ROBERTSON RESEARCH INTERNATIONAL LIMITED

OILFIELDS REPORT NO. 2316

WELLFILE No33

STATOIL 15/9 - 1 NORWEGIAN NORTH SEA WELL: BIOSTRATIGRAPHY OF THE INTERVAL 3300m – 3735m

by

J. W. CHURCH
C. N. DENISON
J. UNDERWOOD

PROJECT NO. RRI/IIA/778/1240

Prepared by:

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

Prepared for:

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

December, 1977

CONTENTS

Enclosures

I

SUMMARY

1. The initial section of the well is a poorly fossiliferous (due to the use of a diamond bit or turbo-drill) indeterminate section presumably of Cretaceous age.

2. The use of a normal bit resulted in dateable Lower Cretaceous microfaunas indicating that early Albian - Aptian to Barremian - Hauterivian sediments occur.

3. The Cretaceous - Jurassic contact is marked by a stratigraphic hiatus.

4. The Upper Jurassic appears to be relatively complete varying from the Middle Volgian (unit o) to early Oxfordian (unit r).

5. A feature of particular note in this well is the development of sands in the base of the Oxfordian (unit q) and in the early Oxfordian (unit r) and ?Callovian (unit ?sl). Sand development is particularly strong from the top of the middle Callovian - late Bathonian (units s2 - t1) interval and persists until the base of the ?Bathonian - ?Bajocian.

6. A large part of the sand appears to have been deposited under shallow inner shelf or marginal marine conditions. This marine influence is more marked in the interval above 3636m.

7. Below 3636m marine influences were less pronounced and only a questionable Bathonian - Bajocian age is possible for the lower part of the sand body.

8. The well terminated in waxy shales and sands of possible Lower Jurassic age.

9. A further stratigraphic hiatus separates the Middle Jurassic from the ?Lower Jurassic.

II

INTRODUCTION

This report summarises the results of the micropalaeontological, palynological and stratigraphical analyses which have been carried out on material received from the interval 3300m - 3735m from the Statoil 15/9-1 Norwegian North Sea Well under Project No. IIA/778/1240.

Under this project a total of 145 ditch cuttings and 6 core samples was analysed utilising standard micropalaeontological techniques. In addition 39 ditch cuttings and 14 core samples covering the interval 3301m - 3735m were treated palynologically.

The data available from a previous study carried out on core samples only from this well (Robertson Research International Limited, Memorandum No. 2158) have been incorporated in this report.

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

The Jurassic biostratigraphic units used in this report are those proposed in our study - "The Jurassic of Northwest Europe: Offshore Project". Their stratigraphical significance is summarised in Appendix I. In addition the dinocyst zones of the Norian - Barremian can be seen in Appendix II.

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.

The personnel involved in this work were:-

John Church: Well Co-ordinator and Micropalaeontology.
Chris Denison: Palynology.
Cyril Haskins: Ostracodes.
John Underwood: Lithologies.

III

SUCCESSION

System/Subsystem	Stage	Interval
Indeterminate	-	3300m - 3322m
Lower Cretaceous	early Albian - Aptian	3325m - 3340m
	Barremian	3343m - 3358m
	Barremian - Hauterivian	3361m - 3370m
---------- UNCONFORMITY ----------		
Upper Jurassic	middle - early Volgian (unit o)	3373m - 3418m
	early Volgian - late Kimmeridgian (units o-p1)	3421m - 3454m
	early Kimmeridgian - late Oxfordian (unit p2)	3457m - 3463m
	middle Oxfordian (unit q)	3466m - 3520m
	early Oxfordian (unit r)	3521m
Middle Jurassic	?Callovian (unit ?s1)	3523.7m - 3528.95m
	middle Callovian - late Bathonian (units s2-t1)	3531m - 3537m
	?Bathonian (unit ?t2)	3540m - ?3648m
	?Bathonian - ?Bajocian	?3651m - 3726m
---------- UNCONFORMITY ----------		
?Lower Jurassic	-	3729m - 3735m

This breakdown is based on ditch cuttings and core samples only. Electric logs were not made available.

IV

INDETERMINATE

INTERVAL 3300m - 3322m; INDETERMINATE

No age determination is possible on this interval because, due to the use of a diamond bit or turbo-drill, no significant microfossils or lithotypes have been recorded.

LITHOLOGY

Light grey, argillaceous limestone or calcareous shale is thought to be the in situ lithology. In addition traces of white chalk and, at 3307m, possible traces of pink chalk are recorded.

MICROPALAEONTOLOGY

The samples from this interval proved to be either devoid of any microfauna or only contained rare long-ranging forms. This is presumably the result of the use of a diamond bit or a turbo-drill. No age determination is possible on this meagre assemblage.

PALYNOLOGY

Palynomorphs are rare: no age-diagnostic taxa were recovered.

ENVIRONMENT

A general shelf environment is suggested for this interval on the slender palaeontological evidence available.

