ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. 2467

PHILLIPS 2/4 - 9X NORWEGIAN NORTH SEA WELL:

BIOSTRATIGRAPHY OF THE INTERVAL 5110' - 12315'

by

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PROJECT NO. RRPS/7980/A/1169

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C O N T E N T S

I

SUMMARY

1. A Tertiary sequence of Middle Miocene - Early Palaeocene aged sediments is present.

2. Claystones are the predominate lithology in the Tertiary, although tuffaceous deposits occur at the top of the Palaeocene.

3. Reworked chalk occurs within the Palaeocene claystones.

4. The Danian is represented by chalk overlain by a thin argillaceous horizon.

5. Late Maastrichtian to early Campanian - Santonian chalk constitutes the Late Cretaceous section of this well.

II

INTRODUCTION

This report summarises the results of the micropalaeontological, and stratigraphical analyses which have been carried out on material received from the section 5110' - 12315' from the Phillips 2/4-9X Norwegian North Sea Well under Project No. RRPS/7980/A/1169.

Under this project 289 ditch cuttings were analysed using standard micropalaeontological and lithological techniques. In addition 59 ditch cuttings covering the section 9310' - 12300' were treated for nannofossils.

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 3.

The lithostratigraphic terminology is taken from Deegan and Scull 1977.

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

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

Robertson Research staff involved in this study were:

Jean Burgess (Bagnall)	- Cretaceous foraminifera and project co-ordinator
Richard Footitt	- Lithologies
Gilly Hamilton	- Nannofossils
Dave Shipp	- Tertiary foraminifera.

III

SUCCESSION

Age		Interval tops
Middle Miocene	-	5110' (top not seen)
Early Miocene	-	5350'
Oligocene	-	6520'
Eocene	-	8380'
Early Eocene	-	9340'
Palaeocene	-	9910'
Early Palaeocene	Danian	10510'
Late Cretaceous	late Maastrichtian - Maastrichtian	10870'
	early Maastrichtian - late Campanian	11020'
	Campanian	11530'
	early Campanian - Santonian	12260' - 12315'

These results are based on the analysis of ditch cuttings only, no electric logs were available.

IV

TERTIARY

INTERVAL 5110' - 5350'; MIDDLE MIOCENE

The age of this interval is based on:

- the presence of *Cibicides peelensis* (5140'), *Eponides umbonatus* (5200'), *Uvigerina hosiusi* (5230') and *Pullenia sphaeroides* (5350').

LITHOLOGY

Soft, light olive grey clay is the predominant lithology throughout this interval. Minor amounts of yellowish grey limestone and very fine grained, angular sand occur at several horizons. Pyrite, often in the form of rods, occurs sporadically throughout.

This lithology and those down to 9910' are indicative of the Hordaland Group.

MICROPALAEONTOLOGY

The presence of *Cibicides peelensis*, *Eponides umbonatus*, *Uvigerina hosiusi* and *Pullenia sphaeroides* within this interval indicates that it is of Middle Miocene age. The assemblages are generally sparse and dominated by calcareous benthonic forms, with very few planktonic specimens. Agglutinating foraminifera are also rare but become more prominent below 5230'.

ENVIRONMENT

General, inner to outer shelf conditions are suggested by the mixed microfaunas dominated by calcareous benthonic foraminifera. The low numbers may reflect somewhat restricted conditions unsuitable for the development of rich assemblages.

INTERVAL 5350' - 6520'; EARLY MIOCENE

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

- the appearance of radiolaria sp. A in association with an influx of planktonic foraminifera at 5350'.

- the subsequent occurrences of *Siphonina* sp. (5530'), the *Globorotalia scitula* group (5680'), *Virgulina pertusa* (5770') and *Globigerinoides triloba* (6010') within the interval.

LITHOLOGY

This interval is dominated by a light olive grey clay or soft claystone which is occasionally micromicaceous and sandy. Dark yellowish brown, cryptocrystalline dolomite, greyish orange, chalky limestone and very fine grained, brown sandstone occur as minor lithologies (probably as thin interbeds or stringers). Siderite is noted at 6190'.

MICROPALAEONTOLOGY

The top of the Early Miocene has been placed at 5350' on the appearance of radiolaria sp. A together with an influx of planktonic foraminifera. The presence of Lower Miocene deposits within this interval is confirmed by the subsequent occurrences of *Siphonina* sp., the *Globorotalia scitula* group, *Virgulina pertusa* and *Globigerinoides triloba*.

The microfaunas from this interval are, relative to the overlying interval, generally richer and contain a much greater proportion of planktonic foraminifera represented mainly by species of *Globigerina* together with members of the *Globorotalia scitula* group.

An influx of spiny radiolaria at 5740' is a feature seen in the Early Miocene of this area and is of value in local correlation. Ostracoda, gastropods, echinoid and fish remains as well as radiolaria are evident in the samples.

ENVIRONMENT

The greater numbers of planktonic foraminifera present suggest an outer shelf environment with strong open marine influences.

INTERVAL 6520' - 8380'; OLIGOCENE

The age of this interval is based on:

- the appearance of *Globigerina ciperoensis* and a specimen tentatively assigned to *Sigmoilina* sp. 1 at 6520'.

- the subsequent occurrences within the interval of *Globorotalia* cf. *opima* (7120') and *Sigmoilina schlumbergeri* (7240').

LITHOLOGY

Light olive grey to olive grey, micaceous, soft claystone which becomes harder towards the base occurs throughout this interval. Dusky brown dolomite and greyish orange limestone occur sporadically, in small amounts, and probably represent thin interbeds or stringers. A very fine grained brown sandstone occurs at 7000' (also as an interbed or stringer). Pyrite and siderite occur throughout, most noticeably near the base of the interval. Cement contaminates the samples between 8050' and 8170'.

MICROPALAEONTOLOGY

The presence of *Globigerina ciperoensis* and *Sigmoilina* sp. 1 at 6520' indicates that Oligocene deposits have been penetrated at this depth. Further evidence for the presence of Oligocene deposits is provided by the subsequent occurrences within the interval of *Globorotalia* cf. *opima* and *Sigmoilina schlumbergeri*.

Assemblages throughout most of the interval are generally poor but are increasingly dominated by agglutinating foraminifera represented mainly by the genera *Bathysiphon* and *Recurvoides*. In the basal section below 8140' greater numbers of foraminifera are present but agglutinating forms still represent the dominant element.

Radiolaria and echinoderm debris occur periodically through the interval together with rare specimens of *Coscinodiscus* spp.

ENVIRONMENT

The dominance of agglutinating foraminifera and the reduction in numbers of calcareous benthonic and planktonic forms suggests deeper, outer shelf to bathyal conditions.

INTERVAL 8380' - 9340'; EOCENE

The upper limit and age of this interval are based on:

- the presence of *Trochammina globigeriniformis* at 8380'.
- the subsequent occurrence of *T. globigeriniformis* var. *altiformis* at 8620'.

LITHOLOGY

This interval is dominated by light olive grey to olive grey, occasionally light greenish grey, micaceous claystone. Pyrite occurs at many horizons, most notably in association with a yellowish grey limestone at 8800'. Cement contaminates the lower samples from this interval.

MICROPALAEONTOLOGY

The top of the Eocene has been placed at 8380' on the appearance of *Trochammina globigeriniformis*, while the subsequent occurrence of *T. globigeriniformis* var. *altiformis* at 8620' provides further evidence for an Eocene age at this depth.

