ROBERTSON RESEARCH INTER

STATOIL 15/9 - 14 NORWEGIAN NORTH SEA WELL: BIOSTRATIGRAPHY OF THE INTERVALS 180m – 2537m AND 2945m – 3563m T.D.

TECHNICAL REPORT

ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. 2829P/A

STATOIL 15/9 - 14 NORWEGIAN NORTH SEA WELL: BIOSTRATIGRAPHY OF THE INTERVALS 180m – 2537m AND 2945m – 3563m T.D.

by

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1. The youngest sediments to be analysed from this well are claystones with interbedded sandstones, of Pleistocene age, which are assigned to the Nordland Group.

2. The Nordland Group, Utsira Formation, which predominantly comprises sandstones, overlies the sandstones and shales of the Hordaland Group of Early Miocene to Early Eocene age.

3. The Hordaland Group Frigg Formation sandstones pass down into the Rogaland Group.

4. The Rogaland Group, deposited during the Late Palaeocene, is represented by shales with minor tuffaceous shales, of the Balder Formation and shales of the Sele and Lista Formations.

5. The interval 2537m-2945m was not examined on instructions from the client.

6. The Late Cretaceous Chalk Group comprises limestones with thin argillaceous partings, of the Hod Formation, argillaceous limestones and calcareous shales of the Plenus Marl Formation which overlie limestones of the Hidra Formation.

7. Non-calcareous shales of the Rødby Formation and the lithologically variable Valhall Formation, both of the Cromer Knoll Group, were deposited during the Early Cretaceous.

8. An unconformity separates the Cromer Knoll Group from the Humber Group, resulting in the absence of sediments of Valanginian and uppermost Ryazanian age.

9. The Humber Group is represented by shales of the Kimmeridge Clay and Heather Formations which overlie an interbedded sequence of coals, shales and sandstones of the Hugin Formation. These sediments range in age from Ryazanian - Volgian to early Callovian.

10. A major unconformity separates the Hugin Formation, of early Callovian age at the oldest, from the Triassic sandstones and claystones.

11. The well terminated in claystones assignable to the Skagerrak Formation.

II

INTRODUCTION

This report summarises the results of the micropalaeontological, palynological and stratigraphic analyses which have been carried out on material received from the intervals 180m-2537m and 2945m-3563m T.D. from the Statoil 15/9-14 Norwegian North Sea Well under Project No. RRPS/823/A/10360.

The interval 2537m-2945m was not analysed on receipt of instructions from the client.

The following analyses were carried out:
Lithology: 410 ditch cuttings, 10 sidewall core and 7 core samples from the entire section.
Micropalaeontology: 152 ditch cuttings and 5 sidewall core samples from the intervals 180m-2537m and 2945m-3167m.
Palynology: 47 ditch cuttings, 8 sidewall core and 7 core samples from the interval 3048m-3563m 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 pages 5 and 6.

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) and Larsen and Jaarvik (1981). The stratigraphic significance of the Rhaetian - Albian dinocyst zonation 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 Statoil with whom we have been associated during the course of this work.

Robertson Research staff involved in this study were:

Jim Fenton	-	Palynology
Dave Renshaw	-	Palynology
Alison Shaw	-	Lithostratigraphy
Rosemary Titterton	-	Micropalaeontology and Project co-ordinator

III

SUCCESSION

Age		Tops
Pleistocene		180m (top not seen)
Pliocene		600m
Late - Middle Miocene		930m
Early Miocene		1010m
Late Oligocene		1270m
Early Oligocene		1650m
Late - Middle? Eocene		1740m
Middle - Early? Eocene		1980m
Early Eocene		2363m
Late Palaeocene		2382m(log)
	Interval 2537m-2945m not examined	
Late Cretaceous		2945m(top not seen)
Late Cretaceous	Coniacian - Turonian	2963m
	Turonian	3017m
	Cenomanian	3074m(log)
	Albian	3127.50m(log)
Early Cretaceous	early Albian - Aptian	3131m
	early Aptian	3137m
	Barremian - Hauterivian	3140m
----------Unconformity----------		
Early Cretaceous - Late Jurassic	Ryazanian - Volgian	3176m(log)

	(Kimmeridgian? - Oxfordian	3211m(log)
	(	
Late Jurassic	(early? Oxfordian - middle Callovian	3221m
	(	
	(early Callovian	3254m

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

Triassic	3274m(log)-3563m T.D.

This breakdown has been achieved by the analysis of ditch cuttings, sidewall core and core piece samples. ISF/BHC/GR electric log information was made available.

Core depths quoted are uncorrected drillers depths.

IV

LITHOSTRATIGRAPHY

The lithostratigraphic nomenclature used in this report is taken from Deegan and Scull (1977) and Larsen and Jaarvik (1981).

Wireline logs (ISF/BHC/GR) were provided for use in this study. All but two of the lithological boundaries are based on log breaks.

LITHOSTRATIGRAPHIC UNITS

NORDLAND GROUP: 180m-1077.50m(log); Age: Pleistocene - Early Miocene.

Unassigned: 180m-926m(log); Age: Pleistocene - Pliocene.
The predominant lithologies between 180m and 324m are inferred from wireline log evidence to be claystones which are moderately soft, light olive grey, silty, and sandy with interbedded sandstones. The ditch cuttings samples contain only traces of claystone, most of which are assumed to have been washed out during the drilling process leaving fine to coarse sand, lithic fragments and shell debris. From 324m to 926m claystones are indicated by wireline logs but these sediments are still poorly represented in the ditch cuttings samples which contain predominantly fine to medium sand grains; pyrite rods occur sporadically below 390m. Sandy claystones are indicated on wireline logs between 675m and 700m and below 890m.

Utsira Formation: 926m(log)-1077.50m(log); Age: Pliocene - Early Miocene.
This unit consists of sandstone, represented in the ditch cuttings samples by very fine to coarse sand, with characteristically abundant shell fragments, pyrite rods and traces of glauconite. Minor argillaceous bands of olive grey, calcareous claystone occur intermittently throughout.

HORDALAND GROUP: 1077.50m(log)-2382m(log); Age: Early Miocene - Early Eocene.

Unassigned: 1077.50m(log)-2048m(log); Age: Early Miocene - Middle - Early ?Eocene.

This group comprises a sequence of sandstones and shales with subordinate carbonate stringers or concretions. The shales are subfissile to blocky, often grading to claystone, light brownish grey to brownish grey and dusky yellowish brown, locally silty, sandy and weakly calcareous, with sponge spicules between 1077.50m(log) and 1172m. Traces of glauconite (from 1525m to 1800m) and sand (between 1525m and 2048m(log)) in the ditch cuttings samples are probably derived from the argillaceous sediments. Sideritic limestone, considered to represent stringers or concretions, occurs sporadically down to 2048m(log). Sand units are indicated on wireline logs between 1170m and 1190m and from 1260m to 1311m being represented in ditch cuttings by fine to medium grained, loose sand. At and below 1960m, the predominant lithology is shale which is slightly waxy, greenish grey and micromicaceous, becoming silty and sandy with minor, very fine to fine grained, white sandstone below 2005m.

Frigg Formation: 2048m(log)-2382m(log); Age: Middle - Early? Eocene to Early Eocene.

The upper boundary top of this formation is taken at the top of a thick sandstone unit which characteristically underlies green shales. The sandstone is white to light brown with fine to medium and rare coarse grains, locally with calcareous cement. An interval of greenish grey to olive grey shales, with minor sandy interbeds is recorded between 2099m and 2146m. The underlying sandstone down to 2195m contains traces of glauconite. The remaining interval consists of greenish grey to olive grey and brownish grey shale with stringers or concretions of dolomitic limestone and limestone, with traces of pyrite and sphaerosiderite. The basal part of this formation, from 2357m to 2382m, comprises shales which are slightly waxy, greyish red, greenish grey and medium grey, with traces of green, waxy claystone. These lithologies typically overlie Rogaland Group volcanics and traces of sandy tuff are observed at and below 2378m in ditch cuttings samples.

ROGALAND GROUP: 2382m(log)-2537m; Age: Late Palaeocene.

Balder Formation: 2382m(log)-2425m(log).
The predominant lithologies are shales which are subfissile, greyish red, greenish grey, medium grey and micromicaceous with pyrite and siderite. These shales are associated with minor tuffaceous shales which are light greenish grey (with light and dark blebs) and light to dark grey with faint laminations. The shales become predominantly medium grey below 2405m. The appearance of traces of sandy tuff at 2378m may be due to a difference between drillers and loggers depths, unless reworking into the basal part of the Frigg Formation is invoked.

Sele Formation: 2425m(log)-2484m(log).
This unit consists of shales which are weakly fissile, light to dark grey and locally finely laminated, becoming more fissile and predominantly medium grey below 2465m. Greyish red and greenish grey shales with associated tuffs persisting in the ditch cuttings samples are presumed to be caved.

Lista Formation: 2484m(log)-2537m.
The predominant lithologies in this formation are fissile to subfissile, medium grey shales with traces of brownish grey, silty shale at 2535m. Traces of siderite are considered to represent stringers or concretions. The base of this formation is not seen due to a sample gap between 2537m and 2945m (including the turbo-drilled interval).

Interval 2537m-2945m not examined on receipt of instructions from client.

CHALK GROUP: 2945m-3127.50m(log); Age: Late Cretaceous, Coniacian to Cenomanian from 2963m.

Hod Formation: 2945m-3045.50m(log); Age: Coniacian to Turonian from 2963m.
This interval consists of limestones which are hard to moderately hard, cryptocrystalline, locally chalky, white to very light grey, pinkish grey and locally argillaceous. Subordinate shales, which are light to dark grey, greenish grey and locally calcareous, probably represent thin argillaceous partings within the limestone. At and below 3025m the limestones become

microcrystalline with very fine grains of glauconite. This is a characteristic feature of the basal part of the Hod Formation.

Plenus Marl Formation: 3045.50m(log)-3074m(log); Age: Turonian.
The lithologies in this formation contrast sharply with the less argillaceous sediments above and below. They comprise argillaceous limestones which are light grey to dark grey, microcrystalline to cryptocrystalline, locally glauconitic and micaceous with traces of pyrite, grading to calcareous shale below 3072m.

Hidra Formation: 3074m(log)-3127.50m(log); Age: Cenomanian.
This formation consists of limestone which is white to light grey and pinkish grey, cryptocrystalline and locally chalky with subordinate calcareous shale which is medium grey to olive grey, slightly silty and micaceous.

CROMER KNOLL GROUP: 3127.50m(log)-3176m(log); Age: Early Cretaceous, Albian to Barremian - Hauterivian.

Rødby Formation: 3127.50m(log)-3131m; Age: Albian.
The predominant lithology in this formation is shale which is subfissile, medium grey to greenish grey and non-calcareous.

Valhall Formation: 3131m-3176m(log); Age: early Albian - Aptian to Barremian - Hauterivian.
The upper boundary of this formation is placed at 3131m on the occurrence, in the ditch cuttings samples, of shales which are subfissile, greyish red and non-calcareous. These shales persist to a depth of 3140m, where wireline log evidence indicates the predominant lithology to be argillaceous limestone which is light grey to dark grey, crystalline and slightly silty. Traces of pale reddish brown and medium grey, calcareous claystones are recorded below 3150m. At and below 3158m, calcareous shales become the predominant lithology, these shales are subfissile, light grey to dark grey and greyish red, with traces of olive grey, slightly silty, calcareous claystone at 3170m. Between 3172.50m and 3176m the lithology comprises a distinctive limestone which is cryptocrystalline, light olive grey to white and pinkish grey with pyrite spheroids.

HUMBER GROUP: 3176m(log)-3274m(log); Age: Early Cretaceous - Late Jurassic, Ryazanian - Volgian to early Callovian.

Kimmeridge Clay Formation: 3176m(log)-3211m(log); Age: Ryazanian - Volgian to Kimmeridgian? - Oxfordian.
The predominant lithology in this unit is shale which is weakly fissile and locally earthy, olive black to dark grey, slightly silty and locally weakly calcareous.

Heather Formation: 3211m(log)-3225.50m(log); Age: early? Oxfordian - middle Callovian.
The presence of this formation is inferred from wireline log evidence, where the shales become less "hot". Lithologies are represented in ditch cuttings samples by olive black to dark grey, silty shales which are similar to the sediments comprising the overlying Kimmeridge Clay Formation and may not represent the in situ lithology.

Hugin Formation: 3225.50m(log)-3274m(log); Age: early? Oxfordian - middle Callovian to early Callovian.
This formation comprises an interbedded sequence of coals which are black and vitreous, locally grading to carbonaceous shales, with shales and claystones which are fissile to blocky, dark grey to brownish black, silty and micromicaceous. These grade to, and are interbedded with, argillaceous sandstones and sandstones which are friable to well cemented, yellowish grey to dusky yellowish brown, very fine to fine grained, locally micaceous, grading to siltstones.

"TRIASSIC GROUP": 3274m(log)-3563m T.D.; Age: Triassic.

Skagerrak Formation:
The upper part of this unit between 3274m(log) and 3350m comprises a sequence of shales and claystones which are light brownish grey and greenish grey, silty and sandy, becoming predominantly greyish red to moderate reddish brown with rare greenish grey colouration below 3305m. These sediments are interbedded with thin sandstones, which are friable to well cemented, white and pinkish grey to light greenish grey, very fine to medium grained and locally highly micaceous. Sandstone becomes the predominant lithology at and below 3350m

represented in ditch cuttings largely by loose sand with minor argillaceous bands and traces of pyrite. Below 3428m the sand becomes fine to coarse with white, moderate orange pink and pale green grains; the proportion of coarse grains and pink and green grains increases below 3455m. The sequence becomes increasingly argillaceous with depth below 3285m and at 3542m, the predominant lithology is claystone. This is greyish red to moderate reddish brown, slightly silty and micaceous with sandy and silty bands, possibly representing a transition to the more argillaceous Smith Bank Formation.

V

BIOSTRATIGRAPHY

V(1) QUATERNARY

INTERVAL 180m-600m; PLEISTOCENE (top not seen)

Lithostratigraphic Unit:
Nordland Group (part);
Unassigned.

Environment: marine, inner shelf.

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

- the occurrence of the Nonion granosum/Protelphidium orbiculare group, the Elphidium incertum group, Elphidium ustulatum and Elphidium asklundi in the sample 180m-190m.
- the subsequent occurrence of Globorotalia humerosa at 260m.

