens of Botryococcus spp. between 2229.40m(SWC) and 2269m(SWC). The marked increase in freshwater influence suggested at and below 2296.40m(SWC) by the common occurrence of Botryococcus spp. is an event which regionally approximates to the late/early Pliensbachian boundary.

Palynofloras recovered from this interval contain few age diagnostic taxa, suggesting only a general Pliensbachian - Hettangian age. Non-marine/brackish assemblages were recovered from 2235m(SWC) - 2269m(SWC), whilst a marginal marine palynoflora was encountered in the sidewall core at 2241m. A single specimen of Nannoceratopsis senex was recorded in the latter sample. This dinocyst which is normally encountered in sediments of late Pliensbachian or younger age, is known to occur in onshore U.K. deposits of latest early Pliensbachian, Davoei ammonite zone age. If in situ, this specimen may indicate an age no older than this ammonite zone for this horizon.

Reworked miospores observed within the interval indicate recycling of sediments of Carboniferous and Late Triassic ages.

INTERVAL 2372m(log) - 2646mT.D.; EARLY JURASSIC - LATE TRIASSIC

Lithostratigraphic Units:

Statfjord Formation:

Nansen Member: 2372m(log) - 2397m(log);

Eirikson Member: 2397m(log) - 2457m(log);

Raude Member: 2457m(log) - 2646mT.D.

Environment: deltaic/marginal marine to fluvio-lacustrine.

The upper limit of this interval is based on a log break at 2372m.

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

- the appearance of lithologies indicative of the Statfjord Formation.
- the presence of a possible in situ specimen of Ovalipollis ovalis at 2604m.

MICROPALAEONTOLOGY

No in situ forms were recovered from this interval.

PALYNOLOGY

Moderately rich microfloras were encountered throughout this interval, characterised by common to abundant specimens of undifferentiated bisaccates. In view of the lithologies encountered the majority of palynomorphs observed are considered to be derived, via caving, from overlying Early Jurassic intervals.

Although reworked palynomorphs are recorded within the interval, a specimens of Ovalipollis ovalis at 2604m may be in situ (based upon preservational state). If this is correct then an age no younger than Late Triassic, Rhaetian would be suggested. No positive evidence, however, has been seen for the presence of palyniferous Upper Triassic deposits.

GEOLOGICAL HISTORY

LATE TRIASSIC - EARLY JURASSIC	The oldest sediments encountered are variegated claystones and sandstones deposited within a fluviatile/lacustrine environment under an arid climate. This depositional style continued uninterrupted into the Early Jurassic. A change in river base levels, possibly associated with the basal Early Jurassic eustatic event led to the onset of reducing conditions within a fluvio-deltaic setting. This facilitated the preservation of organic matter, within carbonaceous shales. A change to a semi-arid climate may also have occurred. Regional considerations suggest that the effective cessation of input of coarse detritus may have been a result of the regionally identifiable late Sinemurian eustatic event. This initiated deposition of claystones and siltstones within marginal marine to inner shelf environments, which continued uninterrupted into the late Pliensbachian.
EARLY TOARCIAN	ABSENT - the arenaceous Cook Formation appears to be absent. Regional and local considerations suggest that the absence of this formation is due to post-Early Jurassic faulting. This faulting may also have removed some upper Burton Formation and lower Drake Formation, although this cannot be accurately defined.

MIDDLE - LATE TOARCIAN to EARLY BAJOCIAN	Within the middle - late Toarcian argillaceous deposits accumulated under marginal marine to inner shelf settings. Towards the end of the Toarcian influx of sand occurred, probably in response to a regionally identifiable eustatic event approximating to the Toarcian/Bajocian boundary. A setting distal to the source of the Broom Formation sands is suggested by the interbedded nature with shales of the Drake Formation. Following deposition of the Broom Formation, an influx of micaceous sand occurred, accumulating in a variety of offshore bar and shoreline settings. Coarser sands of the Etive Formation were deposited later, probably as a beach or bar complex. Progradation of delta-top facies of the Ness Formation resulted in accumulation of sands, shales and coals in a variety of marginal marine to non-marine, deltaic settings.
MIDDLE BAJOCIAN - SANTONIAN	ABSENT - probably due to deposition with subsequent erosion.
CAMPANIAN - LATE MAASTRICHTIAN	Deposition resumed due to the widespread Campanian transgression, with shales accumulating under outer shelf conditions.
EARLY PALAEOCENE	ABSENT - due to either deposition with subsequent erosion or non-depositon.

LATE PALAEOCENE - EOCENE

Sedimentation recommenced in the Late Palaeocene, with shales and interbedded limestones being deposited in outer shelf to upper bathyal depths. The occurrence of tuffaceous shales towards the end of the Palaeocene reflects a marked volcanic episode which was associated with a phase of North Atlantic rifting. Normal shale deposition resumed in the Eocene, following a possible brief phase of non-deposition.

SELECTED REFERENCES

BARTENSTEIN, H. et al. 1962. Leitfossilien der Mikropäleontologie. Gebrüder Borntraeger, Berlin.

BERGGREN, W.A. 1971. Tertiary boundaries and correlations. In: FUNNELL, B.M. & RIEDEL, W.R. (Eds.), Micropalaeontology of the Oceans. Camb. Univ. Press.

BLOW, W.H. 1979. The Cainozoic Globigerinida. E.J. Brill. Leiden.

DEEGAN, C.E. & SCULL, B.J. (Compilers). 1977. A proposed standard lithostratigraphic nomenclature for the Central and Northern North Sea. Rep. Inst. Geol. Sci., No. 77/25; Bull. Norw. Petrol. Direct., No. 1.

GRADSTEIN, F.M. & BERGGREN, W.A. 1981. Flysch-Type Agglutinating Foraminifera and the Maestrichtian to Paleogene History of the Labrador and North Seas. Marine Micropaleontology.

FINSTAD, K.G. & SELLEY, R.C. (Editors). 1975. Proceedings, Jurassic Northern North Sea Symposium. Norwegian Petroleum Society.

FINSTAD, K.G. & SELLEY, R.C. (Editors). 1977. Proceedings, Mesozoic Northern North Sea Symposium. Norwegian Petroleum Society.

HAZEU, G.J.A. 1981. 34/10 Delta Structure: Geological Evaluation and Appraisal. In Norwegian Petroleum Society. Norwegian Symposium on Exploration (NSE '81), Bergen, September 14th-16th, 1981. Proceedings Paper No. NSE/13.

ILLING, L.V. & HOBSON, G.D. 1980. Petroleum Geology of the Continental Shelf of North-West Europe. Institute of Petroleum.

McINTYRE, D.J. 1974. Palynology of an Upper Cretaceous section, Horton River, District of Mackenzie. N.W.T. Geol. Surv. Can. Paper 74-14.

NORWEGIAN PETROLEUM SOCIETY. 1980. The sedimentation of the North Sea Reservoir Rocks.

WOODLAND, A.W. (Editor). 1975. Petroleum and the Continental Shelf of North West Europe, Vol. 1. Geology. Inst. Petrol.

ROBERTSON RESEARCH INTERNATIONAL LIMITED. 1981. Southern Offshore Norway Phase Two Study: The Stratigraphy and Petroleum Geochemistry of the Jurassic to Tertiary Sediments.