The microfaunas throughout this interval are generally rich and continue to be dominated by agglutinating foraminifera represented mainly by *Bathysiphon* spp., *Glomospira charoides* and *Recurvoides* spp. Planktonic foraminifera form a minor portion of the assemblages while calcareous benthonic forms are virtually absent. Echinoderm debris occurs scattered through the interval.

ENVIRONMENT

The virtual absence of calcareous benthonic foraminifera in predominantly agglutinating microfaunas suggests deeper, outer shelf to bathyal conditions with greater emphasis on the bathyal component.

INTERVAL 9340' - 9910'; EARLY EOCENE

The upper limit of this interval is based on:

- the appearance of foraminifera which are markedly green stained at 9340'.

The age is based on:

- the appearance of *Verneuilina subeocaena* at 9460', *Spiroplectammina spectabilis* at 9520' and *Cyclammina* sp. 1 at 9610'.

LITHOLOGY

This interval is dominated by claystone which is mainly light olive grey but becomes light grey towards the base. Argillaceous, greyish orange limestone occurs at several horizons, probably as thin stringers or lenses. Pyrite and siderite occur sporadically. A dark yellowish brown, argillaceous sandstone is noted in subordinate amounts at 9850'.

MICROPALAEONTOLOGY

Agglutinating foraminifera which are markedly green stained appear at 9340'. In this area this phenomenon is associated with the Early Eocene and is frequently coincident with the first appearance of Early Eocene marker fossils. The top of the Early Eocene interval has thus been placed at 9340'.

The presence of Lower Eocene deposits within this interval is confirmed by the subsequent occurrences of *Verneuilina subeocaena, Spiroplectammina spectabilis* and *Cyclammina* sp. 1.

The assemblages are again dominated by agglutinating foraminifera with a few planktonic forms, but virtually no calcareous benthonic specimens.

Coscinodiscus spp. are recorded through much of the interval in small numbers, and radiolaria are noticeable between 9580' and 9670'.

NANNOFOSSILS

All samples analysed from this interval are barren of nannofossils.

ENVIRONMENT

Deep water, outer shelf to bathyal conditions are again reflected by the rich, almost exclusively agglutinating, assemblages. The presence of planktonic foraminifera in small but consistent numbers reflects some open marine influences.

INTERVAL 9910' - 10510'; PALAEOCENE

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

- the appearance of several specimens of *Coscinodiscus* sp. 1 at 9910'.
- the presence of volcanic lithotypes at 9940'.
- the occurrence of *Coscinodiscus* sp. 2 at 9970'.

LITHOLOGY

This interval is dominated by light grey, greenish grey, dark grey and red claystones in association with mottled dark grey and white tuffs and laminated dark grey and white ?tuffaceous shales near the top of the interval. Minor amounts of brown, argillaceous, glauconitic fine grained sandstone occur throughout the interval, probably as thin interbeds within the argillaceous sequence. Between 10150' and 10420' white platy chalk, softer porous chalk and white chert occur in association with the shales and are considered to be reworked. Pyrite and siderite occur throughout.

The argillaceous sequence with associated tuffs and tuffaceous shales and minor sandstone interbeds is indicative of the Rogaland Group. The reworked chalk and shale sequence down to 10540' is considered to represent the Maureen Formation of the Montrose Group.

MICROPALAEONTOLOGY

The appearance of *Coscinodiscus* sp. 1 at 9910' indicates that Palaeocene deposits are present at this depth. The subsequent occurrences of volcanic lithotypes at 9940' and *Coscinodiscus* sp. 2 at 9970' serve to confirm this age diagnosis.

The microfaunas consist exclusively of agglutinating foraminifera with *Bathysiphon* spp. and *Recurvoides* spp. being especially prominent.

An influx of small flattened radiolaria is noted at 10190' and a further one of large, flattened, green stained radiolaria at 10480'. This latter feature is commonly seen at the base of the Palaeocene of this region.

Reworking of Danian and occasional Cretaceous foraminifera is recorded below 10180'. These reworked microfossils have a chalky preservation while the majority of the foraminifera from this interval have an argillaceous preservation.

NANNOFOSSILS

In this interval the nannofossil assemblages are fairly sparse, although species diversity is quite high.

The first occurrence of *Heliolithus reideli* at 9910' suggests a Late Palaeocene age for this level. Although the sample is particularly sparse, this useful datum indicator could be used tentatively to define the NP8 Zone of Martini (1971). Again, the first occurrence of *Heliolithus kleinpelli* at 10000' is indicative of a Middle Palaeocene age and would normally indicate the NP6 Zone of Martini's Tertiary zonation (1971). At 10180' the assemblage is marked by the influx of many reworked Cretaceous species. These are present in the assemblages until 10450'.

ENVIRONMENT

Outer shelf to bathyal conditions are reflected by the exclusively agglutinating foraminiferal assemblage. The absence of planktonic forms suggests poor connections to the open sea and a somewhat restricted environment.

INTERVAL 10510' - 10870'; EARLY PALAEOCENE, DANIAN

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

- an influx of Danian planktonic foraminifera, including *Globigerina pseudobulloides*, *G. triloculinoides* and *Globorotalia compressa*, having an argillaceous preservation at 10510'.

- the subsequent occurrence of other Danian forms including *Anomalinoides velascoensis* (10540'), *Globoconusa daubjergensis* (10600'), *Eponides lunata* (10630'), *Gavelinella vombensis* (10690') and *Allomorphina halli* (10690').

LITHOLOGY

Fissile, red and greenish grey shales continue into the top of this interval. However, at 10540' chalk is noted and becomes the predominant lithology throughout the rest of the interval. The chalk is soft, white to yellowish grey, earthy but locally harder and denser. Dark grey and red, fissile shales occur in minor amounts throughout the interval and whilst these may be caved, regional knowledge suggests they may be representative of thin interbeds or stringers within the chalk sequence.

The argillaceous sequence of the top of this interval is a continuation of the Maureen Formation of the Montrose Group. The chalk sequence is thought to represent the Ekofisk Formation of the Chalk Group. The lower boundary of this formation is drawn solely on age i.e. at the base of the Danian interval.

MICROPALAEONTOLOGY

The top of the Danian is placed at 10510' on the appearance of numerous Danian microfossils which have an argillaceous preservation. The Danian sediments of this area are thought to consist of a thin layer of shale overlying Danian chalk. The first in situ Danian microfossils encountered downhole thus usually have an argillaceous rather than a chalky preservation. The Danian forms recorded in the lower part of the Palaeocene section have a chalky preservation and for this reason are considered to be reworked. In situ Danian forms with a chalky preservation are first seen at 10570'.

The microfaunas are much more varied than in the overlying Palaeocene and contain approximately equal numbers of agglutinating and planktonic foraminifera with a smaller proportion of calcareous benthonic forms. *Globigerina pseudobulloides* is prominent among the planktonic species while *Bathysiphon* spp. and *Recurvoides* spp. continue to be significant among the agglutinating forms. The microfaunas are rich in the upper part of the interval above 10750' but numbers decline below this depth. Small rounded radiolaria are prominent near the top of the interval.

NANNOFOSSILS

At 10510' the assemblage is marked by an influx of abudant Danian species, although some of these species (*Prinsius* spp., *Chiasmolithus danicus, Cruciplacolithus tenuis*) are recorded at younger levels. Martini's Tertiary

zones for the Danian cannot be recognised in this interval because the datum indicators for the NP3, NP2 and NP1 Zones are present throughout.