MICROPALAEONTOLOGY

In the youngest sample to be examined (180m-190m) the Elphidium incertum group/Nonion granosum/Protelphidium orbiculare group Assemblage is recognised by the presence of members of both groups. This assemblage indicates a Pleistocene age, which is substantiated by the occurrence of Elphidium ustulatum and E. asklundi in the same sample and of Globorotalia humerosa at 260m.

Within the upper half of the interval the assemblages are of moderate abundance and diversity and are dominated by calcareous benthonic foraminifera. Between 380m and 510m the microfaunas are poorly preserved, red stained and of low diversity. The microfaunas become particularly impoverished below 510m.

Reworked Palaeogene foraminifera were recorded between 260m and 300m and Late Cretaceous foraminifera at 280m.

V(2) TERTIARY

INTERVAL 600m-930m; PLIOCENE

Lithostratigraphic Units:
Nordland Group (part);
Unassigned: 600m-926m(log),
Utsira Formation : 926m(log)-930m.

Environment: marine, inner shelf.

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

- the occurrence of Cibicides lobatulus var. grossa at 600m.
- the subsequent occurrence of Cibicides pseudoungerianus at 870m and Nonion affine at 890m.

MICROPALAEONTOLOGY

At 600m there is a marked increase in abundance of the microfaunas. At this level the first occurrence of Cibicides lobatulus var. grossa indicates that sediments of Pliocene age have been penetrated. In the lower part of the interval, the incoming of Cibicides pseudoungerianus (870m) and Nonion affine (890m) confirms this age determination.

Although the microfaunas throughout the interval are of low diversity, Cassidulina laevigata and species of Cibicides and Elphidium are particularly abundant. The associations almost exclusively comprise calcareous benthonic foraminifera.

INTERVAL 930m-1010m; LATE - MIDDLE MIOCENE

Lithostratigraphic Unit:
Nordland Group (part);
Utsira Formation (part).

Environment: marine, inner to outer shelf.

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

- the occurrence of Cibicides peelensis, Globigerina praebulloides and Nonion boueanum at 930m.
- the subsequent occurrence of Hoeglundina elegans (950m) and Eponides umbonatus (970m).

MICROPALAEONTOLOGY

The incoming of Cibicides peelensis, in association with Globigerina praebulloides and Nonion boueanum, at 930m, defines the top of the Late - Middle Miocene in this well. The presence of Hoeglundina elegans (950m) and Eponides umbonatus (970m) within the interval, supports this age determination.

There is a marked increase in abundance and diversity of the microfaunas associated with the incoming of the Cibicides peelensis Assemblage. The microfaunas continue to be dominated by calcareous benthonic foraminifera but rare planktonic and agglutinating foraminifera also occur.

INTERVAL 1010m-1270m; EARLY MIOCENE

Lithostratigraphic Units:
Nordland Group (part): 1010m-1077.50m(log);
Utsira Formation (part).
Hordaland Group (part): 1077.50m(log)-1270m;
Unassigned (part).

Environment: marine, inner to outer shelf.

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

- the occurrence of Asterigerina staeschei at 1010m.
- the subsequent occurrence of the ostracod Thaerocythere bassiounii (1030m) and the Globorotalia scitula group (1250m).

MICROPALAEONTOLOGY

The incoming of Asterigerina staeschei at 1010m is considered to define the top of the Early Miocene. Thaerocythere bassiounii (1030m) and the appearance of planktonic foraminifera of the Globorotalia scitula group (1250m) are also characteristic of the Early Miocene.

The samples at the top of the interval yielded diverse assemblages but the abundance and diversity of the microfaunas decrease downwell. Calcareous benthonic foraminifera remain the dominant element, although there is a significant increase in planktonic foraminifera at and below 1230m.

INTERVAL 1270m-1650m; LATE OLIGOCENE

Lithostratigraphic Unit:
Hordaland Group (part);
Unassigned (part).

Environment: marine, outer shelf to upper bathyal shallowing to inner to outer shelf.

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

- the occurrence of Asterigerina gürichi at 1270m.
- the subsequent occurrence of Sigmoilina tenuis (1400m) and Sigmoilina schlumbergeri (1430m).

MICROPALAEONTOLOGY

The Asterigerina gürichi Assemblage of Late Oligocene age is recognised at 1270m with the incoming of the nominate species. At 1400m there is a marked change in the microfaunas, to assemblages dominated by agglutinating foraminifera, which is associated with the upper limit of the Sigmoilina schlumbergeri Assemblage. Associations characteristic of this assemblage, with common to abundant species of Bathysiphon, Cyclammina and Haplophragmoides, continue to the base of the interval.

INTERVAL 1650m-1740m; EARLY OLIGOCENE

Lithostratigraphic Unit:
Hordaland Group (part);
Unassigned (part).

Environment: marine, outer shelf to upper bathyal.

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

- the occurrence of Rotaliatina bulimoides at 1650m.

MICROPALAEONTOLOGY

The upper and lower occurrences of Rotaliatina bulimoides define the limits of the Rotaliatina bulimoides Assemblage which indicates the presence of Early Oligocene sediments. The microfaunas continue to be dominated by agglutinating foraminifera, notably species of Bathysiphon and Cyclammina.

INTERVAL 1740m-1980m; LATE - MIDDLE? EOCENE

Lithostratigraphic Unit:
Hordaland Group (part);
Unassigned (part).

Environment: marine, outer shelf to upper bathyal.

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

- the recognition of the Trochammina globigeriniformis/Trochammina sp. X/ Cystammina sp. Assemblage throughout the interval.
- the stratigraphic position (between Early Oligocene and Middle - Early? Eocene deposits).

MICROPALAEONTOLOGY

No age diagnostic forms were recovered from this interval although the presence of the Trochammina globigeriniformis/Trochammina sp. X/Cystammina sp. Assemblage is consistent with the general Late - Middle? Eocene age assigned. This age is based on the stratigraphic position of the interval between Early Oligocene and Middle - Early? Eocene sediments.

The microfaunal associations within this interval are moderate to high in abundance but of low diversity. Long-ranging agglutinating foraminifera are the dominant element, with species of Bathysiphon and Cyclammina being particularly abundant.

INTERVAL 1980m-2363m; MIDDLE - EARLY? EOCENE

Lithostratigraphic Units:
Hordaland Group (part);
Unassigned (part): 1980m-2048m(log),
Frigg Formation (part): 2048m(log)-2363m.

Environment: marine, outer shelf to upper bathyal.

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

- the occurrence of Spiroplectammina spectabilis at 1980m.
- the subsequent occurrence of Ammobaculites sp. 1 at 2000m.

MICROPALAEONTOLOGY

The incoming of Spiroplectammina spectabilis at 1980m defines the top of the Ammobaculites sp. 1/Verneuilina subeocaena/Spiroplectammina spectabilis Assemblage, with Ammobaculites sp. 1 appearing 2000m. Regional knowledge indicates that this assemblage is Middle - Early? Eocene in age.

Agglutinating foraminifera continue to dominate the microfaunas. The microfaunal associations are generally of moderate abundance and diversity but are impoverished between 2141m and 2237m.

INTERVAL 2363m-2382m(log); EARLY EOCENE

Lithostratigraphic Unit:
Hordaland Group (part);
Frigg Formation (part).

Environment: marine, outer shelf to upper bathyal.

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

- the occurrence of members of the Globigerina linaperta group at 2363m.
- the recognition of the Globigerina triloculinoides Assemblage throughout the interval.

MICROPALAEONTOLOGY

Microfaunas characteristic of the Globigerina triloculinoides Assemblage are recognised at 2363m with the incoming of members of the Globigerina linaperta group and the subsequent influx of Globigerina triloculinoides at 2381m. This assemblage confirms the presence of sediments of Early Eocene age.

At 2381m the first downhole occurrence of the pyritised diatoms Coscinodiscus sp. 1 and sp. 2 is recorded. This is considered to be due to reworking of the underlying Late Palaeocene sediments or due to a discrepancy between drillers and loggers depths.

INTERVAL 2382m(log)-2537m; LATE PALAEOCENE

Lithostratigraphic Units:

Rogaland Group;

Balder Formation : 2382m(log)-2425m(log),

Sele Formation : 2425m(log)-2484m(log),

Lista Formation : 2484m(log)-2537m.

Environment: marine, outer shelf to upper bathyal.

The upper limit of this interval is based on a log break at 2382m which marks the top of the Balder Formation.

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

- the recognition of the Coscinodiscus sp. 1 Assemblage between 2390m and 2483m.
- the subsequent occurrence of Labrospira pacifica (2519m).

MICROPALAEONTOLOGY

The pyritised diatoms Coscinodiscus sp. 1 and sp. 2 are believed to be in situ between 2390m and 2483m, indicating a Late Palaeocene age. This age determination is confirmed by the subsequent occurrence of Labrospira pacifica at 2519m.

The microfaunas throughout the interval are of low diversity and abundance, being dominated by species of the agglutinating genus Bathysiphon.

V(3) CRETACEOUS

INTERVAL 2945m-2963m; LATE CRETACEOUS (top not seen)

Chalk Group (part);
Hod Formation (part).

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

- the stratigraphic position of the interval overlying sediments of Coniacian - Turonian age.
- the occurrence of Inoceramus debris (2954m).

MICROPALAEONTOLOGY

The two samples at 2945m and 2954m, taken at the base of the turbo-drilled section (2684m-2946m), did not yield any age restricted microfossils. A general Late Cretaceous age only can be assigned on the occurrence of Inoceramus debris (2954m) and the stratigraphic position of the interval.

INTERVAL 2963m-3017m; LATE CRETACEOUS, CONIACIAN - TURONIAN

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

Environment: marine, outer shelf.

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

- the occurrence of common actinommid radiolaria at 2963m.
- the subsequent occurrence of Stensioina exsculpta, S. praeexsculpta, Globotruncana linneiana tricarinata (2972m), G. linneiana linneiana (2981m) and G. linneiana cf. coronata (3008m).

MICROPALAEONTOLOGY

The incoming of common actinommid radiolaria at 2963m and the assemblage recovered at 2972m which includes Stensioina exsculpta, S. praeexsculpta and Globotruncana linneiana tricarinata, indicates a Coniacian - Turonian age. The subsequent occurrence of Globotruncana linneiana linneiana (2981m) and G. linneiana cf. coronata (3008m) provides confirmation of this age.

INTERVAL 3017m-3074m(log); LATE CRETACEOUS, TURONIAN

Lithostratigraphic Units:
Chalk Group (part);
Hod Formation (part): 3017m-3045.50m(log),
Plenus Marl Formation: 3045.50m(log)-3074m(log).

Environment: marine, outer shelf.

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

- the occurrence of questionable species of ?Praeglobotruncana cf. stephani at 3017m.
- the subsequent influx of Praeglobotruncana cf. stephani (3062m) and Hedbergella delrioensis (3071m).

MICROPALAEONTOLOGY

The appearance of a questionable species of ?Praeglobotruncana cf. stephani at 3017m suggests that sediments of Turonian age are present. The influx of P. cf. stephani at 3062m confirms this age determination. The influx of Hedbergella delrioensis (3071m) is consistent with this age determination. The microfaunas of the Praeglobotruncana cf. stephani Assemblage from this interval are characteristically impoverished and poorly preserved.

PALYNOLOGY

Relatively diverse microplankton dominated assemblages were recovered from the sidewall core (3048m) and ditch cuttings samples from within this interval. The assemblages are characterised by common to abundant specimens of the Spiniferites ramosus group, Palaeohystrichophora infusorioides and Surculosphaeridium longifurcatum. The ditch cuttings, however, are subject to considerable modification by, predominantly, Palaeocene cavings.

The presence of Pseudoceratium turneri and Litosphaeridium siphoniphorum in the sidewall core at 3048m, which have ranges of Cenomanian - late Albian, is considered to have resulted from drilling mud contamination, in view of the micropalaeontological and other palynological evidence. The presence of Hystrichosphaeridium difficile, at 3048m(SWC) and in a ditch cuttings sample at 3050m, reflects the presence of sediments no older than Turonian in age.

INTERVAL 3074m(log)-3127.50m(log); LATE CRETACEOUS, CENOMANIAN

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

Environment: marine, inner to outer shelf.

The top of this interval is based on the log break at 3074m which marks the top of the Hidra Formation.

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

- the appearance of Litosphaeridium siphoniphorum at and below 3074m.
- the more consistent occurrence of Hedbergella delrioensis from 3083m.
- the occurrence of Eggerelina mariei (3086m) and Gavelinella cf. baltica (3092m).

MICROPALAEONTOLOGY

The penetration of the Hidra Formation of Cenomanian age is indicated by the log break at 3074m. The Rotalipora/Hedbergella - Hedbergella delrioensis/Gavelinella cf. baltica Assemblage is recognised at and below 3086m with the appearance of abundant, well preserved specimens of Hedbergella delrioensis and the subsequent occurrence of Gavelinella cf. baltica (3092m). This assemblage is characteristic of sediments of the Cenomanian. The presence of Eggerelina mariei (3086m) is consistent with this age determination.

PALYNOLOGY

Microplankton dominated palynofloras were recovered from the ditch cuttings and sidewall core analysed from this interval. The assemblages are characterised by the presence of Litosphaeridium siphoniphorum and Palaeohystrichophora infusorioides, together with persistent Spiniferites ramosus group. Impoverished palynofloras were encountered in the lower part of the interval from 3116m. The presence of Litosphaeridium siphoniphorum at and below 3074m indicates the penetration of sediments no younger than Cenomanian in age.

INTERVAL 3127.50m(log)-3131m; EARLY CRETACEOUS, ALBIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part);
Rødby Formation.

Environment: marine, inner to outer shelf.

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

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

- the general nature of the microfaunas.

MICROPALAEONTOLOGY

At 3128m there is a slight increase in diversity of the microfaunas with some selective pink staining. This, and the increase in numbers of well preserved Hedbergella delrioensis, indicate that sediments of Albian age are present at this depth.

PALYNOLOGY

A single ditch cuttings sample was analysed from this interval, yielding an impoverished, non-age diagnostic palynoflora.

INTERVAL 3131m-3137m; EARLY CRETACEOUS, EARLY ALBIAN - APTIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part);
Valhall Formation (part).

Environment: marine, inner to outer shelf.

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

- the influx of agglutinating foraminifera at 3131m.
- the appearance of abundant "Lingulogavelinella" gyroidiniformis and Hedbergella planispira at 3131m.