ROBERTSON RESEARCH INTERNATIONAL LIMITED/ERC ENERGY RESOURCE CONSULTANTS LIMITED 1980. The Brent Sand in the Northern Viking Graben, North Sea: A sedimentological and reservoir engineering study.

APPENDIX I

SIDEWALL CORE DESCRIPTIONS

Depth	Core No.	Rec. (mm)	Qual.	Type of Analysis	Lithology
2155.50m	17	50	Exc.	M P	CLAYSTONE: soft, friable, dark grey to olive black, slightly silty, micromicaceous, faintly pyritic, non-calcareous.
2165m	15	43	Exc.	M P	CLAYSTONE: soft, firm, olive grey, micromicaceous, non-calcareous, with numerous thin, parallel stringers and lenses of SILTSTONE: soft to friable, white, weakly calcareous.
2190m	11	41	Exc.	M P	CLAYSTONE: soft, firm, medium dark grey to olive-grey, micromicaceous, non-calcareous, locally with thin, yellowish grey silty stringers.
2202m	9	42	Exc.	M P	CLAYSTONE: soft, firm, olive grey, faintly micromicaceous, locally waxy, non-calcareous, with occasional thin lenses of SILTSTONE: soft,white, locally with fine sub-angular sand grains, mildly calcareous.
2209m	7	22	Good	M P	CLAYSTONE: soft, firm, light olive grey to olive grey, very silty, faintly micromicaceous, moderately to strongly calcareous.

2229.40m	6	50	Exc.	M P	SHALE: soft, firm, weakly fissile, dark greenish grey to olive grey, micaceous, locally with waxy surfaces, non-calcareous.
2235m	5	30	V.G.	M P	CLAYSTONE: soft, firm, medium dark grey to olive grey, micromicaceous, non-calcareous, with common stringers and lenses of SILTSTONE: white to yellowish grey, slightly sandy and strongly calcareous.
2241m	4	42	Exc.	M P	CLAYSTONE: soft, firm, medium dark grey to olive grey, micromicaceous, non-calcareous, locally slightly silty.
2269m	1	33	Exc.	M P	CLAYSTONE: as 2241m, but not silty.

KEY

Exc. = Excellent
M = Micropalaeontology
P = Palynology
V.G. = Very Good
Qual. = Quality
Rec. = Recovery

APPENDIX II

CORE PIECE DESCRIPTIONS

Depth	Core No.	Type of Analysis	Lithology
1890.75m - 1890.80m	1	M P	SHALE: soft, fissile, dark greenish grey, to olive grey, micaceous.
1895.42m - 1895.45m	1	M P	SHALE: soft but firm, fissile, greenish grey micaceous.
1908.66m - 1908.70m	2	P	SHALE: soft but firm, moderately fissile, dark grey to olive black, micaceous, locally silty with yellowish grey, silt grains, weakly pyritic.
1911.40m - 1911.46m	2	P	SHALE: Soft but firm, moderately fissile, dark grey, micaceous, weakly pyritic, with pockets of SANDSTONE: soft, friable, dusky yellow, silty, to very fine grained, non calcareous.
1916.66m - 1916.70m	2	P	SHALE: soft but firm, moderately fissile, light olive grey micaceous, scattered carbonaceous debris, weakly pyritic.
1918.45m - 1918.50m	2	P	SHALE: soft, but firm, moderately fissile, dark yellowish brown to light olive grey, micaceous, with abundant carbonaceous debris, weakly pyritic.
1926.00m - 1926.05m	3	P	COAL: soft, firm, soily, but locally brittle and subvitreous, black to greyish brown.

1928.15m - 1928.19m	3	P	SHALE: soft, fissile, olive grey to light olive grey, micromicaceous, non-calcareous, locally waxy.
1945.25m	4	P	SANDSTONE: soft friable, light olive grey to olive grey with very fine sub-angular grains, micaceous, argillaceous, non-calcareous, slightly carbonaceous, grades locally to SANDY CLAYSTONE.
1948.00m - 1948.05m	4	P	SHALE: soft, fissile, olive grey to light olive grey, finely laminated, micromicaceous, non-calcareous, slightly carbonaceous, with occasional thin laminae of SAND: very fine sub-angular grains.
1963.45m - 1963.49m	5	P	SHALE: soft, firm, dark grey to brownish black, micromicaceous, non-calcareous, locally with rare, fine laminations of SANDSTONE: soft, yellowish grey, with very fine sub-angular grains.
1973.55m - 1973.60m	6	P	SHALE: soft, medium grey to olive grey, micromicaceous, with rare carbonaceous flecks, non-calcareous.
1978.95m - 1979.00m	6	P	COAL: soft, firm, black, brittle with SILTSTONE: soft, firm, medium dark grey with occasional fine laminations, pale yellowish brown, argillaceous, carbonaceous, micaceous and non-calcareous with a large irregular nodule of pyrite.
1991.42m - 1991.48m	7	P	COAL: as 1978.95m.

2026.40m - 2026.45m	8	P	SANDSTONE: soft, friable, light grey to light olive grey, with very fine to fine subangular grains, micromicaceous, non-calcareous, argillaceous.
2036.45m - 2036.90m	9	P	SANDSTONE: as 2026.45m but medium grey to light olive grey.
2213.65m - 2213.70m	10	P	CLAYSTONE: soft, firm, medium grey to light olive grey, micromicaceous, silty and non-calcareous.
2224.95m - 2225.00m	10	M P	SILTSTONE: soft, firm,medium dark grey with thin, irregular, yellowish grey laminations, micromicaceous, very argillaceous, non-calcareous.

Key:

M = Micropalaeontology
P = Palynology.

APPENDIX III

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		
			oppressus		*Systematophora* spp VIC
		middle	*giganteus*	*Muderongia* sp A VII	*Dichadogonyaulax pannea* VIIA
			gorei		*Dichadogonyaulax culmula* VIIB
			albani		
			Epipallasiceras sp		*Glossodinium dimorphum* VIIC
			rotunda		
			pallasioides		
			Pavlovia sp	*Pareodinia mutabilis* VIII	*Gonyaulacysta pennata* VIIIA
		early	*pectinatus*		*Gonyaulacysta jurassica* VIIIB
			hudlestoni	*Gonyaulacysta longicornis* IX	*Egmontodinium polyplacophorum* IXA
			wheatleyensis		
			scitulus		
			elegans		*Scriniodinium luridum* IXB
	Kimmeridgian		*autissiodorensis*		
			eudoxus		
			mutabilis	*Gonyaulacysta cladophora* X	
			cymodoce		
			baylei	*Scriniodinium crystallinum* XI	*Leptodinium egemenii* XIA
	Oxfordian	late	*pseudocordata*		*Stephanelytron redcliffense* 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	*Dichadogonyaulax gochtii* XVIA
			macrocephalus		
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*		
			sauzei		
			laeviuscula		*Polysphaeridium deflandrei* XVIIIA
			discites		
		early	*concavum*		
			murchisonae		
			opalinum		
EARLY JURASSIC	Toarcian	late	*levesquei*	*Nannoceratopsis gracilis* XVIII	*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 ..... o
- 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