V

CRETACEOUS

INTERVAL 3325m - 3340m; LOWER CRETACEOUS, EARLY ALBIAN - APTIAN

This interval has been assigned an early Albian - Aptian age due to the appearance of a characteristic agglutinating foraminiferal assemblage.

LITHOLOGY

There is an influx of red shale at 3325m in association with medium dark grey shales. Traces of olive-grey shale and light grey limestones also occur whilst at 3337m there is a further appearance of red shales.

MICROPALAEONTOLOGY

The upper limit of this interval has been placed on the occurrence of a red-stained Glomospira gordialis. This is followed at 3328m by an impoverished microfauna also consisting of red-stained species. A 3337m the numbers of specimens recovered increase although the assemblage still remains impoverished.

The occurrence, as a prominent species, of Glomospira gordialis, together with Recurvoides sp. and ?"Lingulogavelinella" gyroidinaeformis indicate that these sediments are of early Albian - Aptian age.

PALYNOLOGY

Although a sample at 3337m yielded a moderate palynoflora, there is considerable evidence of caving. Those forms considered to be in situ indicate only a general Lower Cretaceous age.

ENVIRONMENT

The occurrence of microfaunas dominated by agglutinating foraminifera suggests that deposition took place in a shallow inner shelf environment.

INTERVAL 3343m - 3358m; LOWER CRETACEOUS, BARREMIAN

The age and upper limit of this interval are based on the appearance of Hedbergella infracretacea.

LITHOLOGY

Red shale is common at the top of this interval. Dark grey shales subsequently appear at 3346m where they are associated with traces of light green, waxy shales and light grey, argillaceous limestones. Hard, crystalline, yellowish grey limestone and pyrite are present at and below 3352m. Red-stained limestone occurs at 3358m.

MICROPALAEONTOLOGY

A distinct microfaunal change is apparent at 3343m with an influx of planktonic foraminifera. The presence of Hedbergella infracretacea in this assemblage indicates that the Barremian has been penetrated.

The microfaunas are generally sparse and below 3343m the planktonic element decreases.

PALYNOLOGY

A sample at 3349m yielded a very sparse flora of no age-diagnostic value.

ENVIRONMENT

The association of a strong agglutinating element with significant numbers of planktonic foraminifera suggests that sedimentation took place in an inner to outer shelf environment with strong open marine influence.

INTERVAL 3361m - 3370m; LOWER CRETACEOUS, BARREMIAN - HAUTERIVIAN

The upper limit of this interval is based on a distinct microfaunal change at 3361'.

The age of these sediments is indicated by:-

- the appearance of abundant Uvigerinammina moesiana associated with common polymorphinids, Marssonella spp. and Aulotortus (Spirillina) neocomiana which indicate a Barremian or older Lower Cretaceous age.

LITHOLOGY

White and pink, chalky limestone, fissile, dark grey shale and accessory pyrite are considered to be the in situ lithologies in this interval.

MICROPALAEONTOLOGY

A distinct microfaunal break is apparent at 3361m with an influx of Uvigerinammina moesiana. This is followed at 3364m by an improved microfauna, the appearance of ostracodes and the incoming of Marssonella cf. trochus, M. hauteriviana and common polymorphinids. This assemblage is typical of those recovered from the basal part of many Lower Cretaceous sections from the North Sea area. The age is difficult to define but the microfauna is no younger than the Barremian and is generally considered to be of Barremian to Hauterivian age, although it could extend into older Lower Cretaceous sediments. The occurrence of Aulotortus (Spirillina) neocomiana at 3376m supports this determination.

PALYNOLOGY

A rich and diverse palynomorph assemblage, dominated by dinocysts, was recovered at 3361m. Pseudoceratium pelliferum, which is relatively common, indicates a Barremian or older age, and Necrobroomea longicornuta suggests an age no older than Hauterivian. The presence of Dingodinium cf. cerviculum and large gonyaulacean cysts referred to Gonyaulacysta aff. "neocomica", also suggest a pre-Barremian, possibly Hauterivian age. However, a specimen of Endoscrinium pharo, a species which does not range younger than Valanginian, is present.

As this is the first richly palyniferous Lower Cretaceous sample encountered in this well, it is probable that the effect of caving will be limited and that the assemblage is effectively in situ. It would appear, therefore, that the isolated specimen of E. pharo is reworked and in situ forms are of

Hauterivian age. The absence of other pre-Hauterivian forms either at this horizon or as cavings suggests that Valanginian and Ryazanian deposits are missing, rather than a condensed sequence being present.

ENVIRONMENT

The occurrence of moderate microfaunas, dominated by agglutinating foraminifera with significant numbers of calcareous benthonic forms and ostracodes, indicates that deposition took place in an inner shelf environment.

The rich and diverse dinocyst assemblage also suggests an inner shelf environment, but the miospore assemblage, which contains common bisaccate pollen grains suggests some terrestrial influences.