MICROPALAEONTOLOGY

At 3131m there is a significant change in the microfaunas with an increase in agglutinating foraminifera, particularly species of Recurvoides and Glomospira gordialis, associated with abundant "Lingulogavelinella" gyroidiniformis and Hedbergella planispira. This association, and that in the sample at 3134m, are representative of the Recurvoides/Glomospira Assemblage of early Albian - Aptian age. Although the abundance of H. planispira is a feature which characterises the base of the Albian, it is probably due to caving from the basal part of the overlying interval. The majority of the microfossils are characteristically red stained with some white stained forms.

PALYNOLOGY

A sparse, non-age diagnostic palynoflora was recovered from the ditch cuttings sample at 3134m.

INTERVAL 3137m-3140m; EARLY CRETACEOUS, EARLY APTIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part);
Valhall Formation (part).

Environment: marine, inner to outer shelf.

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

- an influx of species of Hedbergella, including H. infracretacea at 3137m.

MICROPALAEONTOLOGY

The influx of red stained species of Hedbergella and particularly the presence of H. infracretacea at 3137m are characteristic of the Hedbergella infracretacea Assemblage. This assemblage indicates that sediments of early Aptian age have been penetrated.

INTERVAL 3140m-3176m(log); EARLY CRETACEOUS, BARREMIAN - HAUTERIVIAN

Lithostratigraphic Unit:
Cromer Knoll Group (part);
Valhall Formation (part).

Environment: shallow marine, inner shelf.

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

- the occurrence of the ostracod Pontocyprella mandelstami at 3140m.
- the increase in numbers of calcareous benthonic foraminifera (3140m).
- the appearance of Uvigerinammina moesiana (3143m).
- the subsequent appearance of Gonyaulacysta kostromiensis, in association with Sirmiodinium grossii and Pseudoceratium pelliferum in a ditch cuttings sample at 3170m.

MICROPALAEONTOLOGY

Microfaunal associations characteristic of the Calcareous Benthonics/Ostracods Assemblage of Barremian - Neocomian age are recognised at 3140m, and throughout the interval, with the incoming of ostracods and an increase in numbers of calcareous benthonic foraminifera, particularly species of Lenticulina. The occurrence of the ostracod Pontocyprella mandelstami (3140m) and Uvigerinammina moesiana (3143m) supports the Barremian - Hauterivian age for this interval.

PALYNOLOGY

Microplankton dominated palynofloras were recovered from the ditch cuttings samples from this interval. The sidewall core at 3141m is considered to be subject to drilling mud contamination, mainly from the Late Jurassic, while the sidewall core at 3170m contains a poor non-age diagnostic palynoflora.

The assemblages from the ditch cuttings are characterised by the occurrence of the Spiniferites ramosus group and common to abundant undifferentiated bisaccate pollen. Associations within the ditch cuttings at 3146m and 3158m indicate a general Early Cretaceous age. The ditch cuttings sample at 3170m, however, yielded a rich and diverse microplankton dominated assemblage with the appearance of common specimens of Sirmiodinium grossii and

Pseudoceratiumpelliferum; the latter feature, on regional criteria, indicating a Hauterivian age. A Hauterivian age is confirmed by the simultaneous occurrence of Gonyaulacysta kostromiensis, a dinocyst considered to be stratigraphically restricted to deposits of Hauterivian age.

Reworking of Callovian to Ryazanian age is indicated by the presence of single specimens of Gonyaulacysta jurassica and Gochteodinia villosa.

V(4) CRETACEOUS - JURASSIC

INTERVAL 3176m(log)-3211m(log); EARLY CRETACEOUS - LATE JURASSIC, RYAZANIAN - VOLGIAN

Lithostratigraphic Unit:
Humber Group (part);
Kimmeridge Clay Formation.

Environment: marine, inner shelf with anaerobic bottom conditions and possible water stratification.

The top of this interval is based on a log break at 3176m which marks the top of the Kimmeridge Clay Formation.

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

- the appearance of Dingodinium spinosum, in association with Canningia sp. A, in the sidewall core at 3179.30m.
- an influx of amorphous kerogen at 3179.30m(SWC).
- the subsequent appearance of a questionable specimen of Oligosphaeridium pulcherrimum sensu Ioannides et al. at 3206m.

PALYNOLOGY

Microplankton dominated assemblages were recovered from this interval. The assemblages are characterised by the presence of leiospheres and Pterospermella spp. The appearance of Dingodinium spinosum, in association with Canningia sp. A at 3179.30m(SWC) indicates the penetration of Ryazanian - late Volgian sediments. The subsequent occurrence of a questionable specimen of Dichadogonyaulax pannea, in a ditch cuttings sample at 3182m, may indicate the presence of sediments no younger than middle Volgian, whilst at 3206m a questionable specimen of Oligosphaeridium pulcherrimum sensu Ioannides et al. tentatively suggests the penetration of early Volgian sediments. Regional considerations suggest that this interval is probably at least as old as middle Volgian in age. The questionabde specimen of O. pulcherrimum sensu Ioannides et al. tentatively suggests, if in situ, the presence of deposits no younger than early Volgian in age.

An influx of amorphous kerogen at 3179.30m(SWC) indicates the penetration of sediments attributable to the Kimmeridge Clay Formation, this evidence is further supported by information from wireline logs.

A hiatus may be present at the base of this interval, being reflected by a marked log break, resulting in the absence of some deposits of early Volgian and Kimmeridgian ages. Due to the paucity of age diagnostic taxa, however, no positive palynofloral evidence has been encountered.

V(5) JURASSIC

INTERVAL 3211m(log)-3221m; LATE JURASSIC, KIMMERIDGIAN? - OXFORDIAN

Lithostratigraphic Unit:
Humber Group (part);
Heather Formation (part).

Environment: marine, inner shelf with anaerobic/dysaerobic bottom conditions progressively established.

The top of this interval is defined on a log break.

The age of this interval is based on the following palynological evidence:

- the presence of Scriniodinium luridum, in association with Gonyaulacysta jurassica and common specimens of microforaminiferal test linings in a sidewall core at 3219m.
- a questionable specimen of Scriniodinium crystallinum at 3219m(SWC).

PALYNOLOGY

One ditch cuttings sample and a sidewall core were analysed from this interval. The ditch cuttings sample at 3218m yielded a relatively impoverished microplankton dominated assemblage which includes specimens of Oligosphaeridium pulcherrimum sensu Ioannides et al., this, if in situ, suggests an age no older than Kimmeridgian. No age diagnostic forms indicating the presence of older sediments were encountered at this level.

The sidewall core at 3219m yielded a relatively diverse, palynoflora. Miospores include common undifferentiated bisaccates and Cerebropollenites mesozoicus. The appearance of Gonyaulacysta jurassica and Scriniodinium luridum, in association with common microforaminiferal test linings, indicate the penetration of Kimmeridgian - Oxfordian sediments. A questionable specimen of Scriniodinium crystallinum may indicate the presence of sediments no younger than early Kimmeridgian in age, whilst the occurrence of a single specimen of Glossodinium dimorphum suggests an age no older than mid Oxfordian, Subzone (XIIB). Regional considerations suggest that the palynofloras recovered from

this interval may be no younger than Oxfordian in age, although on the evidence seen a Kimmeridgian age at the youngest cannot be excluded.

INTERVAL 3221m-3254m; LATE JURASSIC, EARLY? OXFORDIAN - MIDDLE CALLOVIAN

Lithostratigraphic Units:
Humber Group (part);
Heather Formation (part): 3221m-3225.50m(log),
Hugin Formation (part): 3225.50m(log)-3254m.

Environment: non marine, deltaic - marginal marine to inner shelf (in upper part).

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

- the appearance of Adnatosphaeridium aemulum at 3221m.
- the subsequent appearance of large specimens of Verrucosisporites spp. and Kraeuselisporites "hyalinus" at 3228.61m(core).
- the occurrence of Dichadogonyaulax stauromatos at 3233.22m(core).

PALYNOLOGY

This interval may be divided into two distinct units, the upper is characterised by predominantly marine assemblages. The appearance of several specimens of Adnatosphaeridium aemulum at 3221m suggests, on regional criteria, the presence of sediments of early Oxfordian age. Any positive evidence for the presence of early Oxfordian was not encountered, however. Adnatospheridium aemulum reaches its numerical acme in deposits of early Oxfordian age. The lower unit (below 3225.50m(log)) of the interval contains miospore dominated assemblages, characterised by undifferentiated bisaccates, Deltoidospora spp., Cerebropollenites mesozoicus and Araucariacites australis. The appearance of large Verrucosisporites spp. and Kraeuselisporites "hyalinus" in a core sample at 3228.61m indicates the penetration of Callovian sediments. The subsequent occurrence of Dichadogonyaulax stauromatos at 3233.22m(core) represents the penetration of sediments of late Callovian age, equivalent to the Mendicodinium groenlandicum Subzone (XIVC). At 3242m a questionable specimen of Neoraistrickia gristhorpensis indicates the presence of middle Callovian sediments.

The Oxfordian/Callovian boundary cannot be accurately located, however, regional knowledge suggests the possibility that this boundary may coincide with the Heather/Hugin formational boundary (at 3225.50m(log)).

INTERVAL 3254m-3274m(log); LATE JURASSIC, EARLY CALLOVIAN

Lithostratigraphic Unit:
Humber Group (part);
Hugin Formation (part).

Environment: marginal marine - non-marine, deltaic.

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

- the appearance of abundant Nannoceratopsis pellucida at 3254m.
- the subsequent occurrence of numerous Valensiella spp. in a sidewall core at 3261.30m.

PALYNOLOGY

Palynofloras recovered from this interval range from samples dominated by rich and diverse microplankton assemblages to those containing diverse miospore assemblages. The trend is for samples to reflect stronger terrestrial influences downhole.

The appearance of abundant Nannoceratopsis pellucida, which is a regional event marking the top of the early Callovian, occurs at 3254m. The subsequent occurrence of numerous Valensiella spp. is also associated with sediments of early Callovian age. The core piece at 3271.25m contains a rich and diverse microplankton assemblage which includes abundant Deltoidospora spp., common Cerebropollenites mesozoicus and common undifferentiated bisaccates.

Common to abundant Pareodinia ceratophora, together with numerous specimens of Valensiella spp., in a sidewall core at 3261.30m represent an early Callovian assemblage of marginal marine origin. This is an event of regional significance, which may be of correlative value.

A single specimen of Nannoceratopsis gracilis occurs at 3254m indicating the reworking of Middle - Early Jurassic sediments.

(V)6 TRIASSIC

INTERVAL 3274m(log)-3563m T.D.; TRIASSIC

Lithostratigraphic Unit:
"Triassic Group";
Skagerrak Formation.

Environment: terrestrial, lacustrine/fluviatile.

The upper limit of this interval is defined on a log break. The age is based on lithological criteria.

PALYNOLOGY

In view of the lithologies encountered within this interval and the fact that the core sample at 3285.28m was barren of palynomorphs, the assemblages recovered from the ditch cuttings are considered to result from caving.

GEOLOGICAL HISTORY

TRIASSIC	The oldest sediments examined are claystones which are considered to have been deposited in an arid, terrestrial, fluvio-lacustrine environment. The increasing amount of sand deposited, is possibly a result of the rejuvenation of source areas.
EARLY - MIDDLE JURASSIC	ABSENT; due to either non-deposition or deposition with subsequent erosion.
EARLY CALLOVIAN - EARLY? OXFORDIAN	The early Callovian transgression is indicated by the resumption of sedimentation in a marginal marine environment. Interbedded coal seams, carbonaceous shales, shales and sandstones were deposited, probably in a deltaic or offshore bar complex environment close to a palaeoshoreline. A gradual increase in water depth to inner shelf conditions resulting from the regional early Oxfordian transgression led to the subsequent deposition of shales.
KIMMMERIDGIAN? - OXFORDIAN TO RYAZANIAN	The deposition of shales continued in an inner shelf environment. However, stratification of the water column resulted in the deposition of the Kimmeridge Clay Formation under anaerobic bottom conditions.

VALANGINIAN	ABSENT; sedimentation probably ceased during the regional Valanginian tectonic phase.
HAUTERIVIAN - ALBIAN	The Hauterivian transgression resulted in a shallow inner shelf environment being established, in which calcareous claystones and argillaceous limestones were laid down. Water depth increased, during the early Aptian transgression, to inner to outer shelf conditions in which deposition of shales continued to the Albian.
CENOMANIAN - CONIACIAN	Limestones accumulated in outer shelf seas with little terrigenous input. However, during the Turonian an influx of terrigenous material is indicated by the deposition of argillaceous limestones of the Plenus Marl Formation.
SANTONIAN - DANIAN	Not examined.
LATE PALAEOCENE - EARLY OLIGOCENE	By the Late Palaeocene outer shelf to upper bathyal depths had been established due to basinal subsidence. Continual subsidence and deposition led to the accumulation of a thick sequence of shales of the Rogaland and Hordaland Groups. Tuffaceous shales were deposited at the end of the Palaeocene during tectonic events associated with North Atlantic rifting. During the Middle - Early? Eocene an influx of terrigenous material is indicated by sandstones of the Frigg Formation.

LATE OLIGOCENE - PLEISTOCENE

There was an overall decrease in water depth throughout with a decrease in subsidence resulting in the gradual infilling of the North Sea Basin. Inner to outer shelf conditions prevailed in the Late Oligocene and Early Miocene, shallowing to the inner shelf seas of the Plio-Pleistocene. Predominantly argillaceous sediments were deposited, with shelly sands of the Utsira Formation being deposited during the Miocene. The increase in arenaceous material at the top of the Pleistocene is probably due to the incoming of sands of a glacial origin.

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APPENDIX 1

SIDEWALL CORE DESCRIPTIONS

Depth	Rec.	Qual.	Type of Analysis		Lithology
3048m	Frags.	Fair	M	P	ARGILLACEOUS LIMESTONE: moderately soft, light grey to light olive grey, microcrystalline, glauconitic, micaceous.
3082.40m	Frags.	Fair	M	P	CALCAREOUS CLAYSTONE: moderately hard to soft, slightly waxy, medium grey, with glauconite grains, silty, micaceous, calcareous.
3141m	Frags.	Poor	M	P	ARGILLACEOUS LIMESTONE: hard, medium dark grey to dark grey, cryptocrystalline, slightly silty.
3170m	Frags.	Fair	M	P	CALCAREOUS CLAYSTONE: moderately soft, light olive grey to light grey, slightly silty, strongly calcareous.
3179.30m	Frags.	Fair	M	P	SHALE: soft to moderately soft and firm, subfissile, earthy, olive black, slightly silty and micromicaceous (very weakly calcareous).
3219m	Frags.	Fair		P	SHALE: as 3179.30m.
3239.30m	Frags.	Fair		P	SANDSTONE: friable, white to yellowish grey, very fine to fine grained, subangular, micaceous, silty (non-calcareous), grading to ARGILLACEOUS SANDSTONE: friable, pinkish grey to light brownish grey, very fine to fine grains, with mica and carbonaceous fragments, argillaceous. Also thin bands of SANDY SHALE: moderately soft, subfissile, slightly waxy, dusky yellowish brown, silty, sandy and micaceous.