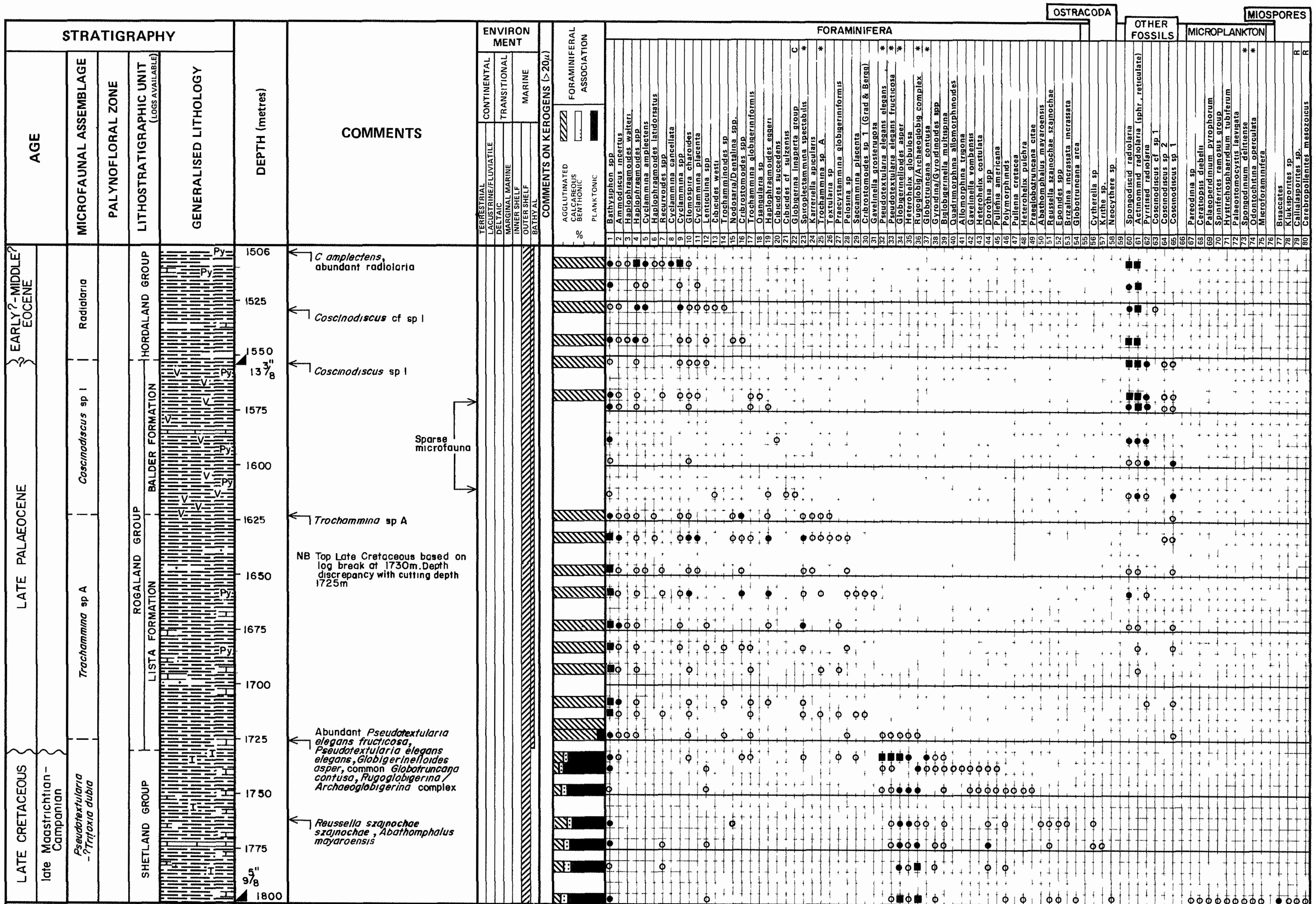
Core

Sidewall core

Sidewall core (analysed for biostratigraphy) *

Sidewall core (no recovery)

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



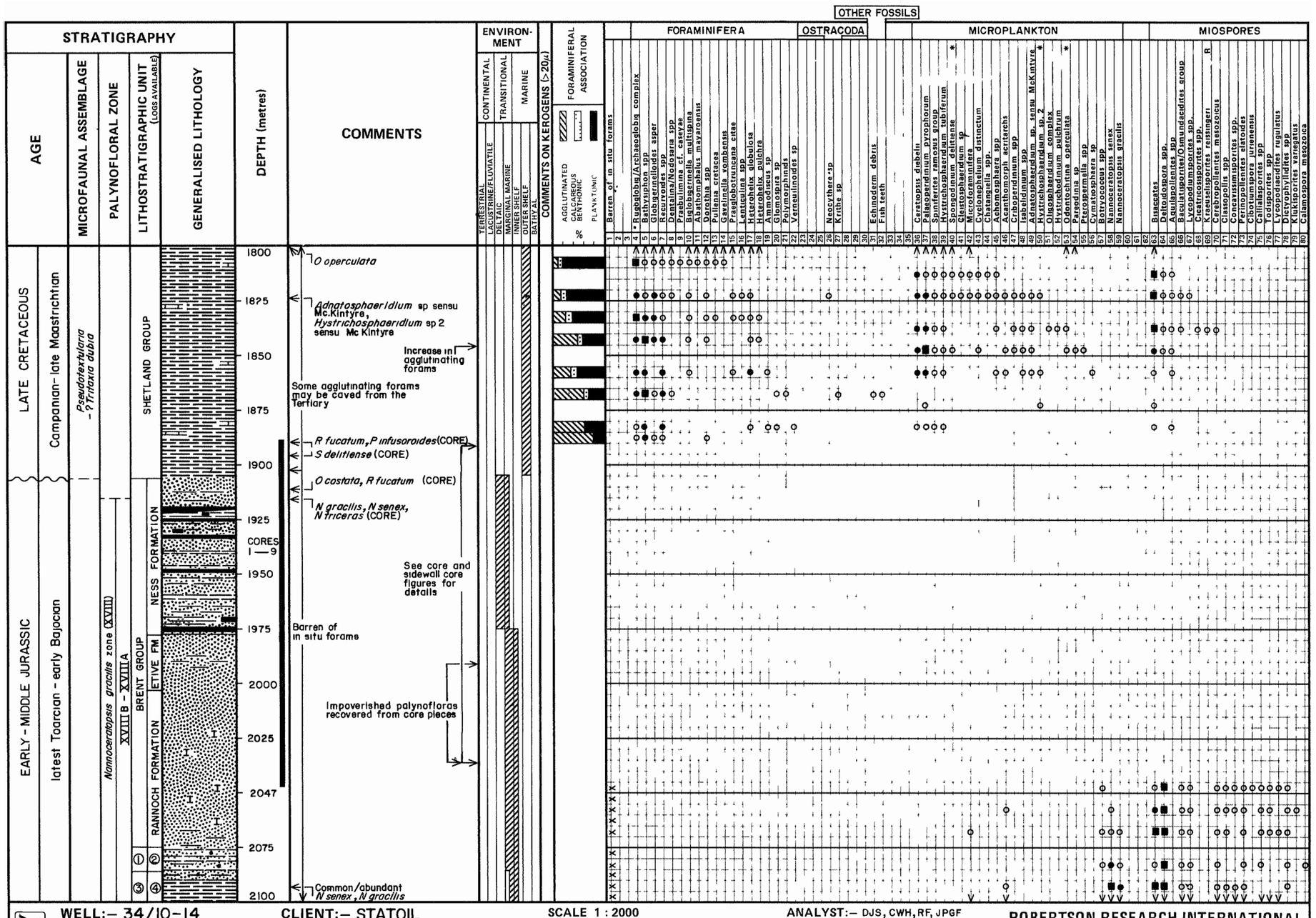
WELL:- 34/10-14
CHART:- 1 of 4
FIGURE:- 2