ENVIRONMENT

The presence of mixed foraminiferal assemblages with a large number of planktonic forms in a predominantly chalk lithology suggests an outer shelf environment with strong open marine influences.

V

CRETACEOUS

INTERVAL 10870' - 11020'; LATE CRETACEOUS, LATE MAASTRICHTIAN - MAASTRICHTIAN

The interval top and age are based on:

- the incoming of the foraminifera *Pseudotextularia elegans elegans, P. elegans fructicosa* and *Globotruncana contusa* at 10870'.

LITHOLOGY

Hard, platy, white, yellowish grey to light olive grey, dense, locally softer, more porous and earthy chalk is the predominant lithology throughout this interval. Chert is a minor lithotype.

This lithology is considered to be representative of the Chalk Group.

MICROPALAEONTOLOGY

The appearance of the above-mentioned foraminifera at 10870' indicates a late Maastrichtian age. The subsequent samples are highly impoverished and yielded only long-ranging Late Cretaceous forms. The nannofossils suggest a late Maastrichtian age at 10960', but since this would mean 90' of late Maastrichtian chalk, there may be some contamination by caving. Therefore, the interval has been termed late Maastrichtian - Maastrichtian since it is not possible to define the base of the late Maastrichtian.

NANNOFOSSILS

Only two samples were examined for nannofossils in this interval at 10900' and 10960'.

The presence of *Nephrolithus frequens* in the assemblage at 10960' is indicative of Perch-Nielsen's late Maastrichtian M3 Zone. Danian nannofossils occur in this interval as a result of caving.

ENVIRONMENT

The microfauna, microflora and lithology suggest that deposition occurred in an open marine, outer shelf environment.

INTERVAL 11020' - 11530'; LATE CRETACEOUS, EARLY MAASTRICHTIAN - LATE CAMPANIAN

The interval top and age are based on:

- the appearance of the nannofossil *Reinhardtites levis* at 11020'.

LITHOLOGY

Hard, dense, white and light grey, locally softer and more porous chalk is the predominant lithology throughout this interval. Between 11110' and 11170' the chalk becomes light olive grey, softer and more argillaceous. Stylolitic texture is noted at 11480'.

This lithology is a continuation of the Chalk Group.

MICROPALAEONTOLOGY

This interval is highly impoverished and yielded only rare long-ranging foraminifera such as *Rugoglobigerina rugosa rugosa, Globigerinelloides asper* and *Gyroidina/ Gyroidinoides* spp.

NANNOFOSSILS

This interval is assigned to Perch-Nielsen's Early Maastrichtian/Late Campanian M1 Zone on the presence of *Reinhardtites levis*, which first occurs at 11020', and on the presence of *Arkhangelskiella cymbiformis* in the assemblages until 11460'. Caved Danian nannofossils are found in many of the 8 samples examined in this interval.

ENVIRONMENT

Open marine, outer shelf conditions are proposed on the basis of the lithology and microfossils.

INTERVAL 11530' - 12260'; LATE CRETACEOUS, CAMPANIAN

The interval top is based on:

- the absence of the nannofossil *Arkhangelskiella cymbiformis*.

LITHOLOGY

This interval is dominated by light grey, medium light grey and light olive grey chalk which grades towards harder chalky limestone with depth. At and below 12080' dark grey shale partings are seen in the chalk which becomes more argillaceous between 12100' and 12180'.

This lithology represents a continuation of the Chalk Group.

MICROPALAEONTOLOGY

The section from the top of the interval to 12080' is similar to that of the overlying sequence and yielded only rare, long-ranging foraminifera. There is a change in the microfauna at 12100', however, below which depth *Rugoglobigerina rugosa rugosa* occurs commonly in association with other Late Cretaceous species. Significant species present within the assemblage are *Globotruncana linneiana linneiana* and *G. marginata* which confirm that the sediments are of Campanian age at the youngest. The presence of *Conorbina supracretacea* at 12180' and the common occurrence of *Eponides* spp. at 12200' tentatively suggest that early Campanian deposits are present.

NANNOFOSSILS

A Campanian age is assigned to this interval on the absence of *Arkhangelskiella cymbiformis*. The nannofossil assemblages are sparse, although the first occurrence of *Eiffellithus eximius* and the presence of *Parhabdolithus regularis* (Maastrichtian - Campanian) until 12220' do confirm this age assignment.

ENVIRONMENT

An open marine, outer shelf environment is again proposed.

INTERVAL 12260' - 12315'; LATE CRETACEOUS, EARLY CAMPANIAN - SANTONIAN

The age is based on:

- the incoming of red stained *Tritaxia dubia* in association with *T. tricarinata* and common *Eponides* spp. at 12260'.
- the appearance of *Stensioina praeexsculpta* at 12280'.

LITHOLOGY

Hard, light grey chalk and chalky limestone are the predominant lithologies throughout this interval, although some pale red chalk is noted in minor amounts at 12260'.

This lithology is a continuation of the Chalk Group. The red colouration at 12260' may represent the change from the Tor Formation to the Hod Formation but without log data this cannot be verified.

MICROPALAEONTOLOGY

The incoming of red stained foraminifera at 12260', in particular common *Eponides* spp., *Tritaxia dubia* and *T. tricarinata* suggests an early Campanian age. However, the presence of a questionable specimen of *Stensioina praeexsculpta* at this depth tentatively suggests that Santonian sediments have been penetrated. Definite evidence of a Santonian age is afforded by the occurrence of undoubted *S. praeexsculpta* in the succeeding sample, at 12280'.

The planktonic element predominates in the assemblages, although calcareous benthonic species are common at 12260' and 12280'.

NANNOFOSSILS

The nannofossil assemblages indicate a ?Santonian age on the absence of *Parhabdolithus regularis*. However, since no Santonian datum indicators are found this determination is only tentative.

ENVIRONMENT

The lithology and microfossils suggest that deposition occurred in an open marine, outer shelf environment.

VI

PALAEOENVIRONMENTAL SUMMARY

Chalk of Santonian - early Campanian age is the oldest lithology analysed in this well. Deposition probably occurred in open marine, outer shelf seas which persisted throughout the remainder of the Late Cretaceous and into the Danian. Deepening to outer shelf - bathyal depths subsequently occurred and Palaeocene claystones with minor sandstones were deposited. Reworking of both Danian and Upper Cretaceous chalk occurred at this time. A period of volcanic activity is indicated late in Palaeocene times by the presence of tuffs and tuffaceous shales.

Outer shelf to bathyal conditions prevailed through the Eocene and Oligocene, with claystone deposition predominating. Slight shallowing to outer shelf is indicated for the Early Miocene claystones, a trend which continued, with the Middle Miocene sediments being deposited in an inner to outer shelf regime.