3261.30m	15mm+ Frags.	Fair	P	SANDSTONE: friable, pinkish grey with dark bands (light brownish grey), very fine grained, with mica, fine carbonaceous particles and argillaceous bands.
3337m	Frags.	Fair		SHALE: soft, subfissile, greenish grey, micaceous with very fine sand and rare fine, light brown quartz grains.
3560m	18mm	Good		CLAYSTONE: soft, moderate reddish brown, micromicaceous.

KEY

M = Micropalaeontology

P = Palynology

Frags. = Fragments

Qual. = Quality

Rec. = Recovery

APPENDIX 2

CORE PIECE DESCRIPTIONS

Depth	Core No.	Type of Analysis	Lithology
3228.56m-3228.61m	1	P	SILTY CLAYSTONE: hard, dark grey to brownish black, micromicaceous, silty, non-calcareous.
3231.27m-3231.30m	1	P	SILTY CLAYSTONE: as 3228.56m-3228.61m, with thin, discontinuous lenses of CLAYSTONE: hard, brownish black, and SANDSTONE: hard, medium grey, very fine grained, argillaceous, micaceous, grading to SILTSTONE: (flaser bedding).
3233.15m-3233.22m	1	P	SANDSTONE: hard, yellowish grey, very fine grained micaceous, grading to SILTSTONE: as 3231.27m-3231.30m, with SILTY CLAYSTONE: and CLAYSTONE: as 3231.27m-3231.30m, but strongly bioturbated.
3267.56m-3267.61m	2	P	CARBONACEOUS SHALE/COAL: hard, subfissile, greyish black, highly carbonaceous shale, with lenses and rootlets of hard, vitreous, black coal.
3271.20m-3271.25m	2	P	SILTSTONE: hard, olive grey, micromicaceous, with black carbonaceous rootlets and fragments of plant debris.
3275.72m-3275.76m	2	P	MICACEOUS SILTSTONE: moderately soft, fissile, light grey, rare very fine sand, highly micaceous, bioturbated with burrow consisting of MICACEOUS SANDSTONE: moderately hard, very light grey, very fine grained, micaceous.

3285.23m-3285.28m	2	P	SANDSTONE: hard, light greenish grey, very fine grained (subangular to subrounded) with rare dark grains concentrated in laminae (probably heavy minerals), showing cross bedding.

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		
		middle	*lautus*		*Systematophora cretacea* OIIC
			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
		early	*rarocinctum*		*Kleithriasphaeridium corrugatum* IC
	Hauterivian*	late	*variabilis*	*Subtilisphaera terrula* II	*Adnatosphaeridium vetuscuium* 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* spp. 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
			oppressus		
		middle	*giganteus*	*Muderongia* sp. A VII	*Dichadogonyaulax pannea* VIIA
			gorei		*Dichadogonyaulax culmula* VIIB
			albani		*Glossodinium dimorphum* VIIC
			Epipallasiceras sp.		
			rotunda		
			pallasioides	*Pareodinia mutabilis* VIII	*Gonyaulacysta pennata* VIIIA
			Pavlovia sp.		*Gonyaulacysta jurassica* VIIIB
		early	*pectinatus*		
			hudlestoni	*Gonyaulacysta longicornis* IX	*Egmontodinium polyplacophorum* IXA
			wheatleyensis		
			scitulus		*Scriniodinium luridum* IXB
			elegans		
	Kimmeridgian		*autissiodorensis*	*Gonyaulacysta cladophora* X	
			eudoxus		
			mutabilis		
			cymodoce		
			baylei	*Scriniodinium crystallinum* XI	*Leptodinium egemenii* XIA
					Stephanelytron redcliffense XIB
	Oxfordian	late	*pseudocordata*	*Scriniodinium galeritum* XII	*Scriniodinium oxfordianum* XIIA
			decipiens		*Compositosphaeridium costatum* XIIB
			cautisnigrae		
		middle	*transversarium*	*Acanthaulax spinosissima* XIII	
			plicatilis		
		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		*Gonyaulacysta filapicata* XVIC
		middle	*morrisi*		
			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*		"Sphaeromorphs" XVIIIC
			bifrons		
		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)
Dolomitic limestone

Calcareous dolomite
Dolomite
Chalk
Chert
Anhydrite
Salt (halite)
Potassium salts
Concretions/nodules
Igneous rocks, undifferentiated
Basement, undifferentiated
Granite

Qualifiers

Argillaceous
Silty/sandy
Pebbly
Carbonaceous
Calcareous
Dolomitic
Red sediments — red

Accessories

Calcite — C
Ironstone (ferruginous) — 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

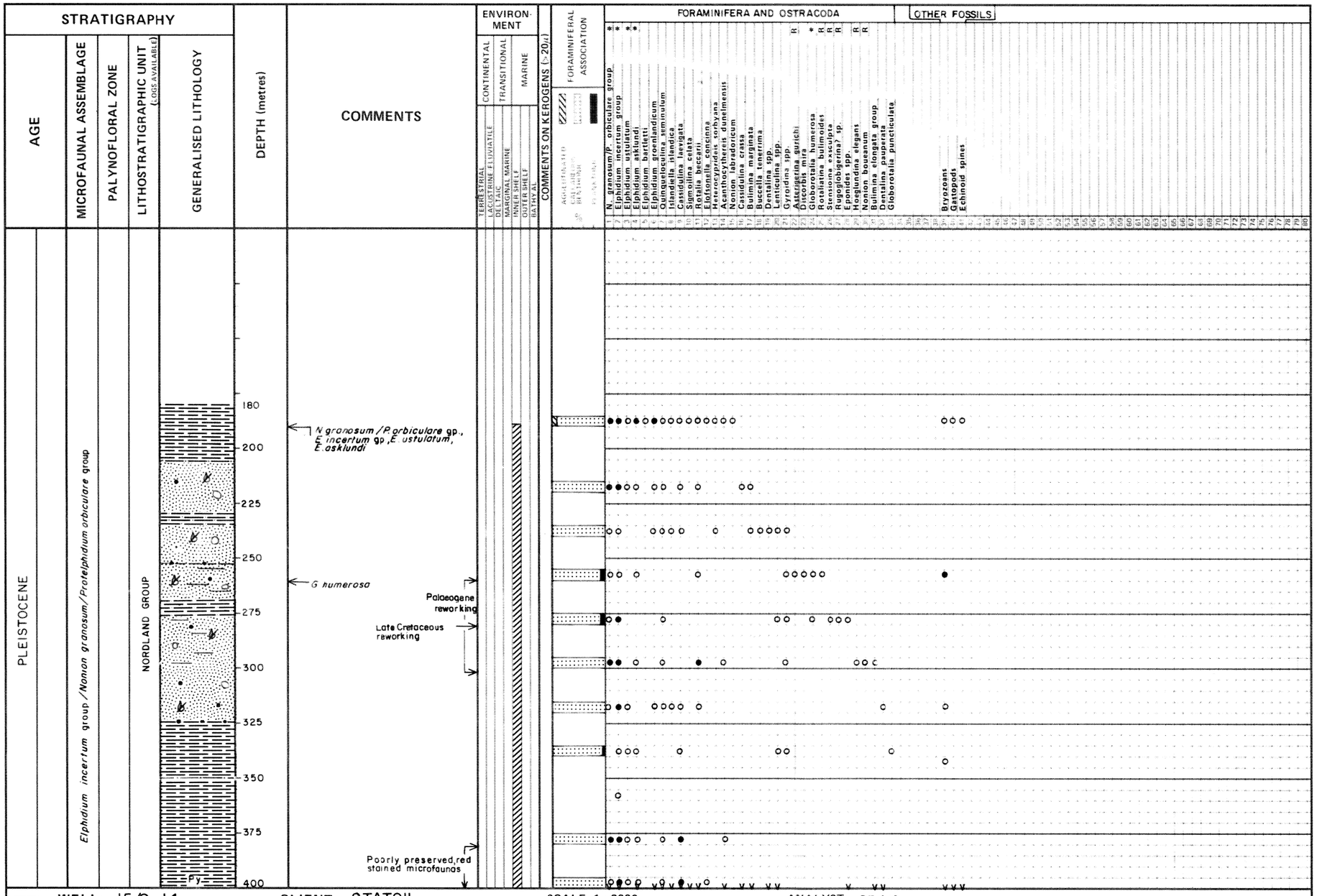
Fossil Abundances
- Present — o
- Common — ●
- Abundant — ■

Diagnostic forms — *
Caved forms — C
Reworked forms — R
Incoming of
Outgoing of
Unconformity/stratigraphic hiatus
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 (no recovery)

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



WELL:–15/9-14
CHART:–1 of 12
FIGURE:– 2

CLIENT:–STATOIL
DEPTH:–180m–400m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RT, AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

WELL:- 15/9-14
CHART:- 2 of 12
FIGURE:- 3

CLIENT:- STATOIL
DEPTH:- 400m-700m
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:- RT, AJS
DRAWING NO.:- 829P/10360/5243
DATE:- OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: PLIOCENE | PLEISTOCENE

MICROFAUNAL ASSEMBLAGE: *Cibicides lobatulus* var. *grossa*/*Nonion affine* | *Elphidium incertum* group/*Nonion granosum*/*Protelphidium orbiculare* group

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): NORDLAND GROUP

GENERALISED LITHOLOGY: Py Py Py Py

DEPTH (metres): 700 675 650 625 600 575 550 525 500 475 450 425 400

COMMENTS:
- *C. lobatulus* var. *grossa*
- Poorly preserved, red stained microfaunas
- Poorly preserved, red stained microfaunas

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

COMMENTS ON KEROGENS (>20μ)

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA AND OSTRACODA

1	Cassidulina laevigata	
2	Elphidium incertum group	
3	Elphidium spp.	
4	Elphidium asklundi	
5	Quinqueloculina seminulum	
6	Dentalina pauperata	
7	N. granosum/P. orbiculare group	
8	Rabilimis mirabilis	
9	Acanthocythereis dunelmensis	?
10	Cibicides lobatulus var. grossa	*
11	Cassidulina crassa	
12	Polymorphinids	
13	Elphidium groenlandicum	
14	Angulogerina fluens	

WELL:– 15/9–14
CHART:–3 of 12
FIGURE:–4

CLIENT:– STATOIL
DEPTH:– 700m–1000m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RT,AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL

BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: MIDDLE–LATE MIOCENE | PLIOCENE

MICROFAUNAL ASSEMBLAGE: *Cibicides peelensis* | *Cibicides lobatulus* var. *grossa*/*Nonion affine*

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): UTSIRA FORMATION | NORDLAND GROUP

GENERALISED LITHOLOGY

DEPTH (metres): 1000, 975, 950, 925, 900, 875, 850, 825, 800, 775, 750, 725, 700

COMMENTS:
- *E. umbonatus*
- *H. elegans*
- *C. peelensis*, *G. praebulloides*, *N. boueanum*
- *N. affine*
- *C. pseudoungerianus*

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

COMMENTS ON KEROGENS (>20μ)

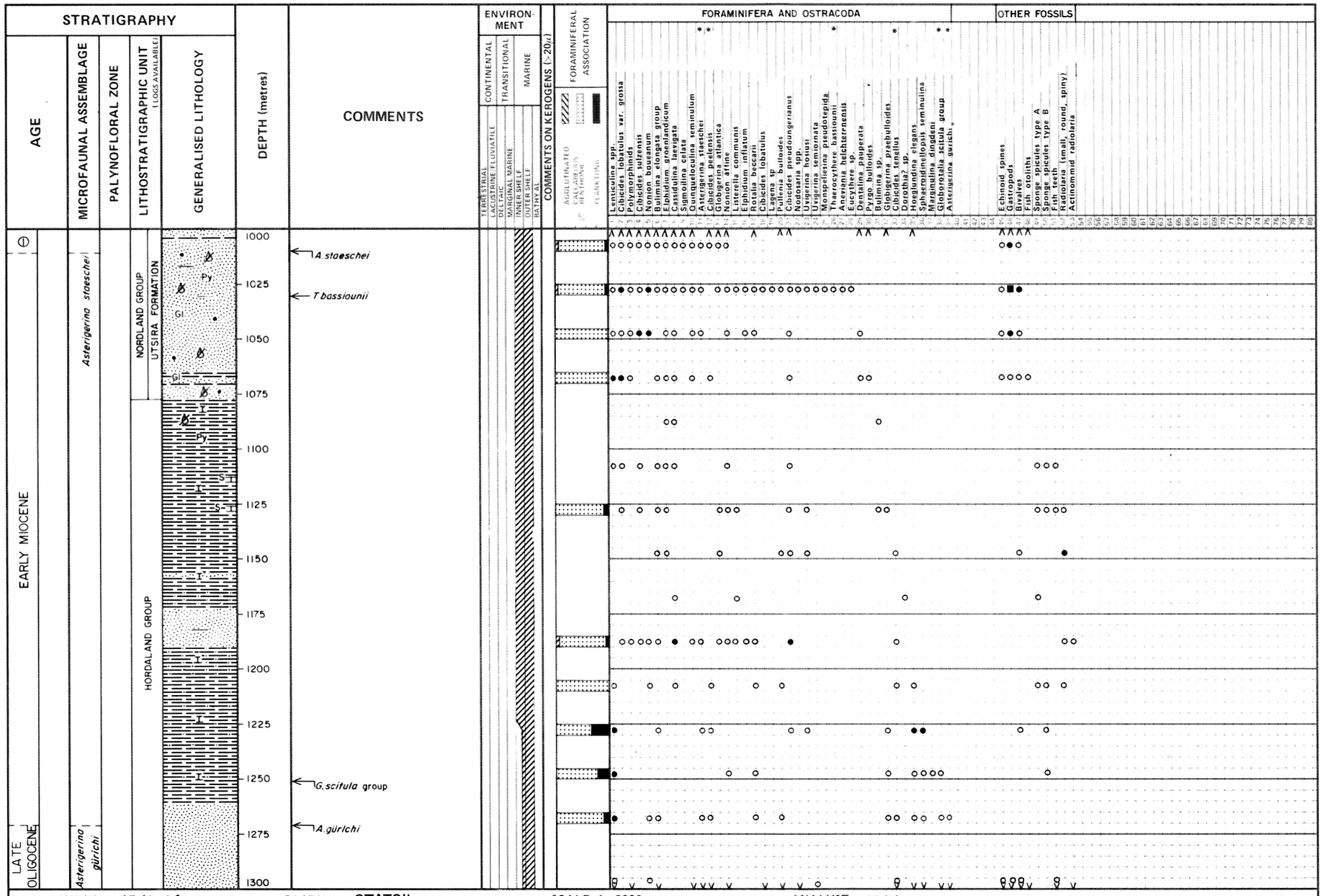
FORAMINIFERAL ASSOCIATION: AGGLUTINATED CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA AND OSTRACODA