CLIENT:- STATOIL
DEPTH:- 1500m - 1800m
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

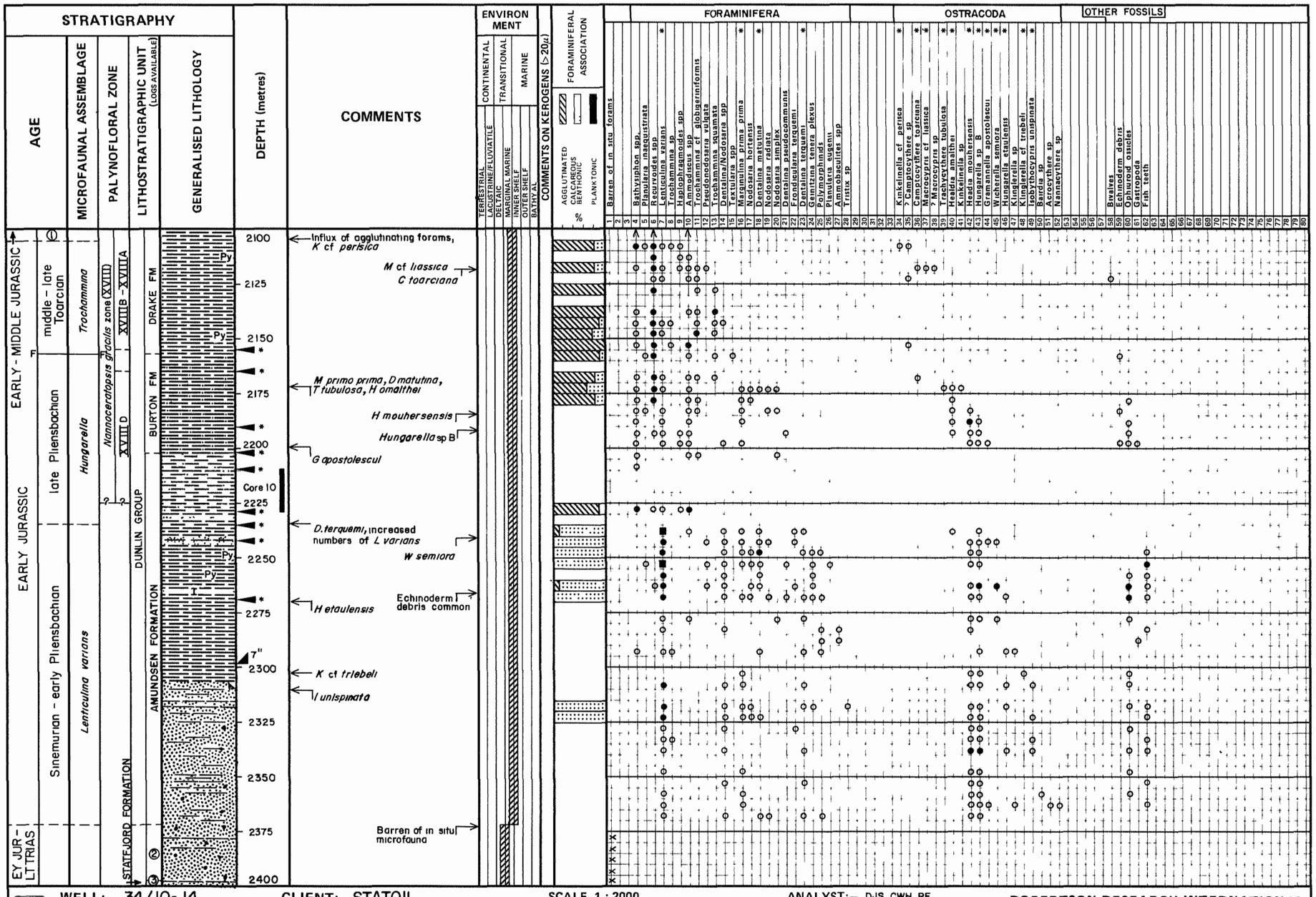
ANALYST:- PGC, DJS, RF, JPGF
DRAWING NO.:- 763P/10287/5156
DATE:- JUNE 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



① BRENT/DUNLIN GROUP ③ DUNLIN GROUP

② BROOM/DRAKE FORMATION ④ DRAKE FORMATION



WELL:– 34/10-14
CHART:– 3a of 4
FIGURE:– 4

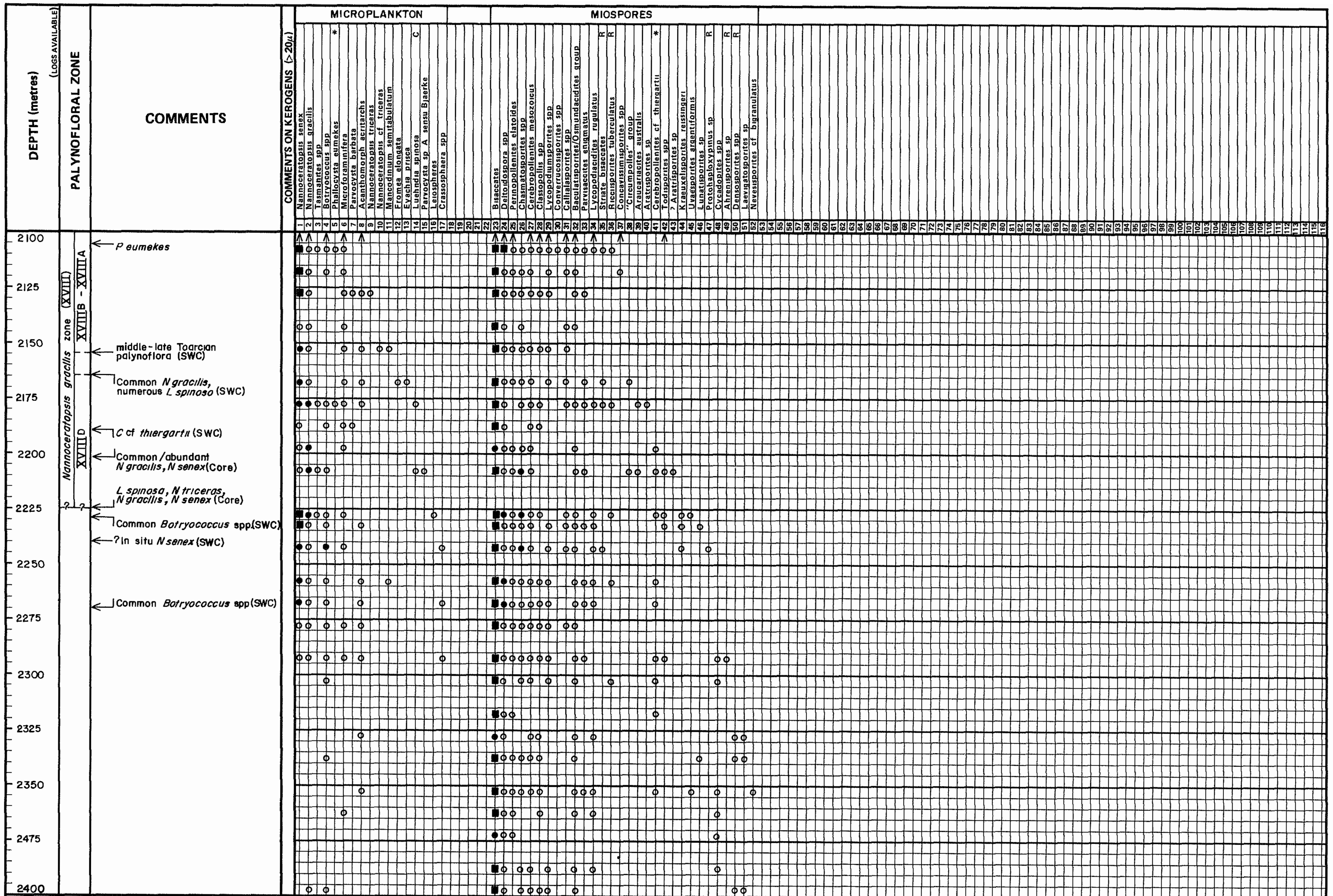
CLIENT:– STATOIL
DEPTH:– 2100m - 2400m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– DJS, CWH, RF
DRAWING NO.:– 763P/10287/5156
DATE.– JUNE 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① early Bajocian - latest Toarcian
② NANSEN MEMBER
③ EIRIKSON MEMBER