VII

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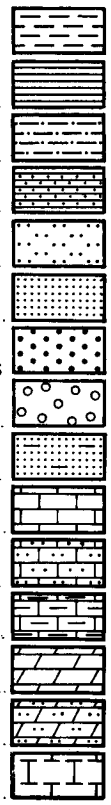
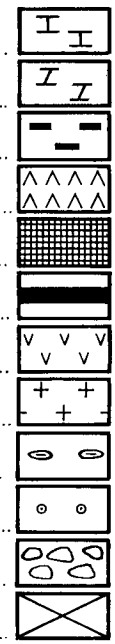
LEGEND FOR STRATIGRAPHIC CHARTS

LITHOLOGY COLUMNS

- Clay
- Shale/claystone/mudstone
- Silty/sandy clay
- Silty/sandy shale/claystone/mudstone
- Silt/siltstone
- Sand/sandstone
  - very fine to medium
  - coarse sand to granules
  - pebbles
- Argillaceous sandstone
- Limestone
- Silty/sandy limestone
- Argillaceous limestone
- Dolomite
- Silty/sandy dolomite
- Chalk



- Calcareous sediments
- Dolomitic sediments
- Carbonaceous sediments
- Anhydrite
- Salt
- Coal/lignite
- Undifferentiated volcanics
- Basement (undifferentiated)
- Mudflakes
- Ooliths
- Concretions
- Sample gap



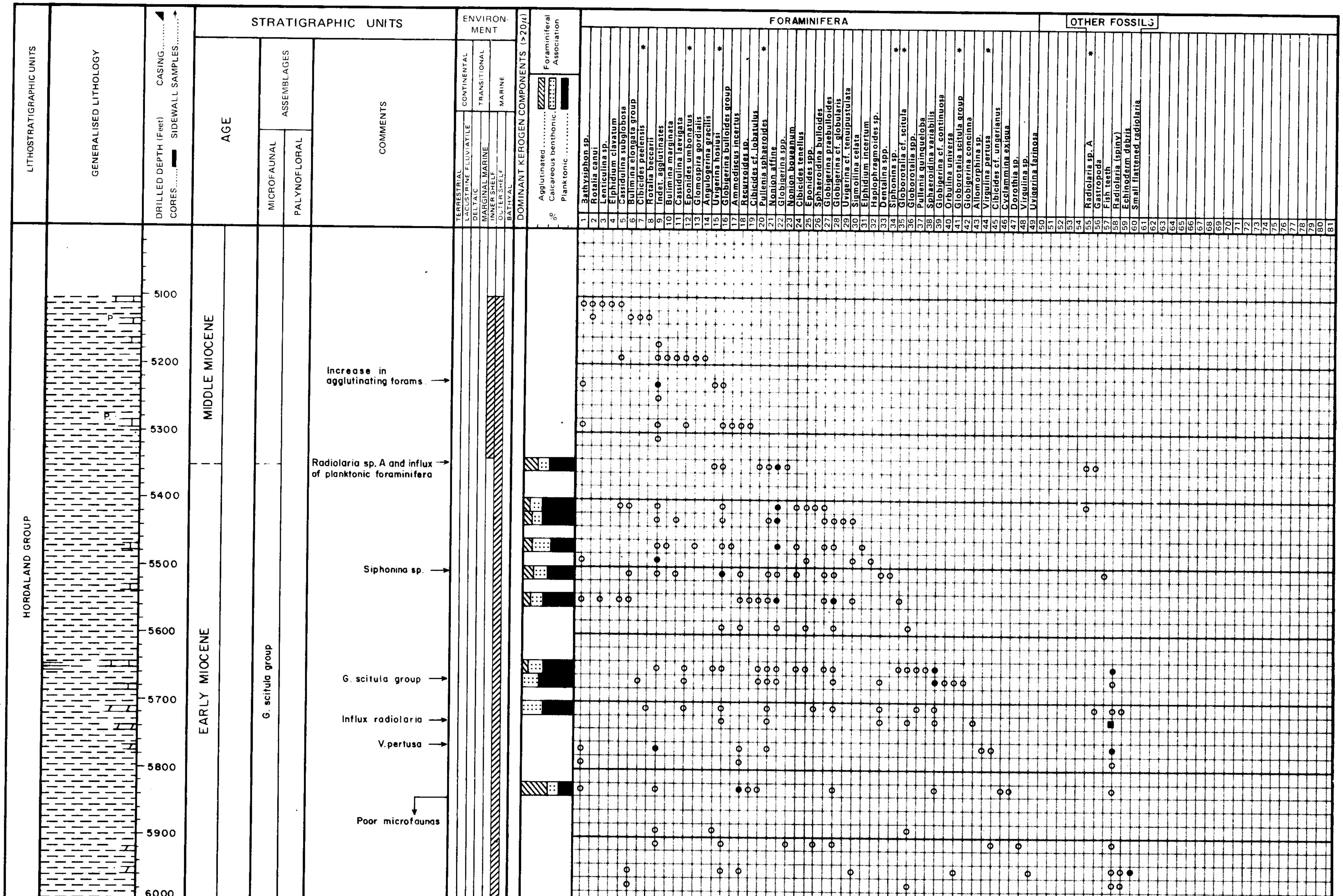
LITHOLOGICAL AND DRILLING ABBREVIATIONS

- Red sedimentary rocks ..... red
- Silica ..... Si
- Chert ..... ▼
- Pyrite ..... P
- Ironstone ..... Fe
- Glauconite ..... G
- Kaolinite ..... K
- Siderite/sphaerosiderite ..... S
- Shell fragments ..... ~
- Cement ..... cmt
- Lost circulation material ..... lcm
- Turbo drilling or diamond drilling ..... tu
  (Samples unsuitable for good stratigraphic analysis)

PALAEONTOLOGICAL SYMBOLS

- Present ..... o
- Common ..... ●
- Abundant ..... ■
- Diagnostic forms ..... *
- Caved forms C
- Reworked forms ..... R
- Dominant Kerogen Components
  - Inertinite I
  - Vitrinite V
  - Exinite ..... E
  - Amorphous sapropel ..... S
- Incoming of ..... ⌐→
- Outgoing of ..... └→

ENCLOSURE 1



ROBERTSON RESEARCH INTERNATIONAL

WELL :– 2/4-9X
LOCATION :– NORWEGIAN NORTH SEA
CLIENT :– PHILLIPS NORWAY

DEPTH :– 5110'–6000'
SHEET 1 OF 8
ANALYST :– DJS, RF

DRAWING NO. :– 467/1169/4530
DATE :– Oct. '79

SCALE 1 : 2,000
ENCLOSURE 2

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

ROBERTSON RESEARCH INTERNATIONAL

WELL :– 2/4 – 9X

LOCATION :– NORWEGIAN NORTH SEA

CLIENT :– PHILLIPS NORWAY

DEPTH :– 6000' – 7000'

SHEET 2 OF 8

ANALYST :– DJS, RF

DRAWING NO. :– 467/1169/4530

DATE :– Oct.'79

SCALE 1 : 2,000

ENCLOSURE 3

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

HORDALAND GROUP

LITHOSTRATIGRAPHIC UNITS

GENERALISED LITHOLOGY

DRILLED DEPTH (Feet) CASING.....

CORES..... SIDEWALL SAMPLES.....

7000 6900 6800 6700 6600 6500 6400 6300 6200 6100 6000

OLIGOCENE | EARLY MIOCENE

AGE

G scitula group

MICROFAUNAL / PALYNOFLORAL — ASSEMBLAGES

STRATIGRAPHIC UNITS

Increasing proportion of agglutinating foraminifera

G ciperoensis

G triloba

COMMENTS

TERRESTRIAL
LACUSTRINE FLUVIATILE
DELTA
MARGINAL MARINE
INNER SHELF
OUTER SHELF
BATHYAL

CONTINENTAL / TRANSITIONAL / MARINE

ENVIRONMENT

DOMINANT KEROGEN COMPONENTS (>20μ)

Agglutinated .....
Calcareous benthonic.....
Planktonic .....