1	Elphidium incertum group	
2	Cassidulina laevigata	
3	Cibicides lobatulus var. grossa	*
4	Quinqueloculina seminulum	
5	Elphidium spp.	
6	Dentalina spp.	
7	Bulimina marginata	
8	Cassidulina crassa	
9	Islandella islandica	
10	Rabilimis mirabilis	
11	Buccella frigida	
12	Pyrgo williamsoni	
13	Elphidium groenlandicum	
14	Angulogerina fluens	
15	Krithe cf. bartonensis	
16	Cibicides pseudoungerianus	*
17	Cibicides sulzensis	
18	Pyrgo bulloides	
19	Nonion affine	
20	Sigmoilina celata	
21	Buccella tenerrima	
22	Polymorphina charlottensis	
23	Planulina ariminensis	
24	Glandulina laevigata	
25	Nonion boueanum	*
26	Polymorphinids	
27	Rotalia beccarii	
28	Cytherella spp.	
29	Pullenia bulloides	
30	Elphidiella hannai	
31	Bulimina elongata group	
32	Cibicides peelensis	*
33	Globigerina praebulloides	*
34	Sigmomorphina bornemanni	
35	Dentalina mucronata	
36	Hoeglundina elegans	
37	Guttulina problema	
38	Cytheridea hoerstgenensis	
39	Sphaeroidina bulloides	
40	Lenticulina spp.	
41	Globigerina atlantica	
42	Eponides umbonatus	*
43	Globigerina pachyderma	

OTHER FOSSILS

Gastropods
Bryozoans
Echinoid spines
Bivalves
Fish otoliths



① MIDDLE–LATE MIOCENE

WELL:- 15/9-14
CHART:- 5 of 12
FIGURE:- 6

CLIENT:- STATOIL
DEPTH:- 1300m-1600m
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:- RT,AJS
DRAWING NO.:- 829P/0360/5243
DATE:- OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL

BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: LATE OLIGOCENE

MICROFAUNAL ASSEMBLAGE: *Sigmoilina schlumbergeri*

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): HORDALAND GROUP

GENERALISED LITHOLOGY

DEPTH (metres): 1600, 1575, 1550, 1525, 1500, 1475, 1450, 1425, 1400, 1375, 1350, 1325, 1300

COMMENTS: *T.globigeriniformis*; *S.schlumbergeri*; *S.tenuis*

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

COMMENTS ON KEROGENS (>20μ)

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA

1 Lenticulina spp.
2 Uvigerina tenuipustulata
3 Quinqueloculina seminulum
4 Polymorphinids
5 Ceratobulimina contraria
6 Asterigerina gurichi *
7 Asterigerina staeschei
8 Cibicides tenellus
9 Cibicides peelensis
10 Gyroidina soldanii
11 Globorotalia scitula group
12 Globigerina woodi
13 Sphaeroidinellopsis seminulina
14 Globigerina spp.
15 Bulimina marginata
16 Bulimina elongata group
17 Hoeglundina elegans
18 Dentalina spp.
19 Globigerina angustiumbilicata
20 Haplophragmoides spp. *
21 Textularia spp.
22 Pullenia bulloides
23 Alabamina tangentialis
24 Triloculina spp.
25 Bathysiphon spp.
26 Sigmoilina tenuis *
27 Nonion affine
28 Sigmoilina schlumbergeri *
29 Karreriella siphonella
30 Saccammina placenta
31 Cyclammina placenta
32 Cyclammina spp.
33 Guttulina problema
34 Trochammina globigeriniformis
35 Ammodiscus incertus
36 Hormosina spp.
37 Valvulineria petrolei
38 Cribrostomoides spp.
39 Globobulimina spp.

OTHER FOSSILS

44 Fish otoliths
45 Gastropods
46 Bivalve debris
47 Actinommid radiolaria
48 Coscinodiscus spp.
49 Coscinodiscus sp. 4
50 Echinoid spines
51 Sponge spicules
52 Coscinodiscus sp. 7
53 Coscinodiscus sp. 6

WELL:- 15/9-14
CHART:- 7 of 12
FIGURE:- 8

CLIENT:- STATOIL
DEPTH:- 1900m-2200m
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:- RT.AUS
DRAWING NO.:- 829P/0360/5243
DATE:- OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: EARLY? - MIDDLE EOCENE | MIDDLE ? - LATE EOCENE

MICROFAUNAL ASSEMBLAGE: *Ammobaculites* sp. 1 / *Verneuilina subeocaena* / *Spiroplectammina spectabilis* | *T. globigeriniformis* / *Trochammina* sp. X / *Cystammina* sp.

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): HORDALAND GROUP; FRIGG FORMATION

GENERALISED LITHOLOGY

DEPTH (metres): 2200, 2175, 2150, 2125, 2100, 2075, 2050, 2025, 2000, 1975, 1950, 1925, 1900

COMMENTS

Ammobaculites sp.1

S. spectabilis

Selective green staining of microfaunas

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
4 Bathysiphon spp.
5 Cyclammina challinori
6 Cribrostomoides spp.
7 Saccammina placenta
8 Recurvoides spp.
9 Ammodiscus incertus
10 Glomospira charoides
11 Trochammina sp. X
12 Trochammina spp.
13 Cyclammina spp.
14 Haplophragmoides spp.
15 Sigmoilina schlumbergeri
16 Quinqueloculina spp.
17 Trochammina globigeriniformis
18 Dentalina spp.
19 T. globigeriniformis var. altiformis
20 Spiroplectammina spectabilis
21 Karreriella apicularis
22 Cystammina spp.
23 Textularia spp.
24 Ammobaculites sp. 1

OTHER FOSSILS

Fish teeth

WELL:-15/9-14
CHART:-6 of 12
FIGURE:-7

CLIENT:-STATOIL
DEPTH:-1600m-1900m
LOCATION:-NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:-RT,AJS
DRAWING NO.:- 829P/10360/5243
DATE:-OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: MIDDLE?-LATE EOCENE | EARLY OLIGOCENE | LATE OLIGOCENE

MICROFAUNAL ASSEMBLAGE: *Trochammina globigeriniformis/Trochammina* sp.X/*Cystammina* sp. | *Rotaliatina bulimoides* | *Sigmoilina schlumbergeri*

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): HORDALAND GROUP

GENERALISED LITHOLOGY

DEPTH (metres): 1900, 1875, 1850, 1825, 1800, 1775, 1750, 1725, 1700, 1675, 1650, 1625, 1600

COMMENTS
- ↑ *Trochammina* sp.X
- ↑ *R. bulimoides*
- ↑ *R. bulimoides*

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

COMMENTS ON KEROGENS (>20μ)

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA
- Bathysiphon spp.
- Recurvoides spp.
- Cyclammina spp.
- Haplophragmoides spp.
- Cribrostomoides spp.
- Sigmoilina schlumbergeri
- Globobulimina spp.
- Lenticulina spp.
- Sigmoilina tenuis
- Trochammina globigeriniformis
- Globigerina spp.
- Cyclammina placenta
- Ammodiscus incertus
- Triloculina spp.
- Rotaliatina bulimoides
- Saccammina placenta
- Trochammina spp.
- Glomospira charoides
- Cyclammina challinori
- Textularia spp.
- Ammodiscus spp.
- Guttulina problema
- Saccammina sphaerica
- Polymorphinids
- Pyrgo spp.
- Quinqueloculina spp
- Globigerina angulisuturalis
- Dentalina spp.
- Reophax spp.
- Cibicides lobatulus
- Asterigerina gurichi
- Cystammina spp.
- Trochammina sp. X
- Globigerina eocaena
- Cibicides spp.
- T. globigeriniformis var. altiformis
- Nodosaria spp.
- Globigerina linaperta group
- Karreriella apicularis

OTHER FOSSILS
- Actinommid radiolaria
- Bivalve debris
- Coscinodiscus spp.
- Echinoid spines
- Undiff. ostracod
- Gastropods

WELL:– 15/9–14
CHART:– 8 of 12
FIGURE:– 9

CLIENT:– STATOIL
DEPTH:– 2200m–2500m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RT, AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

① LISTA FORMATION

STRATIGRAPHY	
AGE	LATE PALAEOCENE / EY. EOC. / EARLY ? – MIDDLE EOCENE
MICROFAUNAL ASSEMBLAGE	? *Coscinodiscus* sp.1 / *Glob. triloc.* / *Ammobaculities* sp.1 /*Verneuilina subeocaena*/ *Spiroplectammina spectabilis*
PALYNOFLORAL ZONE	
LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE)	ROGALAND GROUP: ① SELE FORMATION, BALDER FM. / HORDALAND GROUP: FRIGG FORMATION
GENERALISED LITHOLOGY	
DEPTH (metres)	2500, 2475, 2450, 2425, 2400, 2375, 2350, 2325, 2300, 2275, 2250, 2225, 2200
COMMENTS	*Coscinodiscus* sp.1; *G. triloculinoides*; *Coscinodiscus* sp.1 and sp.2; Selective pink staining of microfaunas; *G. linaperta* group
ENVIRONMENT	TERRESTRIAL, LACUSTRINE/FLUVIATILE (CONTINENTAL); DELTAIC, MARGINAL MARINE (TRANSITIONAL); INNER SHELF, OUTER SHELF, BATHYAL (MARINE)
COMMENTS ON KEROGENS (>20μ)	
FORAMINIFERAL ASSOCIATION	AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA AND OSTRACODA	OTHER FOSSILS
Bathysiphon spp.	
Recurvoides spp.	
Cyclammina challinori	
Karreriella apicularis	
Ammobaculites sp. 1	
Ammodiscus incertus	
Cystammina spp.	
Trochammina spp.	
Haplophragmoides spp.	
Glomospira charoides	
Cyclammina spp.	
Lenticulina spp.	
Trochammina globigeriniformis	
Polymorphinids	
Globobulimina spp.	
Globigerina linaperta group	
Anomalina grosserugosa	
Eponides spp.	
Saccammina placenta	
Paracypris spp.	
Reophax spp.	
Dentalina spp.	
Gyroidina soldanii	
Anomalinoides nobilis	
Cancris subconicus	
Asterigerina spp.	
Globigerina triloculinoides	
Neoeponides sp.	
Xestoleberis sp.	
Anomalinoides acuta ?	
Acarinina soldadoensis	
Allomorphinia subtriangularis	
	Coscinodiscus sp. 1 (?R)
	Coscinodiscus sp. 2 (?R)
	Actinommid radiolaria
	Echinoderm spines
	Coscinodiscus sp. 1
	Coscinodiscus sp. 2

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BIOSTRATIGRAPHIC ANALYSIS CHART

WELL:- 15/9 - 14
CHART:- 9 of 12
FIGURE:- 10

CLIENT:- STATOIL
DEPTH:- 2500m - 2800m
LOCATION:- NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:- SEE FIGURE 1

ANALYST:- RT, AJS
DRAWING NO.:- 829P/10360/5243
DATE:- OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: LATE PALAEOCENE

MICROFAUNAL ASSEMBLAGE

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): ROGALAND GP. / LISTA FM.

GENERALISED LITHOLOGY

DEPTH (metres): 2800, 2775, 2750, 2725, 2700, 2675, 2650, 2625, 2600, 2575, 2550, 2525, 2500

COMMENTS: *L. pacifica*

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

COMMENTS ON KEROGENS (>20μ)

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA

1	Bathysiphon spp.
2	Haplophragmoides spp.
3	Spiroplectammina spectabilis
4	Ammodiscus incertus
5	Cystammina spp.
6	Karreriella apicularis
7	Glomospira charoides
8	Recurvoides spp.
9	Cyclammina spp.
10	Trochammina spp.
11	Labrospira pacifica *
12	
13	
14	
15	
16	
17	Coscinodiscus sp. 1 ?C
18–80	

OTHER FOSSILS

WELL:– 15/9–14
CHART:–10a of 12
FIGURE:–11

CLIENT:– STATOIL
DEPTH:– 2800m–3100m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RT, AJS
DRAWING NO.:– 829P/0360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL

BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: LATE CRETACEOUS — Cen. | Turonian | Turonian–Coniacian

MICROFAUNAL ASSEMBLAGE: ① — *P.* cf. *stephani* | *Globotruncana/ G.marginata /* Radiolaria ?