DEPTH (metres)
(LOGS AVAILABLE)
PALYNOFLORAL ZONE
COMMENTS
COMMENTS ON KEROGENS (>20μ)
MICROPLANKTON
MIOSPORES
1 Nannoceratopsis senex
2 Nannoceratopsis gracilis
3 Tasmanites spp
4 Botryococcus spp
5 Phallocysta eumekes *
6 Microforaminifera
7 Parvocysta barbata
8 Acanthomorph acritarchs
9 Nannoceratopsis triceras
10 Nannoceratopsis cf triceras
11 Mancodinium semitabulatum
12 Fromea elongata
13 Eyachia prisca
14 Luehndia spinosa C
15 Parvocysta sp A sensu Bjaerke
16 Leiospheres
17 Crassosphaera spp
23 Bisaccates
24 Deltoidospora spp
25 Perinopollenites elatoides
26 Chasmatosporites spp
27 Cerebropollenites mesozoicus
28 Classopollis spp
29 Lycopodiumsporites spp
30 Converrucosisporites spp
31 Callialasporites spp
32 Baculatisporites/Osmundacidites group
33 Parvisaccites enigmatus
34 Lycopodiacidites rugulatus
35 Striate bisaccates R
36 Ricciisporites tuberculatus R
37 Concavissimisporites spp
38 "Circumpolles" group
39 Araucariacites australis
40 Aratrisporites sp
41 Cerebropollenites cf thiergartii *
42 Todisporites spp
43 ? Aratrisporites sp
44 Kraeuxelisporites reissingeri
45 Uvaesporites argentiformis
46 Lunatisporites sp
47 Protohaploxypinus sp R
48 Cycadopites spp
49 Ahrenisporites sp R
50 Densosporites spp R
51 Laevigatosporites sp
52 Nevesisporites cf bigranulatus
2100
2125
2150
2175
2200
2225
2250
2275
2300
2325
2350
2475
2400
Nannoceratopsis gracilis zone (XVIII)
XVIII A
XVIII B - XVIII A
XVIII D
P eumekes
middle-late Toarcian palynoflora (SWC)
Common N gracilis, numerous L spinosa (SWC)
C cf thiergartii (SWC)
Common/abundant N gracilis, N senex (Core)
L spinosa, N triceras, N gracilis, N senex (Core)
Common Botryococcus spp (SWC)
?in situ N senex (SWC)
Common Botryococcus spp (SWC)

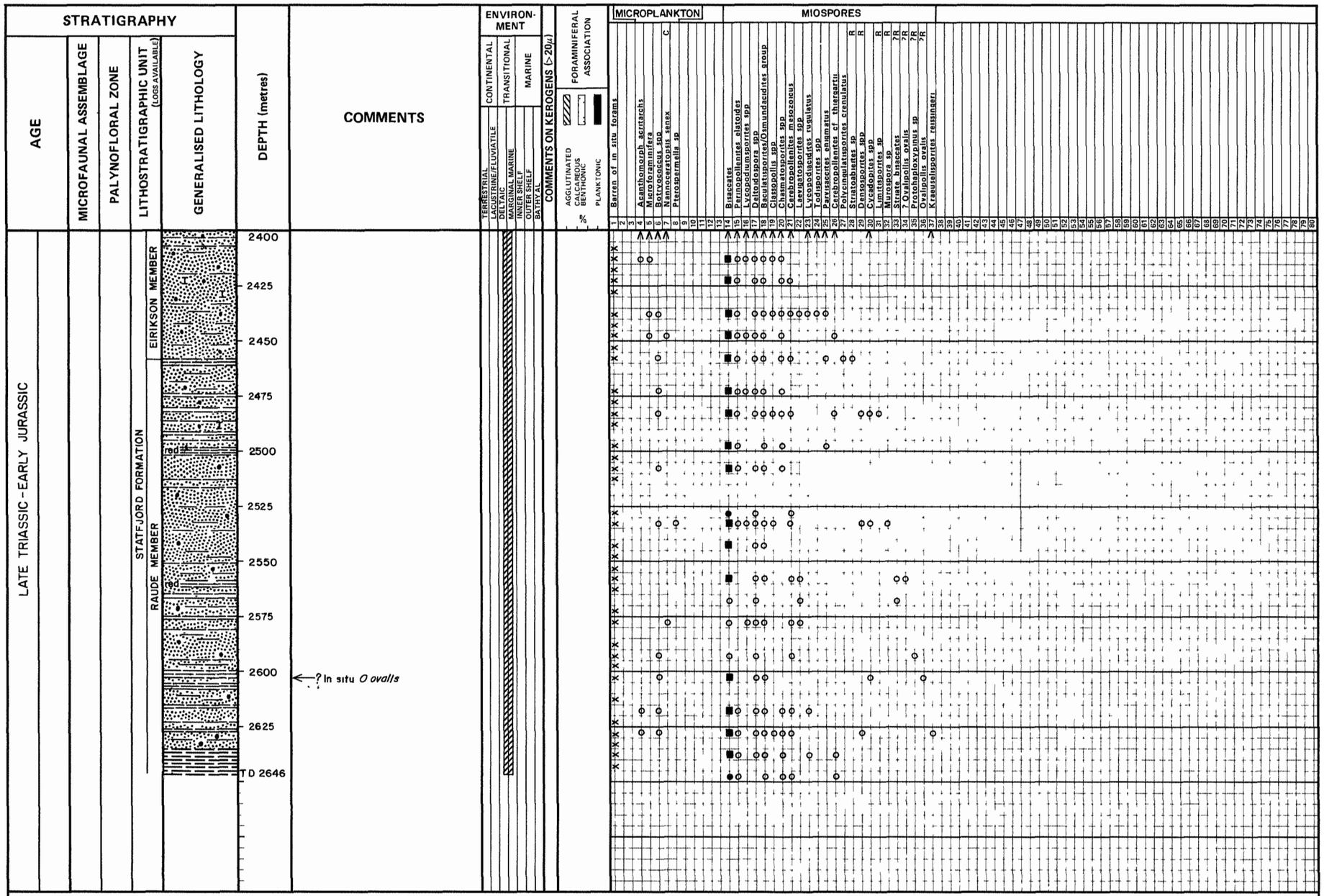
WELL:– 34/10-14
CHART:– 3b of 4
FIGURE:– 5