Foraminiferal Association

FORAMINIFERA

1	Globigerinoides triloba	*
2	Globigerina globularis	
3	Nonion affine	
4	Globorotalia scitula group	*
5	Virgulina schreibersiana	
6	Quinqueloculina sp.	
7	Globigerina bulloides group	
8	Uvigerina cf. hosiusi	
9	Asterigerina staeschei	
10	Bulimina elongata group	
11	Bathysiphon spp.	
12	Quinqueloculina spp.	
13	Indet. agglutinates	
14	Cibicides lobatulus	
15	Globigerina spp.	
16	Globigerina cf. continuosa	
17	Sphaeroidina bulloides	
18	Sigmoilina sp.	
19	Eponides spp.	
20	Polymorphinids	
21	Ceratobulimina sp.	
22	Globigerina concinna	
23	Angulogerina gracilis	
24	Pelosina sp.	
25	Pullenia sphaeroides	
26	Globigerina obesa	
27	Nonion boueanum	
28	Bolivina dilatata	
29	Rotalia beccarii	
30	Cassidulina laevigata	
31	Ammodiscus incertus	
32	Cibicides peelensis	
33	Cibicides spp.	
34	Gyroidinoides girardana	
35	Glomospira gordialis	
36	Uvigerina tenuipustulata	
37	Globigerina ciperoensis	*
38	Sigmoilina cf. sp. 1	*
39	Recurvoides spp.	
40	Cibicides tenellus	
41	Lenticulina sp.	
42	Orbulina universa	C
43	Cibicides dutemplei	
44	Cyclammina exigua	
45	Cyclammina sp.	
46	Haplophragmoides sp.	
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OTHER FOSSILS

52	Ostracoda indet.	
53	Echinoderm debris	
54	Radiolaria	
55	Coscinodiscus sp.	
56	Gastropoda	
57	Fish teeth	
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ROBERTSON RESEARCH INTERNATIONAL

WELL :- 2/4-9X
LOCATION :- NORWEGIAN NORTH SEA
CLIENT :- PHILLIPS NORWAY

DEPTH :- 7000'- 8000'
SHEET 3 OF 8
ANALYST :- DJS, RF

DRAWING NO. 467/1169/4530
DATE :- Oct.'79

SCALE 1 : 2,000
ENCLOSURE 4

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

LITHOSTRATIGRAPHIC UNITS: HORDALAND GROUP

GENERALISED LITHOLOGY

DRILLED DEPTH (Feet) 8000 7900 7800 7700 7600 7500 7400 7300 7200 7100 7000
CASING.....
CORES..... SIDEWALL SAMPLES.....

STRATIGRAPHIC UNITS

AGE: OLIGOCENE

MICROFAUNAL ASSEMBLAGES: S. schlumbergeri

PALYNOFLORAL ASSEMBLAGES

COMMENTS: Poor microfaunas dominated by agglutinating foraminifera

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

DOMINANT KEROGEN COMPONENTS (>20µ)

% Agglutinated ..... Calcareous benthonic ..... Planktonic .....

Foraminiferal Association

FORAMINIFERA

1	Ammodiscus incertus
2	Recurvoides spp.
3	Bathysiphon spp.
4	Globorotalia scitula group
5	Nonion boueanum
6	Pullenia sphaeroides
7	Textularia sp.
8	Globigerina cf. continuosa
9	Quinqueloculina spp.
10	Globigerinoides cf. triloba
11	Globorotalia cf. opima *
12	Indet. agglutinates
13	Bulimina elongata group
14	Glomospira gordialis
15	Cibicides tenellus
16	Trochammina sp.
17	Pelosina sp.
18	Sigmoilina schlumbergeri *
19	~~Globorotalia spp.~~
20	Cyclammina cf. exigua
21	Globigerina bulloides group
22	Dentalina sp.
23	Pyrgo bulloides C
24	Cibicides ungerianus
25	Angulogerina gracilis
26	Cyclammina placenta
27	Rotalia sp.
28	Sphaeroidina bulloides
29	Cyclammina spp.
30	Nonion affine
31	
32	
33	
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OTHER FOSSILS

36	Echinoderm debris
37	Coscinodiscus spp.
38	Radiolaria
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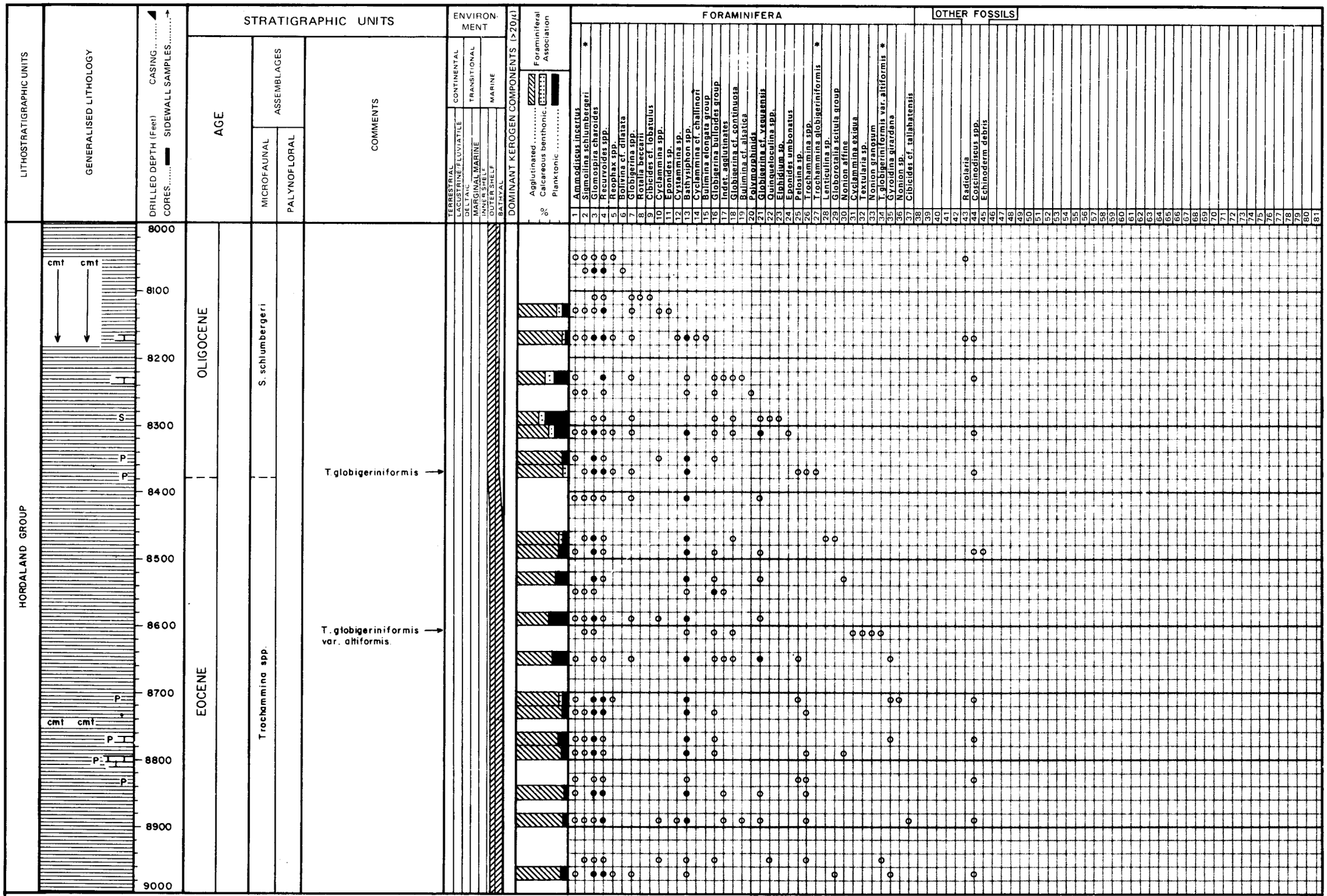