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): CHALK GROUP — HIDRA FM. | P MARL FM. | HOD FORMATION

GENERALISED LITHOLOGY

DEPTH (metres): 3100, 3075, 3050, 3025, 3000, 2975, 2950, 2925, 2900, 2875, 2850, 2825, 2800

COMMENTS

- *G.* cf. *baltica*
- *E. mariei*, abundant *H. delrioensis*
- Common/abundant *P* cf. *stephani*
- Common *H. delrioensis*
- *P.* cf. *stephani*
- *G. linneiana* cf. *coronata*
- *S. exsculpta*
- *G. linneiana tricarinata*, radiolaria
- *G. praeexsculpta*
- *G. linneiana linneiana*
- Common Actinommid
- Inoceramus debris

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

COMMENTS ON KEROGENS (> 20μ): Mixed

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

FORAMINIFERA AND OSTRACODA

1. Barren of in situ foraminifera
2.
3.
4. Bathysiphon spp.
5. Haplophragmoides spp.
6. Ammodiscus incertus
7. Recurvoides spp.
8. Cyclamina spp.
9. Polymorphinids
10. Glomospira charoides
11. Nuttalides trumpyi
12. Globigerinelloides asper
13. Gyroidina/Gyroidinoides spp.
14. Rugoglobigerina/Archaeoglobigerina complex
15. Saccammina sp.
16. Quadrimorphina sp.
17. Gaudryina cf. dividens
18. Stensioina exsculpta
19. Stensioina praeexsculpta
20. Eponides spp.
21. Globotruncana linneiana tricarinata *
22. Gavelinella spp.
23. Lenticulina spp.
24. Globotruncana linneiana linneiana *
25. Hedbergella spp.
26. Tritaxia tricarinata
27. Anomalinoides velascoensis
28. Globotruncana linneiana cf. coronata *
29. Guttulina problema
30. Ataxophragmium spp.
31. Cytherella cf. equisita
32. Praebulimina sp.
33. ?Praeglobotruncana cf. stephani *
34. Marsonella sp.
35. Globotruncana sp.
36. Dorothia sp. 1
37. Praeglobotruncana cf. stephani
38. Hedbergella delrioensis
39. Globotruncana imbricata
40. Nodosaria spp.
41. Eggerellina mariei *
42. Spiroplectammina sp.
43. Gavelinella cf. baltica *
44. Praeglobotruncana delrioensis
45. Valvulinaria gracillima
46.
47.
48.
49.
50.

OTHER FOSSILS

51. Actinommid radiolaria
52. Inoceramus debris
53. Spongodiscid radiolaria
54.
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56.
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80.

① *Rotalipora / Hedbergella – Hedbergella delrioensis / Gavelinella* cf. *baltica*

DEPTH (metres) (LOGS AVAILABLE)

PALYNOFLORAL ZONE

COMMENTS

COMMENTS ON KEROGENS (>20µ)

MICROPLANKTON

MIOSPORES

1 Spiniferites ramosus group
2 Leiosphaeres
3 Systematophoridium longifurcatum
4 Hystrichosphaeridium difficile
5 Cyclonephelium spp.
6 Hystrichosphaeridium tubiferum
7 Oligosphaeridium complex
8 Hystrichodinium voigtii
9 Florentinia spp.
10 Pterodinium aliferum
11 Sciniodinium companulum
12 Cleistosphaeridium ancoriferum
13 Palaeocystodinium cretaceum
14 Palaeohystrichophora infusorioides
15 Impletosphaeridium spp.
16 Pterospermella spp.
17 Odontochitina operculata
18 Palaeocystodinium pyrophorum
19 Systematophora areolata
20 Kleithriasphaeridium reddei
21 Odontochitina sp.
22 Exochosphaeridium striolatum
23 Impletosphaeridium whitei
24 Cannosia spp.
25 Odontochitina costata
26 Spinidinium coronatum
27 Hystrichosphaeridium stellatum
28 Areoligera gippslandica
29 Exochosphaeridium bifidum
30 Caddasphaera halosa
31 Oligosphaeridium asterigerum
32 Xiphophoridium alatum
33 Exochosphaeridium arnase
34 Chlamydophorella hugoniotii
35 Cleistosphaeridium polypes
36 Santusidinium spp.
37 Exochosphaeridium phragmites
38 Achomosphaera ramulifera
39 Impletosphaeridium sp. A
40 Litosphaeridium siphoniphorum
41 Hystrichodinium pulchrum
42 Coronifera oceanica
43 Hystrichosphaeridium spp.
44 Cribroperidinium cf. recurvatum
45 ?Labyrinthodinium truncatum
46 Oligosphaeridium cf. pulvinum
47 Kleithriasphaeridium loffrense
48 Prolixosphaeridium sp.
49 Prolixosphaeridium spp.
50 Lebediocysta dellocysta
51 Membranilarnacia polyclediata
52 Ovoidinium spp.
53 Xenascus ceratioides
54 Ellipsoidictyum imperfectum group
55
56
57
58
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60 Bisaccates
61 Cicatricosisporites spp.
62 Deltoidospora spp.
63 Todisporites spp.
64 Cerebropollenites mesozoicus
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2800
2825
2850
2875
2900
2925
2950
2975
3000
3025
3050
3075
3100

S.coronatum, *H.difficile*, *P.turneri* (SWC)

L.siphoniphorum

L.siphoniphorum (SWC)

Mixed

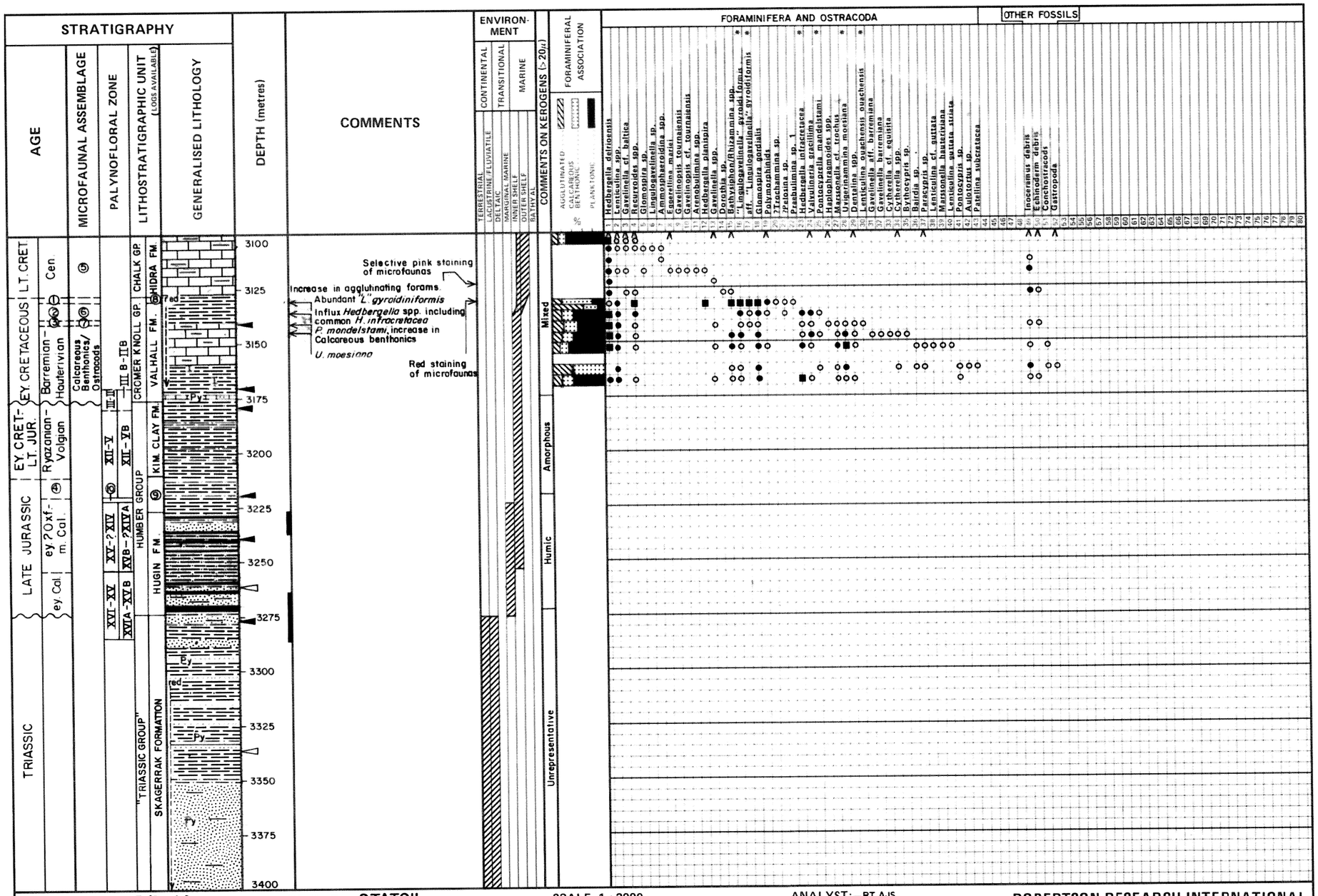
WELL:– 15/9-14
CHART:– 10b of 12
FIGURE:– 12

CLIENT:– STATOIL
DEPTH:– 2800m– 3100m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– DKR
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART



WELL:– 15/9–14
CHART:–11a of 12
FIGURE:–13

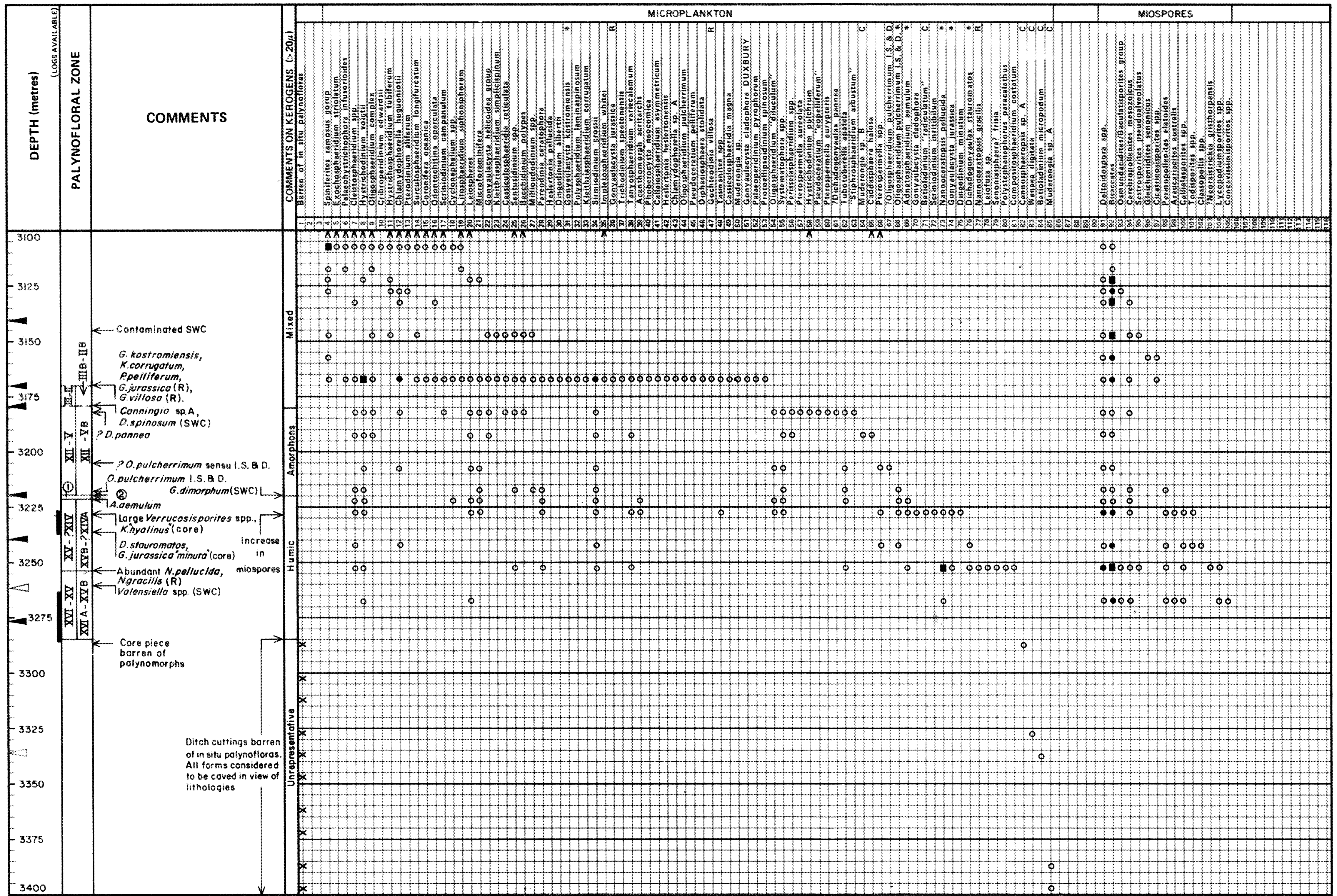
CLIENT:– STATOIL
DEPTH:– 3100m–3400m
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– RT, AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① Albian
② early Albian – Aptian
③ early Aptian
④ Kimmeridgian? – Oxfordian
⑤ *Rotalipora/Hedbergella – Hedbergella delrioensis/ Gavelinella* cf. *baltica*
⑥ *Recurvoides / Glomospira*
⑦ *Hedbergella infracretacea*
⑧ RØDBY FORMATION
⑨ HEATHER FORMATION
⑩ XIII



WELL:– 15/9-14	CLIENT:– STATOIL	SCALE 1 : 2000	ANALYST:– DKR
CHART:– IIb of 12	DEPTH:– 3100m–3400m	LEGEND:– SEE FIGURE 1	DRAWING NO.:– 829P/10360/5243
FIGURE:– 14	LOCATION:– NORWEGIAN NORTH SEA		DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① XIII ② *G jurassica, S. luridum*, common microforaminifera (SWC)