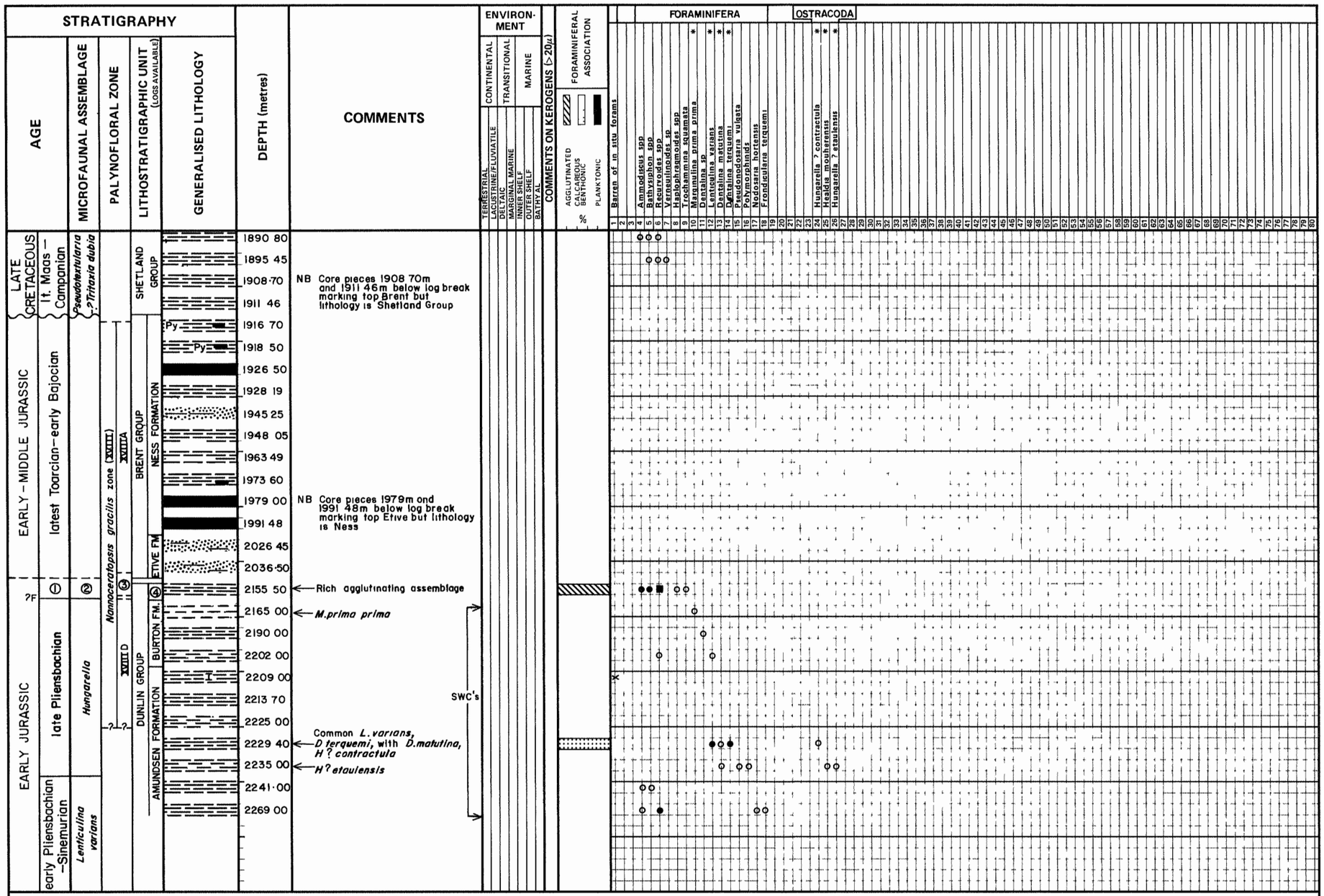
CLIENT:– STATOIL
DEPTH:– 2100m - 2400m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RSWN, JPGF
DRAWING NO.:– 763P/10287/5156
DATE:– JUNE 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART


STRATIGRAPHY
AGE
MICROFAUNAL ASSEMBLAGE
PALYNOFLORAL ZONE
LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE)
GENERALISED LITHOLOGY
DEPTH (metres)
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
%
MICROPLANKTON
MIOSPORES
LATE TRIASSIC - EARLY JURASSIC
STATFJORD FORMATION
RAUDE MEMBER
EIRIKSON MEMBER
2400
2425
2450
2475
2500
2525
2550
2575
2600
2625
TD 2646
? In situ O ovalis
1 Barren of in situ forms
3 Acanthomorph acritarchs
5 Microforaminifera
6 Botryococcus spp
7 Nannoceratopsis senex C
8 Pterospermella sp
14 Bisaccates
15 Pernopollenites elatoides
16 Lycopodiumsporites spp
17 Deltodospora spp
18 Baculatisporites/Osmundacidites group
19 Chasmatosporites spp
20 Cerebropollenites mesozoicus
21 Leevigatosporites spp
22 Lycopodiacidites rugulatus
23 Todisporites spp
24 Parvisaccites enigmatus
25 Cerebropollenites cf thiergartii
26 Polycingulatisporites crenulatus R
27 Striatella sp R
28 Densoisporites spp
29 Cycadopites spp
30 Limtisporites sp R
31 Murospora sp R
32 Striatella bisaccates ?R
33 ? Ovalipollis ovalis ?R
34 Protohaploxypinus sp ?R
35 Ovalipollis ovalis ?R
36 Krauselisporites reissingeri
WELL:- 34/10-14
CHART:- 4 of 4
FIGURE:- 6
CLIENT:- STATOIL
DEPTH:- 2400m - 2646m
LOCATION:- NORWEGIAN NORTH SEA
SCALE 1 : 2000
LEGEND:- SEE FIGURE 1
ANALYST:- RSWN, JPGF
DRAWING NO.:- 763P/10287/5156
DATE:- JUNE 1982
ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