ROBERTSON RESEARCH INTERNATIONAL

WELL :– 2/4-9X
LOCATION :– NORWEGIAN NORTH SEA
CLIENT :– PHILLIPS NORWAY

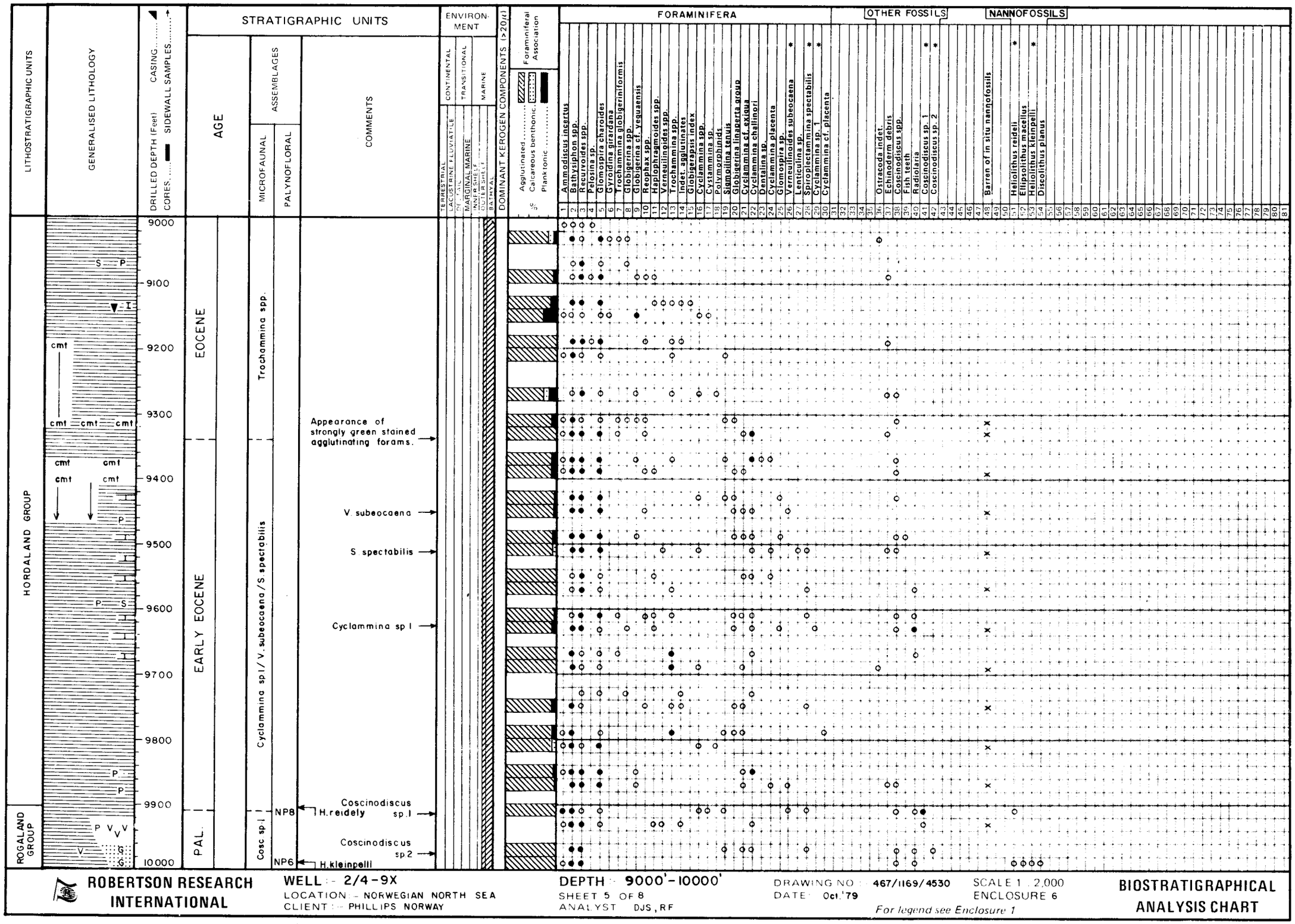
DEPTH :– 8000'–9000'
SHEET 4 OF 8
ANALYST :– DJS, RF

DRAWING NO. :– 467/1169/4530
DATE :– Oct.'79

SCALE 1 : 2,000
ENCLOSURE 5

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART



ROBERTSON RESEARCH INTERNATIONAL

WELL :- 2/4-9X
LOCATION :- NORWEGIAN NORTH SEA
CLIENT :- PHILLIPS NORWAY

DEPTH :- 9000'-10000'
SHEET 5 OF 8
ANALYST DJS, RF

DRAWING NO :- 467/1169/4530
DATE :- Oct.'79

SCALE 1 : 2,000
ENCLOSURE 6

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

LITHOSTRATIGRAPHIC UNITS

ROGALAND GROUP

MONTROSE GROUP

MAUREEN FORMATION

EKOFISK FORMATION

CHALK GROUP

GENERALISED LITHOLOGY

DRILLED DEPTH (Feet) CASING..... CORES..... SIDEWALL SAMPLES.....

10000 10100 10200 10300 10400 10500 10600 10700 10800 10900 11000

STRATIGRAPHIC UNITS

AGE

PALAEOCENE

LOWER PALAEOCENE

LATE CRETACEOUS

DANIAN

LATE MAAS. – MAAS.

MICROFAUNAL ASSEMBLAGES

PALYNOFLORAL

Coscinodiscus sp 1

G. pseudobulloides/A. velascoensis/ G. vombensis

Pseud. spp.

COMMENTS

Influx reworked Cretaceous nannofossils

Danian and occasional Cretaceous reworked foraminifera

Influx of presumed in situ Danian planktonics and nannofossils

Poor assemblages

P. elegans elegans, P. elegans fructicosa

Tertiary caving

N. frequens

ENVIRONMENT

TERRESTRIAL

LACUSTRINE-FLUVIATILE

CONTINENTAL

DELTAIC

MARGINAL MARINE

INNER SHELF

OUTER SHELF

BATHYAL

TRANSITIONAL

MARINE

DOMINANT KEROGEN COMPONENTS (>20%)