WELL:– 15/9-14
CHART:– 12 of 12
FIGURE:– 15

CLIENT:– STATOIL
DEPTH:– 3400m - 3563m T.D.
LOCATION:– NORWEGIAN NORTH SEA

SCALE 1 : 2000
LEGEND:– SEE FIGURE 1

ANALYST:– DKR, AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

STRATIGRAPHY

AGE: TRIASSIC

MICROFAUNAL ASSEMBLAGE

PALYNOFLORAL ZONE

LITHOSTRATIGRAPHIC UNIT (LOGS AVAILABLE): "TRIASSIC GROUP" / SKAGERRAK FORMATION

GENERALISED LITHOLOGY: red, Py, T

DEPTH (metres): 3400, 3425, 3450, 3475, 3500, 3525, 3550, T.D. 3563

COMMENTS: Barren of in situ palynomorphs

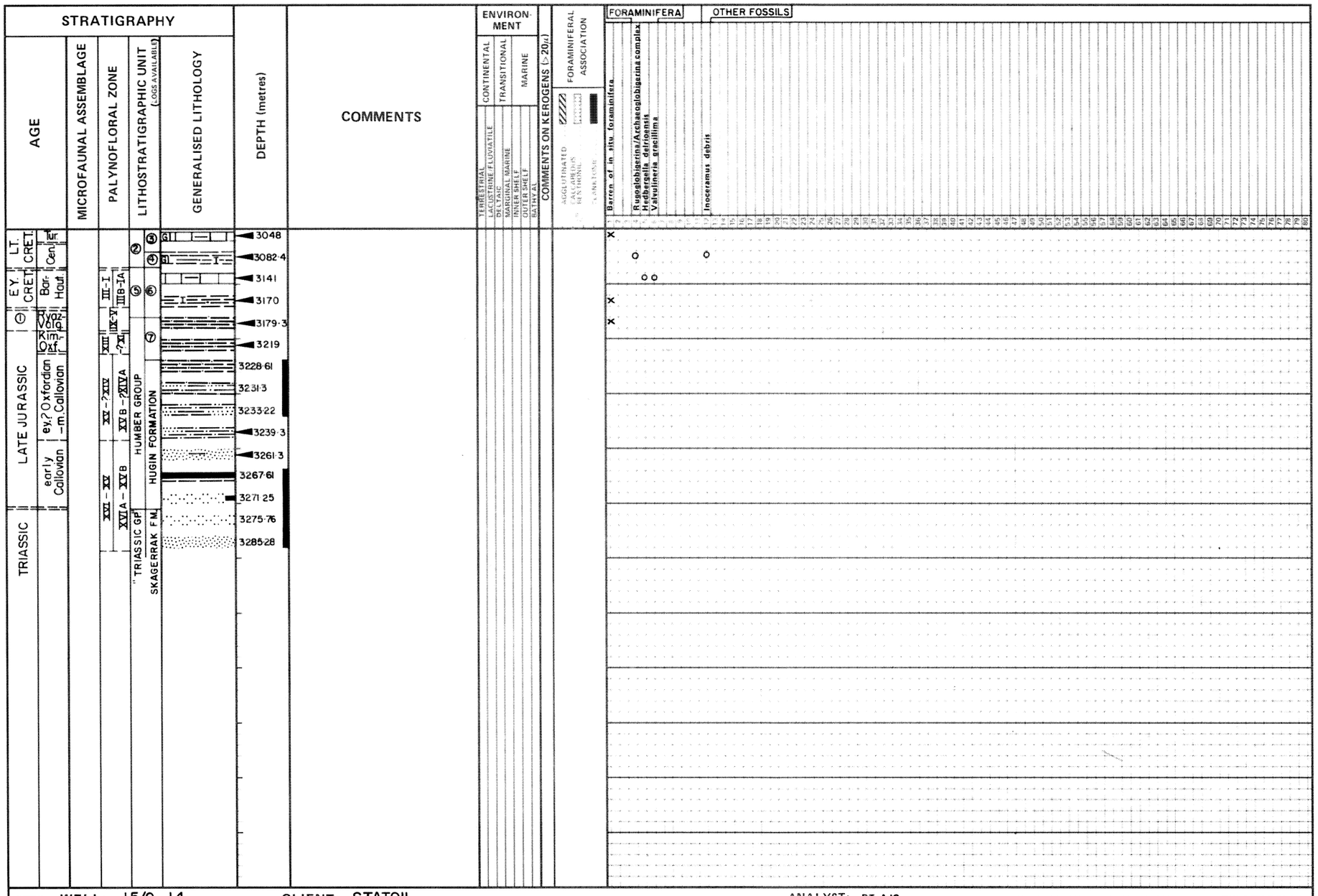
ENVIRON-MENT: CONTINENTAL (TERRESTRIAL, LACUSTRINE/FLUVIATILE, DELTAIC); TRANSITIONAL (MARGINAL MARINE); MARINE (INNER SHELF, OUTER SHELF, BATHYAL)

COMMENTS ON KEROGENS (>20μ): Unrepresentative

FORAMINIFERAL ASSOCIATION: AGGLUTINATED; CALCAREOUS BENTHONIC; PLANKTONIC

MICROPLANKTON

1 Barren of in situ palynofloras
4 Muderongia sp. A C



WELL:– 15/9–14
CHART:– 1a of 1
FIGURE:– 16

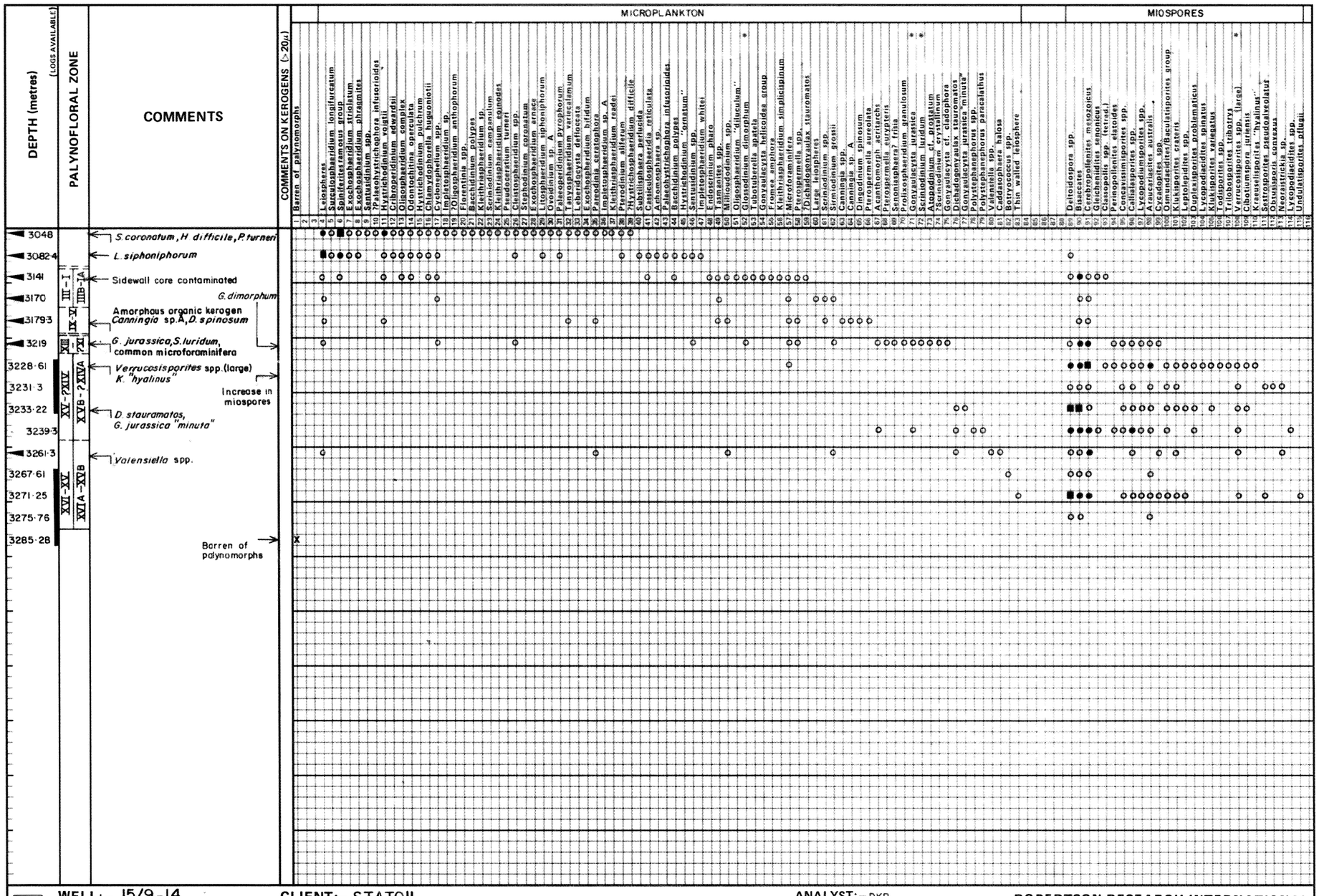
CLIENT:–STATOIL
SIDEWALL CORE AND CORE PIECES
LOCATION:–NORWEGIAN NORTH SEA

LEGEND:– SEE FIGURE 1

ANALYST:– RT, AJS
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

① LATE JURASSIC – EARLY CRETACEOUS
② CHALK GROUP
③ PLENUS MARL FORMATION
④ HIDRA FORMATION
⑤ CROMER KNOLL GROUP
⑥ VALHALL FORMATION
⑦ KIMMERIDGE CLAY FORMATION



WELL:– 15/9-14
CHART:– 1b of 1
FIGURE:– 17

CLIENT:– STATOIL
SIDEWALL CORE AND CORE PIECES
LOCATION:– NORWEGIAN NORTH SEA

LEGEND:– SEE FIGURE 1

ANALYST:– DKR
DRAWING NO.:– 829P/10360/5243
DATE:– OCTOBER 1982

ROBERTSON RESEARCH INTERNATIONAL
BIOSTRATIGRAPHIC ANALYSIS CHART

SUMMARY LOG

ROBERTSON RESEARCH INTERNATIONAL

ENCLOSURE 1

SCALE 1 : 500

STATOIL 15/9 - 14

AREA: NORWEGIAN NORTH SEA

SPUD DATE: 2nd MAY 1982

COMPANY: STATOIL

COMPLETION DATE: 27th JUNE 1982

INTERVAL STUDIED: 180m – 3563m

T.D.: 3563m

Drawing No. 829P/10360/5243

ANALYST RT, AJS, DKR

Date OCTOBER 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)

Wireline log indicates CLAYSTONE: presumed to be removed from ditch cutting samples during processing. Ditch cuttings contain loose SAND: fine to coarse, subrounded and translucent with lithic fragments and shell debris. Also traces of CLAYSTONE: moderately soft, light olive grey, silty and sandy. Wireline log indicates interbedded sands and argillaceous sediments.

EOCENE

MIDDLE ? — LAT

HORDALAND GROUP

of glauconite.

1875

1900

Wireline log suggests frequent sideritic stringers or concretions.

1925

1950

SHALE and CLAYSTONE: as above, grading to SHALE: moderately hard, weakly fissile, brittle, slightly waxy, greenish grey and micromicaceous.

1975

1980

S. spectabilis

Trochammina globigeriniformis / Tr

HORDALAND GROUP

2000

Ammobaculites sp. 1

Wireline log indicates increase in sand in SHALES.
Ditch cuttings contain SHALE: greenish grey as above with rare SAND and SANDSTONE: very fine to fine, white, locally with pyrite cement or calcareous cement.

Selective green staining of microfaunas

2025

EOCENE

EARLY ? — MIDDLE EOCENE

2048 (log)

HORDALAND GROUP

FRIGG FORMATION

SANDSTONE: fine to medium, rare coarse, subangular to subrounded, translucent grains, locally light brown and pink, white, locally with calcareous cement.

SHALE: as above.

Interbedded SHALES: moderately hard, subfissile to fissile, greenish grey to olive grey and brownish grey, micromicacoeus with minor SANDSTONES and ARGILLACEOUS SANDSTONES: very fine to medium, subangular to subrounded grains, white to greenish grey with rare dark green grains, locally with calcareous cement.

SANDSTONE: very fine to medium, rarely coarse, white to light brown, locally glauconitic, locally calcareous or pyrite cement.

SHALE: moderately hard, subfissile, greenish grey to olive grey and brownish grey, locally light greenish grey with sphaerosiderite.
Minor DOLOMITIC LIMESTONE: hard, cryptocrystalline and moderate brown — probably stringers or concretions. Also pyrite rods, siderite and sphaerosiderite.

SHALE: as above, but slightly waxy.

2050 2075 2100 2125 2150 2175 2200 2225

Py Gl S

Ammobaculites sp. 1 / *Vernauilina subeocaena* / *Spiroplectammina spectabilis*

EOCENE

MIDDLE EOCENE

Vernauilina subeocaena / *Spiroplectammina spectabilis*

EARLY ? —

EARLY EOCENE

2363

2382 (log)

2425 (log)

BALDER FORMATION

SANDSTONE: fine to medium, rarely coarse, white with rare pink grains, locally calcareous.

Traces of LIMESTONE: hard, cryptocrystalline, very light grey to light grey.
SHALE: as above, but predominantly olive grey.
SHALE: as above, with medium grey.

SHALE: moderately hard, subfissile, medium grey, greenish grey and greyish red, locally waxy, micromicaceous and locally weakly calcareous. Minor green, waxy CLAYSTONE. Pyrite and siderite, with traces of LIMESTONE: as above.

Traces of SANDY TUFF: friable, grey and white.

Traces of TUFFACEOUS SHALE: moderately hard, brittle, slightly waxy, light greenish grey with light and dark blebs.

SHALE: predominantly medium grey, as above.
Traces of TUFFACEOUS SHALE: light to dark grey and laminated.

SHALE: moderately hard, weakly fissile, light to dark grey, locally laminated. Greyish red and greenish grey shales with tuffs are presumed caved.

2250 2275 2300 2325 2350 2375 2400 2425

Selective pink staining of microfaunas

G. linaperta group

G. triloculinoides

Coscinodiscus sp. 1 and sp. 2

Ammobaculites sp. 1 / *Vermeuilin*

Globigerina triloculinoides

Coscinodiscus sp. 1

PALAEOCENE

LATE PALAEOCENE

ROGALAND GROUP

SELE FORMATION

SHALE: moderately hard, fissile to subfissile, medium dark grey and slightly micro-micaceous.

2484 (log)

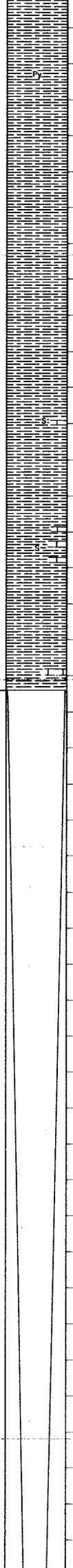
LISTA FORMATION

Ditch cuttings contain SHALE: as above, with traces of greyish red SHALE and rare fragments of tuff – probably caved.

Traces of siderite – probably stringers or concretions.

SHALE: as above, with traces of brownish grey SILTY SHALE.

Interval not examined.