WELL:–34/10–14
CHART:– Ia of I
FIGURE:– 7

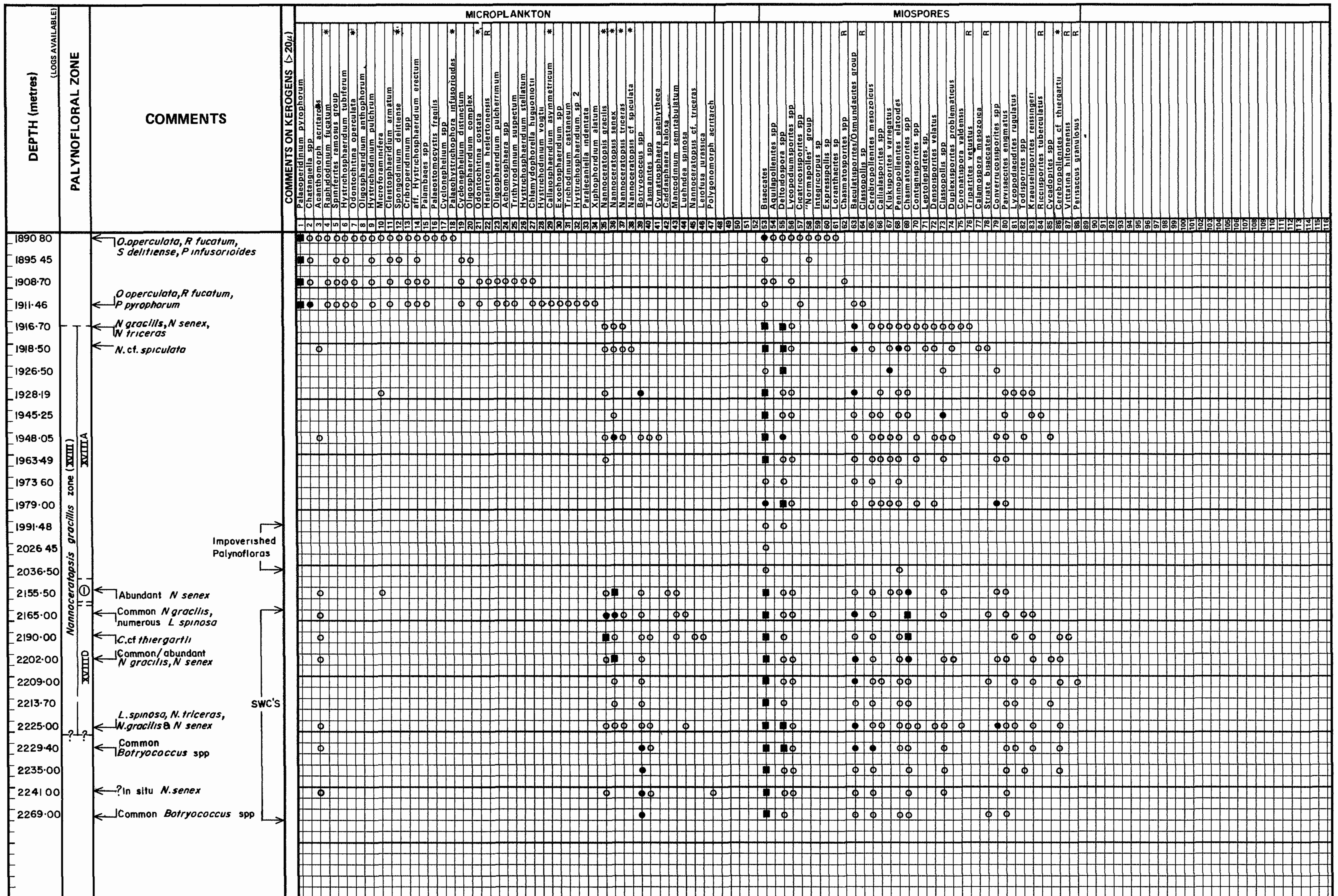
CLIENT:– STATOIL
CORES AND SIDEWALL CORES
LOCATION:– NORWEGIAN NORTH SEA

LEGEND:– SEE FIGURE 1

ANALYST:– DJS, RF, CWH
DRAWING NO.:– 763P/10287/5156
DATE:– JUNE 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① late - middle Toarcian
② *Trochammina*
③ XVIII B
④ DRAKE FORMATION



WELL:– 34/10–14 CHART:– Ib of I FIGURE:– 8	CLIENT:– STATOIL CORES AND SIDEWALL CORES LOCATION:– NORWEGIAN NORTH SEA	LEGEND:– SEE FIGURE 1	ANALYST:– JPGF DRAWING NO.:– 763P/10287/5156 DATE:– JUNE 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① XVIIIB

ENCLOSURE 1

ROBERTSON RESEARCH INTERNATIONAL

SUMMARY LOG

SCALE 1 : 500

STATOIL 34/10 - 14

AREA: NORWEGIAN NORTHERN NORTH SEA
SPUD DATE: 24th DECEMBER 1981

COMPANY: STATOIL
COMPLETION DATE: 19th MARCH 1982

INTERVAL STUDIED: 1500m – 2646m
T.D.: 2646m

Drawing No.: 763P/10287/5156
ANALYST: PGC, DJS, JPGF, CWH, RF.
Date: JUNE 1982

Cored Interval
Casing Shoe
Sidewall Core
Sidewall Core (no recovery)
Sidewall Core analysed for biostratigraphy *