Agglutinated

Calcareous benthonic

Planktonic

Foraminiferal Association

FORAMINIFERA

OTHER FOSSILS

1	Verneuilinoides subeocaena	
2	Bathysiphon sp.	
3	Recurvoides spp.	
4	Cyclammina chalmori	
5	Ammodiscus incertus	
6	Sigmoilina tenuis	
7	Cyclammina cf. exigua	
8	Cystammina sp.	
9	Haplophragmoides spp.	
10	Glomospira charoides	
11	Spiroplectammina spectabilis	
12	Reophax spp.	
13	Indet. agglutinates	
14	Gavelinella vombensis	R
15	Globigerina pseudobulloides	R
16	Gyroidina sp.	R
17	Globorotalia compressa	R
18	Globigerinelloides asper	R
19	Rugoglobigerina sp.	R
20	Globigerina triloculinoides	R
21	Praebulimina sp.	R
22	Trochammina spp.	
23	Dorothia sp.	
24	Globigerina pseudobulloides	*
25	Globigerina triloculinoides	*
26	Lenticulina spp.	
27	Eponides cf. frankei	
28	Globorotalia compressa	*
29	Gyroidinoides subangulatus	
30	Pullenia cretacea	
31	Dentalina sp.	
32	Anomalinoides velascoensis	*
33	Pullenia americana	
34	Tritaxia sp.	
35	Globoconusa daubjergensis	*
36	Dorothia spp.	
37	Eponides lunata	
38	Polymorphinids	*
39	Gavelinella vombensis	*
40	Allomorphina halli	*
41	Globigerinelloides asper	*
42	Pseudotextularia elegans elegans	*
43	Pseudotextularia elegans fructicosa	*
44	Globotruncana contusa	*
45	Heterohelix spp.	*
46	Rugoglobigerina rugosa rugosa	*
47	Praeglobotruncana citae	
48	Gavelinopsis bembix	
49	Gyroidina/Gyroidinoides spp.	
50	Gavelinopsis sp.	
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56	Radiolaria (small flattened)	
57	Fish teeth	
58	Coscinodiscus sp.	
59	Coscinodiscus sp. 1	
60	Echinoderm debris	
61	Radiolaria (large flattened)	
62	Radiolaria (small rounded)	
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ROBERTSON RESEARCH INTERNATIONAL

WELL : 2/4-9X

LOCATION : NORWEGIAN NORTH SEA

CLIENT : PHILLIPS NORWAY

DEPTH : 10000'-11000'

SHEET 6a OF 8

ANALYST : DJS, JMB, RF

DRAWING NO. 467/1169/4530

DATE : Oct.'79

SCALE 1 : 2,000

ENCLOSURE 7

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

DRILLED DEPTH (Feet)

PALYNOFLORAL ASSEMBLAGES

COMMENTS

DOMINANT KEROGEN COMPONENTS (>20µ)

NANNOFOSSILS

1	Coccolithus pelagicus	
2	Heliolithus reideli	*
3	Neochiastozygus digitosus	
4	Cribrosphaerella primitiva	R
5	Prediscosphaera spinosa	R
6	Broinsonia parca	R
7	Discorhabdus ignotus	R
8	Reinhardtites levis	R
9	Watznaueria barnesae	R
10	Cribrosphaerella ehrenbergi	R
11	Parhabdolithus regularis	R
12	Eiffellithus turriseiffeli	R
13	Eiffellithus sp.	R
14	Prediscosphaera cretacea	R
15	Arkhangelskiella cymbiformis	R
16	Kamptnerius magnificus	R
17	Micula staurophora	R
18	Markalius sp.	R
19	Primsius dimorphosum	
20	Ericsonia cava	
21	Markalius inversus	
22	Primsius martinii	
23	Chiasmolithus danicus	
24	Heliolithus kleinpellii	*
25	Discolithus distinctus	
26	Braarudosphaera bigelowi	
27	Criciplacolithus tenuis	
28	Discolithus planus	
29	Ericsonia subpertusa	
30	Thoracosphaera sp.	
31	Neochiastozygus perfectus	
32	Eiffellithus trabeculatus	R
33	Lucianorhabdus cayeuxii	R
34	Biscutum ellipticum	R
35	Kamptnerius magnificus	*
36	Eiffellithus sp.	
37	Arkhangelskiella cymbiformis	*
38	Micula staurophora	*
39	Prediscosphaera cretacea	*
40	Cribrosphaerella ehrenbergi	*
41	Watznaueria barnesae	*
42	Eiffellithus turriseiffeli	*
43	Parhabdolithus regularis	*
44	Lucianorhabdus cayeuxii	*
45	Biscutum ellipticum	*
46	Cyclagelosphaera margereli	*
47	Nephrolithus frequens	*
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11000

Influx of reworked Cretaceous nannofossils →

Reworked Cretaceous species

Influx of abundant Danian nannofossils →

Reworked Cretaceous nannofossils

Caved Danian nannofossils

M 3 ← N. frequens

ROBERTSON RESEARCH INTERNATIONAL

WELL : 2/4-9X
LOCATION :- NORWEGIAN NORTH SEA
CLIENT :- PHILLIPS NORWAY

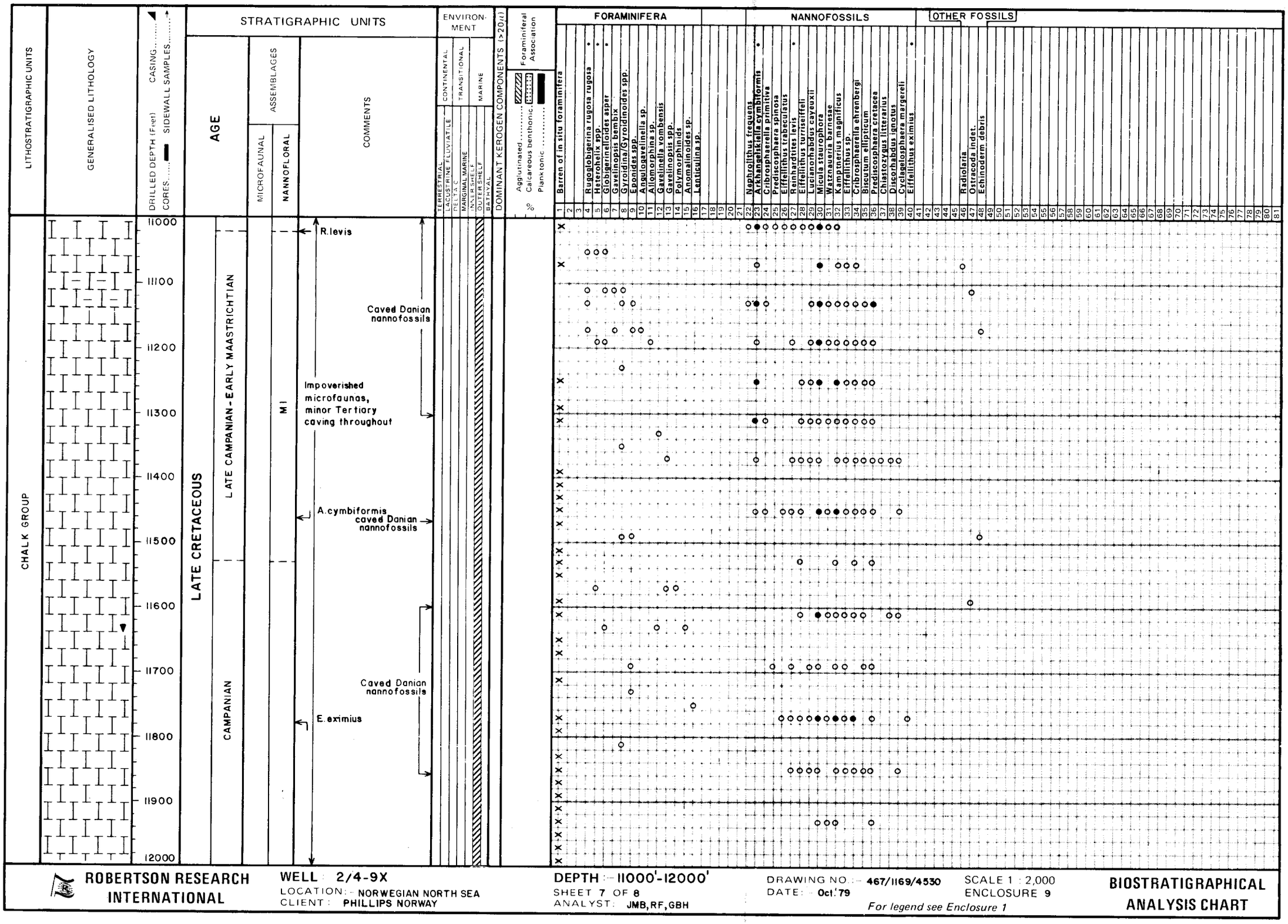
DEPTH - 10000' - 11000'
SHEET 6b OF 8
ANALYST :- GBH