2450

2475

2500

2525

2550

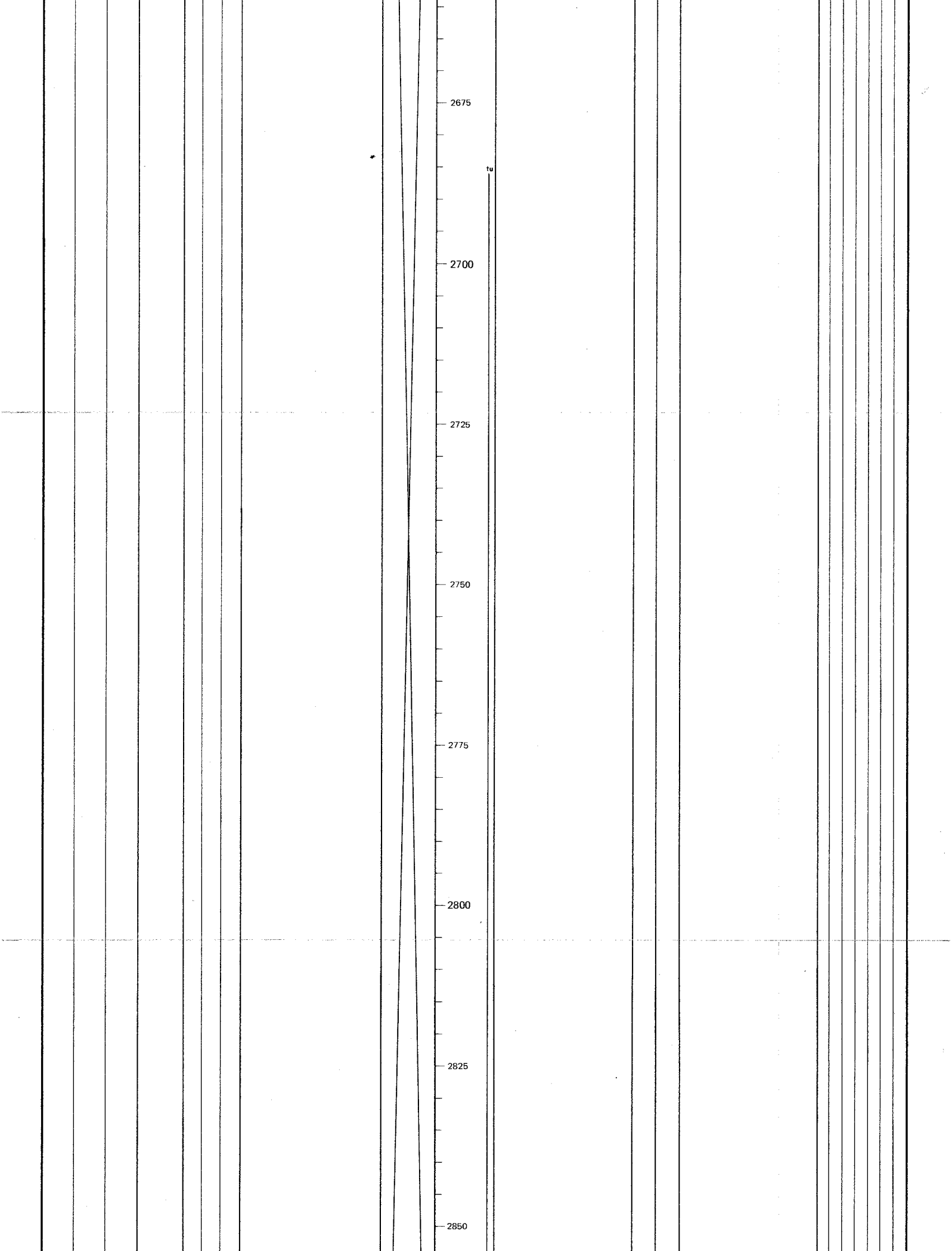
2575

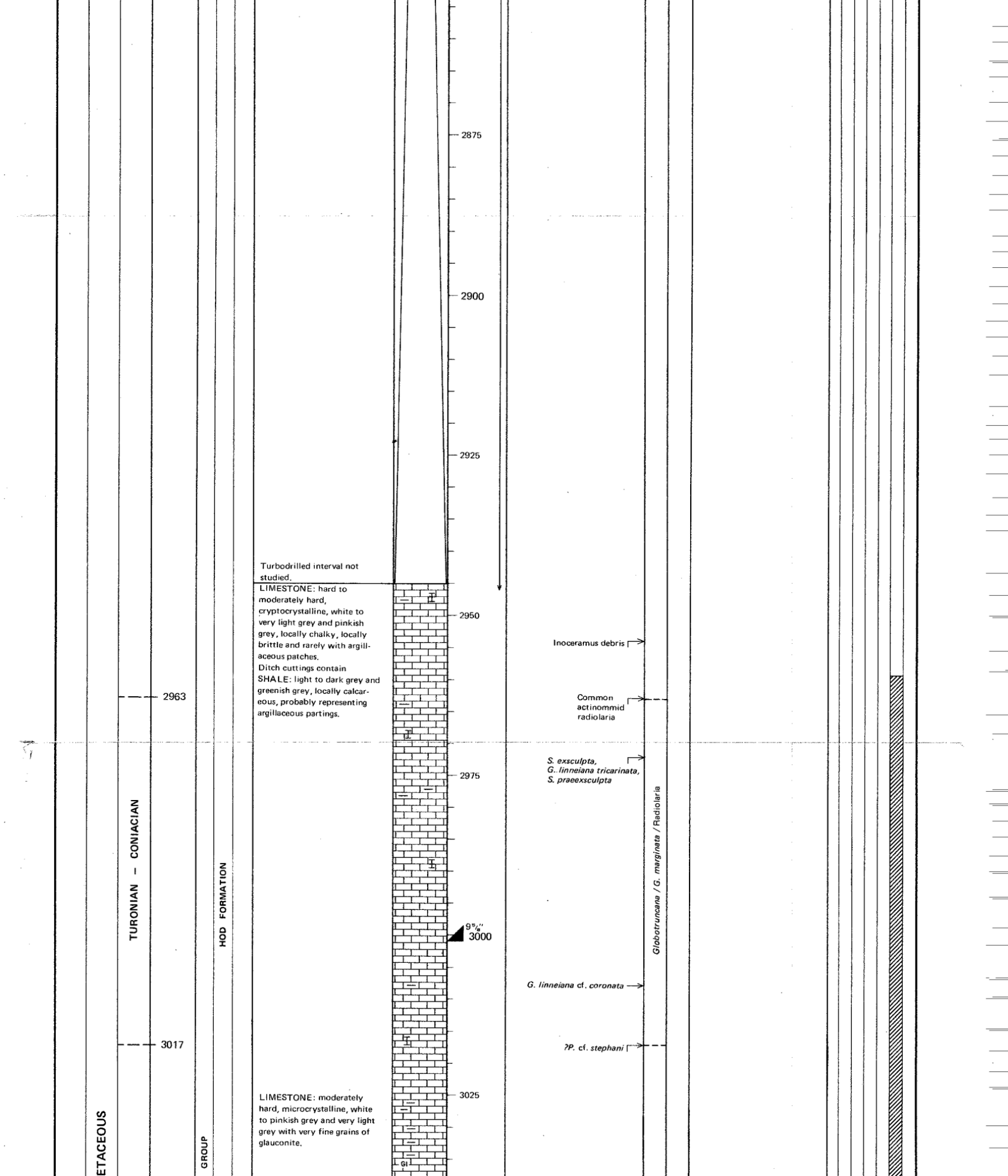
2600

2625

2650

Coscinodiscus sp. 1 → ?


2675
tu
2700
2725
2750
2775
2800
2825
2850


2875
2900
2925
Turbodrilled interval not studied.
LIMESTONE: hard to moderately hard, cryptocrystalline, white to very light grey and pinkish grey, locally chalky, locally brittle and rarely with argillaceous patches.
Ditch cuttings contain
SHALE: light to dark grey and greenish grey, locally calcareous, probably representing argillaceous partings.
2950
Inoceramus debris
2963
Common actinommid radiolaria
S. exsculpta,
G. linneiana tricarinata,
S. praeexsculpta
2975
TURONIAN – CONIACIAN
HOD FORMATION
Globotruncana / G. marginata / Radiolaria
9⅝"
3000
G. linneiana cf. coronata
3017
?P. cf. stephani
LIMESTONE: moderately hard, microcrystalline, white to pinkish grey and very light grey with very fine grains of glauconite.
3025
GI
ETACEOUS
GROUP

CRETACEOUS

LATE CR.

TURONIAN

3045.5 (log)

CHALK

PLENUS MARL FORMATION

ARGILLACEOUS LIMESTONE: moderately hard to moderately soft, light grey to dark grey, microcrystalline to cryptocrystalline, locally glauconitic and micaceous.

Traces of pyrite.
ARGILLACEOUS LIMESTONE: as above grading to CALCAREOUS SHALE.

3074 (log)

HIDRA FORMATION

LIMESTONE: hard to moderately hard cryptocrystalline, locally chalky, white to light grey and pinkish grey, locally argillaceous. Minor CALCAREOUS SHALE: moderately hard, medium grey to olive grey, silty and micaceous, with traces of glauconite.

CENOMANIAN

RØDBY FORMATION

3127.5

EY. ALB. – APT.

ALB.

3131

3137

EARLY APTIAN

3140

EARLY CRETACEOUS

HAUTERIVIAN – BARREMIAN

CROMER KNOLL GROUP

VALHALL FORMATION

SHALE: moderately hard, subfissile, medium grey to greenish grey.
SHALE: as above, but predominantly greyish red.

ARGILLACEOUS LIMESTONE: hard, cryptocrystalline, light to dark grey, slightly silty.
Ditch cuttings contain SHALE: as above – probably caved.

Traces of CALCAREOUS CLAYSTONE: moderately hard, pale reddish brown, medium grey, locally moderately soft, pale red and white laminated.

CALCAREOUS CLAYSTONE: as above with CALCAREOUS SHALE: moderately hard, subfissile, light to dark grey and greyish red.

CALCAREOUS CLAYSTONE: as above, but light olive grey to light grey and slightly silty
LIMESTONE: hard, cryptocrystalline, light olive grey to white and pinkish grey with pyrite spheroids

3176 (log)

JUR. – CRET.

EARLY CRETACEOUS – LATE JURASSIC

VOLGIAN – RYAZANIAN

KIMMERIDGE CLAY FORMATION

SHALE: modetately soft to moderately hard, weakly fissile, earthy, olive black to dark grey, slightly silty, locally weakly calcareous.

3211 (log)

3050

3075

3100

3125

3150

3175

3200

Common/abundant *P. cf. stephani*

Common *H. delrioensis*

E. mariei, abundant
H. delrioensis

G. cf. *baltica*

Selective pink staining of microfaunas

Increase in agglutinating foraminifera, abundant

Red staining of microfaunas

"L." gyroidinaeformis

Influx of *Hedbergella* spp. including *H. infracretacea*

P. mandelstami, increase in calcareous benthonics

U. moesiana

P. cf. stephani

Rotalipora / Hedbergella – Hedbergella delrioensis / Gavelinella cf. baltica

Recurvoides / Glomospira

Hedbergella infracretacea

Calcareous benthonics

S. coronatum, P. turneri, H. difficile (SWC)

L. siphoniphorum

L. siphoniphorum (SWC)

SWC contaminated

G. kostromiensis, P. pelliferum, K. corrugatum, G. jurassica and *G. villosa* reworked

Canningia sp. A, *D. spinosum* (SWC)

?D. pannea

Influx of amorphous organic kerogen (SWC)

? O. pulcherrimum sensu I.S. & D.

JURASSIC

LATE JURASSIC

EARLY? OXFORDIAN – MIDDLE CALLOVIAN

EARLY CALLOVIAN

HUMBER GROUP

HEATHER FORMATION

HUGIN FORMATION

3221 (log)

3225.5 (log)

3274 (log)

Ditch cuttings contain SHALE: as above.

Interbedded sequence of COALS: hard, brittle, vitreous and black; SHALE and CLAYSTONE: moderately hard, fissile to blocky, dark grey to brownish black and olive black, silty and micromicaceous;
SANDSTONE and ARGILLACEOUS SANDSTONE: friable to well cemented, very fine to fine grained, yellowish grey to medium grey and dusky yellowish brown, locally micaceous, grading to SILTSTONE. Wireline log indicates rare cemented bands.

COAL: grading to CARBONACEOUS SHALE: hard subfissile, greyish black, with lenses and rootlets of black, vitreous COAL.

SANDSTONE: friable to well cemented, very fine to medium, subangular to subrounded grains, white and pinkish grey to light greenish grey, locally micaceous and ?kaolinitic.
Also minor MICACEOUS SILTSTONE and SANDSTONE: very light grey.
Trace of coarse, lithic grains
SHALE and CLAYSTONE: light brownish grey and greenish grey, grading to SANDSTONE.

Ditch cuttings contain CLAYSTONE: moderately soft to moderately hard, greyish red to moderate reddish brown, micromicaceous, silty and sandy, locally weakly calcareous.
Also traces of SHALE: moderately soft, subfissile, greenish grey, micaceous and sandy.

SANDSTONE: as above, locally with pyrite cement.
SANDSTONE: becomes predominant lithology, represented in ditch cuttings by loose SAND.

XIII

XIV – ? XIVA

XV – XVB

XVI – XVIA

XV – XVB

G. dimorphum (SWC)

O. pulcherrimum sensu I.S. & D.

G. jurassica, S. luridum

common micro-foraminifera (SWC)

A. aemulum

Large Verrucosisporites spp., K."hyalinus" (Core)

Influx of miospores

D. stauromatos, G. jurassica "minuta" (Core)

Abundant N. pellucida, N. gracilis reworked (Core)

Marine influx

Valensiella spp. (SWC)

Core piece, barren of palynomorphs

TRIASSIC

" TRIASSIC GROUP "

SKAGERRAK FORMATION

SAND: fine to coarse, sub-angular to subrounded, translucent, white, moderate orange pink and pale green grains. Traces of SANDSTONE: locally pyrite cemented or kaolinitic.

Increase in coarse SAND grains — becoming rounded.

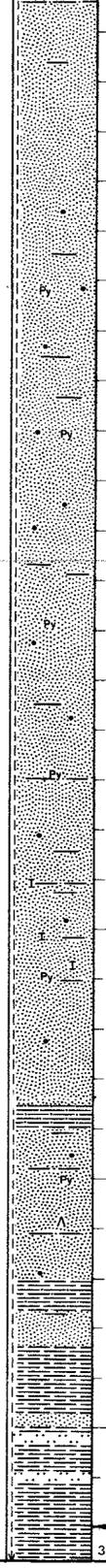
Increasing number of pink and green grains.

Traces of CALCAREOUS CLAYSTONE: soft, pinkish grey and weakly calcareous. SAND: as above, with rare SANDSTONE: moderate reddish brown and very weakly calcareous.

Increasing argillaceous content.

Trace of anhydrite.

CLAYSTONE: moderately soft, greyish red to moderate reddish brown, slightly silty and micaceous, with sandy and silty bands.



Ditch cuttings barren of in situ palynofloras All forms considered to be caved in view of lithologies