AGE
STRATIGRAPHIC INTERVAL TOPS LITHOSTRATIGRAPHIC
METRES
LITHOSTRATIGRAPHIC UNITS
LITHOLOGICAL COMMENTS
LITHOLOGY
DEPTHS, CASING AND CORING DETAILS
METRES
MICROPALAEONTOLOGICAL COMMENTS
MICROFAUNAL ASSEMBLAGE/ZONE
DINOCYST ZONE
PALYNOLOGICAL COMMENTS
ENVIRONMENT OF DEPOSITION
TERRESTRIAL
LACUSTRINE/FLUVIATILE
DELTAIC
MARGINAL MARINE
INNER SHELF
OUTER SHELF
BATHYAL
EOCENE
EARLY ? – MIDDLE ? EOCENE
HORDALAND GROUP
SHALE: moderately fissile, dark greenish grey, often pyritic. Traces of light olive-grey, granular LIMESTONE – probably as stringers or concretions. Also rare fragments of white, fine grained SANDSTONE seen in ditch cuttings samples – possibly caved.
Ditch cuttings samples from 1509m to 1554m virtually all lost circulation material.
Cyclammina amplectens, abundant Actinommid radiolaria
Radiolaria
Cibicides westi
1554
13⅜"
Coscinodiscus sp. 1, pyritised radiolaria N.B. Log (1557m) to cuttings (1554m) depth for top Palaeocene
SHALES: as above but slightly darker – dark grey, to dark greenish grey. TUFF/TUFFACEOUS SHALE: olive-grey to medium dark grey and light olive-grey to greenish grey speckled white, 'rubbly' textured, ?sandy. Pyrite often abundant.
BALDER FORMATION
LIMESTONE: hard, cryptocrystalline, dark grey – ? altered volcanic.
Very sparse microfauna
Coscinodiscus sp. 1
Traces of fine, angular SAND.
PALAEOCENE
LATE PALAEOCENE
1621 (log)
ROGALAND GROUP
SHALE: moderately fissile, light olive-grey to greenish grey with thin interbeds of SAND: white, fine to coarse grained, angular. Also stringers or concretions of LIMESTONE: light olive-grey to olive-grey.
Trochammina sp. A
Cribrostomoides sp. 1
LISTA FORMATION
Lost circulation dominates the ditch cuttings samples down to 1887m.
'Rubbly' tuffs and tuffaceous shales – presumed caved.
1730 (log)
Abundant Pseudotextularia elegans elegans, P. elegans fructicosa, Globigerinelloides asper, common Globotruncana contusa, Rugoglobigerina/Archaeoglobigerina complex N.B. Log depth (1730m) to cuttings (1725m) descrepancy for top Cretaceous
SHALES: light grey to light olive-grey and olive-grey, variably calcareous with thin interbeds of LIMESTONE: white, yellowish grey and light grey.
Ditch cuttings samples are of very poor quality due to presence of lost circulation material.
Reussella szajnochae szajnochae, Abathomphalus mayaroensis
CRETACEOUS
LATE CRETACEOUS
CAMPANIAN – LATE MAASTRICHTIAN
SHETLAND GROUP
9⅝"
O. operculata
Palynological analysis
Tritaxia dubia ? - Pseudotextularia
Adnatosphaeridium sp. and Hystrichosphaeridium sp. 2
SHALES: as above but generally darker – olive-grey to dark greenish grey.
Increase in agglutinating foraminifera
Some agglutinating foraminifera may be caved from Tertiary
Core depths quoted below are uncorrected
CORED INTERVAL: lithologies deduced from selected core pieces and wireline log evidence. Ditch cuttings not examined.
SHALE (core): moderately fissile, dark grey to olive-black, micaceous with lenses of SANDSTONE: friable, dusky yellowish brown, silty to fine grained.
R. fucatum, P. infusorioides (Core, 1891.80m)
S. delitiense (Core, 1895.45m)
1907 (log)
O. operculata, R. fucatum, P. pyrophorum (Core, 1911.46m)
N. gracilis, N. senex, N. triceras (Core, 1916.70m)
N. cf. spiculata (Core, 1918.50m)
Interbedded sequence of SANDSTONES, SHALES and COALS.
SANDSTONE: soft, friable, light olive-grey to olive-grey, very fine grained, subangular, micaceous, argillaceous, carbonaceous. SHALE: fissile, light olive-grey to olive-grey and dark yellowish brown carbonaceous, pyritic, often silty.
COAL: firm, black to greyish brown, brittle, subvitreous to earthy.
NESS FORMATION
CORES 1 - 9
1977 (log)
SANDSTONE: occasionally argillaceous.
EARLY JURASSIC – MIDDLE JURASSIC
LATEST TOARCIAN – EARLY BAJOCIAN
BRENT GROUP
ETIVE FORMATION
2003 (log)
Barren of in situ foraminiferas
Mancodinium semitabulatum subzone (XVIIIB) – Polysphaeridium deflandrei subzone (XVIIIA)
SANDSTONE (core): friable, light grey to light olive-grey, very fine to fine grained, angular, micromicaceous, often argillaceous – ? with calcareous concretions (log evidence).
RANNOCH FORMATION
JURASSIC
Nannoceratopsis gracilis zone (XVIII)
2074 (log)
DUNLIN/BRENT GROUP
DRAKE/BROOM FORMATION
SANDSTONE: friable, white, fine to very coarse, angular to subrounded with olive-grey CLAYSTONE interbeds.
2086 (log)
CLAYSTONE: (first seen in ditch cuttings samples at 2103m) olive-grey, to dark grey, micaceous, occasionally slightly silty.
Common/Abundant N. senex, N. gracilis
2106
Influx of agglutinating forms
K. cf. perisica
P. eumekes
MIDDLE – LATE TOARCIAN
DRAKE FORMATION
M. cf. liassica
C. toarciana
Trochammina
Mancodinium semitabulatum subzone (XVIIIB)
Probable faulted contact between the Drake and Burton formations between 2155m (SWC) and 2165m (SWC).
Middle – late Toarcian palynoflora (SWC)
2159 (log)
F ? F
CLAYSTONE: firm, olive-grey to medium dark grey, micaceous, silty occasionally with friable white SILTSTONE lenses.
Common N. gracilis, numerous L. spinosa (SWC)
EARLY JURASSIC
LATE PLIENSBACHIAN
DUNLIN GROUP
BURTON FORMATION
M. prima prima, D. matutina, T. tubulosa, H. amalthei
H. mouhersensis
Hungarella sp. B
C. cf. thiergartii (SWC)
G. apostolescui
Hungarella
Luehndea spinosa subzone (XVIIID)
Common/Abundant N. gracilis/N. senex (SWC)
2203 (log)
CLAYSTONE: firm, olive-grey to light olive-grey, micaceous, often highly silty and closely interbedded with SILTSTONE: firm, medium dark grey, micaceous, argillaceous.
CORE 10
L. spinosa, N. gracilis N. triceras (core)
Common Botryococcus spp. (SWC)
2235 (SWC)
D. terqueni, increased numbers of L. varians
CLAYSTONE: firm, medium dark grey to olive-grey, micromicaceous, locally slightly silty with rare SILTSTONE interbeds.
W. semiora
? In situ N. senex (SWC)
Common Echinoderm debris
H. etaulensis
Common Botryococcus spp. (SWC)
EARLY JURASSIC
SINEMURIAN – EARLY PLIENSBACHIAN
DUNLIN GROUP
AMUNDSEN FORMATION
7"
Ditch cuttings dominated by casing cement down to 2316m. Lithologies inferred from log.
K. cf. triebeli
I. unispinata
Lenticulina varians
Below 2319m ditch cuttings dominated by white, very fine to fine grained, angular SAND. From log evidence this would appear to be highly argillaceous and probably micaceous. Rare CLAYSTONE: olive-grey to medium grey, micaceous.
Incoming of coarser SAND – fine to medium but some coarse grained.
2372 (log)
SAND: unconsolidated, white, translucent to opaque, fine to very coarse grained, angular.
Barren of in situ foraminifera
NANSEN MEMBER
2397 (log)
Ditch cuttings dominated by SAND: as above but with rare carbonaceous debris; SHALES inferred from log evidence.
EIRIKSON MEMBER
SAND: as above but very coarse and highly angular.
2457 (log)
SAND: as above with CLAYSTONE: waxy, sandy, dark grey to olive-grey, rarely greyish red.
TRIASSIC – JURASSIC
LATE TRIASSIC – EARLY JURASSIC
STATFJORD FORMATION
red
RAUDE MEMBER
SAND: as above but CLAYSTONE is variegated, being olive-grey to dark grey, very dark red to purple, greenish grey, light olive-brown.
? In situ O. ovalis
1500
1525
1550
1575
1600
1625
1650
1675
1700
1725
1750
1775
1800
1825
1850
1875
1900
1925
1950
1975
2000
2025
2050
2075
2100
2125
2150
2175
2200
2225
2250
2275
2300
2325
2350
2375
2400
2425
2450
2475
2500
2525
2550
2575
2600
2625
T.D. 2646m