DRAWING NO. :- 467/1169/4530
DATE :- Oct.'79

SCALE 1 : 2,000
ENCLOSURE 8

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART



ROBERTSON RESEARCH INTERNATIONAL

WELL: 2/4-9X
LOCATION: NORWEGIAN NORTH SEA
CLIENT: PHILLIPS NORWAY

DEPTH: 11000'-12000'
SHEET 7 OF 8
ANALYST: JMB,RF,GBH

DRAWING NO.: 467/1169/4530
DATE: Oct.'79

SCALE 1 : 2,000
ENCLOSURE 9

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

ROBERTSON RESEARCH INTERNATIONAL

WELL 2/4-9X
LOCATION: NORWEGIAN NORTH SEA
CLIENT: PHILLIPS NORWAY

DEPTH 12000'-12315'
SHEET 8 OF 8
ANALYST JMB,RF,GBH

DRAWING NO 467/1169/4530
DATE Oct.'79

SCALE 1:2,000
ENCLOSURE 10

BIOSTRATIGRAPHICAL ANALYSIS CHART

For legend see Enclosure 1

CHALK GROUP

LITHOSTRATIGRAPHIC UNITS

GENERALISED LITHOLOGY

DRILLED DEPTH (Feet) CASING
CORES SIDEWALL SAMPLES

12400 12300 12200 12100 12000

LATE CRETACEOUS

AGE

E.Y. CAMP.-SANT. | CAMPANIAN

MICROFAUNAL ASSEMBLAGES

T.dub./Stens. | Globotruncana marginata

PALYNOFLORAL

STRATIGRAPHIC UNITS

COMMENTS

S. praeexsculpta
T.dubia, increase in calc. benths. Red staining
P. regularis
Minor Tertiary caving
Increase in R.rugosa rugosa
G. linneiana linneiana

ENVIRONMENT

TERRESTRIAL
LACUSTRINE FLUVIATILE
DELTAIC — CONTINENTAL
MARGINAL MARINE
INNER SHELF
OUTER SHELF — MARINE
BATHYAL — TRANSITIONAL

DOMINANT KEROGEN COMPONENTS (>20μ)

Foraminiferal Association

Agglutinated
Calcareous benthonic
Planktonic

FORAMINIFERA

1	Barren of in situ foraminifera
2	
3	
4	Globigerinelloides asper *
5	? Rugoglobigerina sp.
6	Rugoglobigerina rugosa rugosa *
7	Rugoglobigerina rugosa rotundata *
8	Eponides spp.
9	Dorothia/Marssonella spp.
10	Globotruncana spp.
11	Gyroidina/Gyroidinoides spp.
12	Globotruncana linneiana linneiana *
13	Gavelinella vombiensis
14	Gyroidina quadrata
15	? Tritaxia dubia
16	Marssonella spp.
17	Globotruncana arca *
18	Conorbina supracretacea *
19	Globorotalites spp.
20	Globotruncana marginata *
21	Spiroplectammina spp.
22	Polymorphinids
23	Praebulimina spp.
24	Tritaxia dubia *
25	Heterohelix spp.
26	Rhizammina/Bathysiphon group
27	Tritaxia tricarinata *
28	? Stensioina praeexsculpta
29	Stensioina praeexsculpta *
30	Reussella szajnochae szajnochae *
31	Lenticulina sp.
32	Hedbergella cf. planispira
33	Globorotalites multisepta *
34	
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NANNOFOSSILS

39	Micula staurophora
40	Prediscosphaera cretacea
41	Eiffellithus sp.
42	Watznaueria barnesae
43	Kamptnerius magnificus
44	Lucianorhabdus cayeuxii
45	Biscutum ellipticum
46	Cribrosphaerella primitiva
47	Eiffellithus eximius
48	Reinhardtites levis
49	Discorhabdus ignotus
50	Parhabdolithus regularis *
51	Eiffellithus trabeculatus
52	Cribrosphaerella ehrenbergi
53	Eiffellithus turriseiffeli
54	Cyclagelosphaera margereli
55	Broinsonia parca
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OTHER FOSSILS

61	Ostracoda indet.
62	Radiolaria
63	Echinoderm debris
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ROBERTSON RESEARCH INTERNATIONAL LIMITED

SUMMARY LOG 2/4-9X

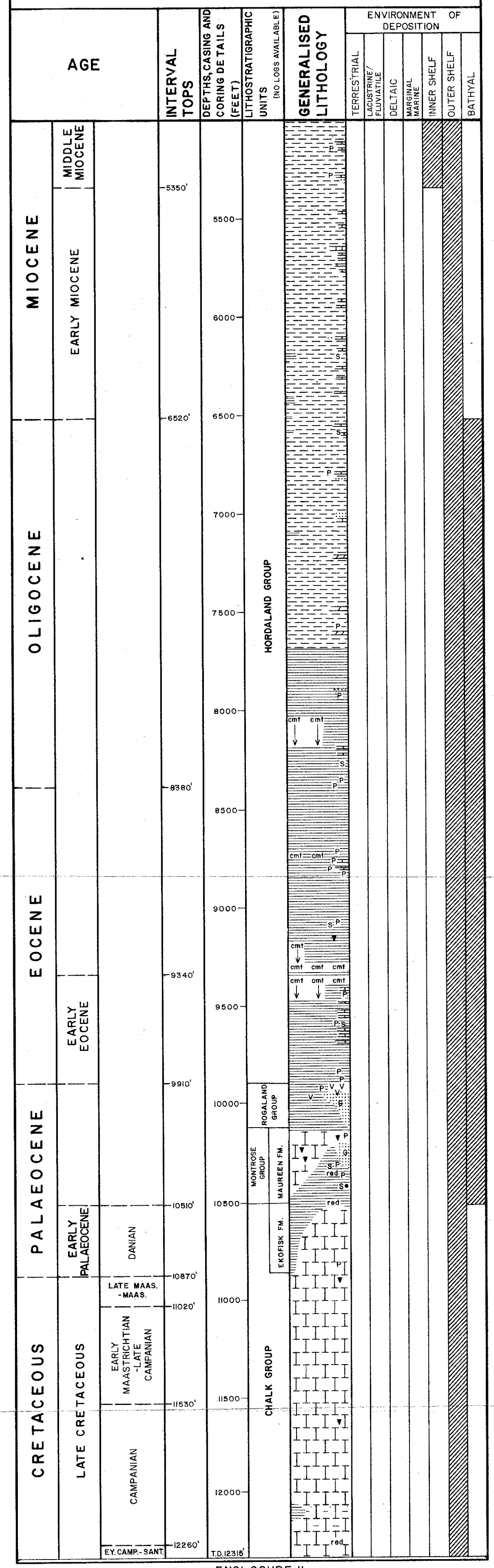
AREA : NORWEGIAN NORTH SEA SPUD DATE :

COMPANY : PHILLIPS NORWAY COMPLETION DATE :

INTERVAL STUDIED : 5110'-12315' T. D. 12315

Dr. No. 467/1169/4530 SCALE 1 : 5000 Date : Oct.'79

▌ Cored Interval ◣ Casing Shoe



ENCLOSURE II