VI

JURASSIC

INTERVAL 3373m - 3418m; UPPER JURASSIC, MIDDLE - EARLY VOLGIAN (unit o)

The upper limit of this interval is indicated by:

- the appearance of dark grey-black shale typical of the Upper Jurassic.

The age of these sediments is based on:

- the appearance of Glossodinium dimorphum and Dichadogonyaulax pannea at 3379m.

LITHOLOGY

Dark grey, black and olive-grey shales and common carbonaceous fragments occur in this interval. In addition scattered medium-grained, white sand is recorded at 3403m - 3406m, and traces of pyrite at 3412m.

MICROPALAEONTOLOGY

No in situ foraminifera have been recovered from this interval. Bone fragments occur commonly from 3376m and provide some support for an Upper Jurassic age whilst at 3406m Rhaxella perforata appears and occurs in abundance from 3412m. The incoming of this sponge spicule again provides some support for an Upper Jurassic age because it normally occurs in abundance in early Kimmeridgian - Oxfordian sediments, although it does range into the Volgian and Lower Cretaceous.

PALYNOLOGY

The upper limit of this interval is marked by the appearance of amorphous sapropel kerogen, which is diluted by caved humic kerogen at 3373m, but below becomes the dominant kerogen component.

The palynomorph assemblage at 3373m is rich in leiospheres and

Pterospermopsis spp., which are typical of middle and late Volgian assemblages, but forms restricted to the late Volgian are absent, indicating that the youngest Jurassic deposits are of middle Volgian age. An age no older than middle Volgian at 3373m is indicated by the presence of Muderongia simplex, although this specimen may be caved from the overlying Barremian - Hauterivian interval.

Evidence of a middle Volgian age is present at 3379m, with the first appearance of Glossodinium dimorphum and Dichadogonyaulax pannea, both of which indicate an age no younger than the Dichadogonyaulax pannea Subzone (VIIA) but both forms range into the early Volgian.

Evidence below this depth is poorer, but the overall decrease in leiosphere and Pterospermopsis spp. abundances suggest the penetration of early middle Volgian to early Volgian deposits. A form referred to ?Pareodinia mutabilis at 3409m may indicate an age no younger than the lower part of the Dichadogonyaulax culmula Subzone (VIIB).

Miospore assemblages are generally rather sparse, although at 3397m bisaccates become common and, to a lesser extent, Cerebropollenites mesozoicus.

Amorphous sapropel continues to be the dominant kerogen component throughout this interval.

ENVIRONMENT

The association of carbonaceous shales and sponge spicules suggests that deposition took place in a shallow water inner shelf environment. Terrestrial influences are poor, as miospores are generally sparse, although at 3397m there was an isolated influx of material of terrestrial origin.

INTERVAL 3421m - 3454m; UPPER JURASSIC, EARLY VOLGIAN - LATE KIMMERIDIGIAN (units o-p1)

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

- the appearance of Gonyaulacysta jurassica.

LITHOLOGY

Dark grey, black and olive-grey shales persist into this interval, although the shales have become waxy at 3427m and slightly micaceous at 3442m. Yellowish brown crystalline limestone forms a distinct bed at 3436m.

MICROPALAEONTOLOGY

This interval contains rare specimens of agglutinating foraminifera and common to abundant Rhaxella perforata. No specific age determination is possible on this assemblage, although the abundance of pyritised Rhaxella perforata is more usually encountered in sediments of early Kimmeridgian - Oxfordian age.

PALYNOLOGY

The appearance of a specimen of Gonyaulacysta jurassica at 3421m, in an otherwise sparse assemblage, indicates an age no younger than the Gonyaulacysta jurassica Subzone (VIIIB).

An assemblage at 3433m is again sparse, and contains a non-age diagnostic microflora, but at 3445m there is an increase in the abundance and diversity of microplankton and miospores. The concurrence in this deeper sample of a fragmentary specimen of ?G. jurassica and Leptodinium egemenii indicates an age no younger than the G. jurassica Subzone (VIIIB), but a fragment attributed to ?Scriniodinium luridum may indicate an age no younger than the Gonyaulacysta cladophora Zone (X).

Miospores assemblages are rich and reasonably diverse, particularly in the lower part of the interval, where bisaccates, Perinopollenites elatoides and Cerebropollenites mesozoicus are common.

Amorphous sapropel is again the dominant kerogen component.

ENVIRONMENT

A shallow water inner shelf environment is indicated for these deposits by the presence of abundant sponge spicules. The dominance of amorphous sapropelic kerogen indicates anaerobic bottom conditions. Abundant miospores, which form the dominant element of the palynofloras, suggest proximity to a source of terrestrial debris.

INTERVAL 3457m - 3463m; UPPER JURASSIC, EARLY KIMMERIDGIAN - LATE OXFORDIAN (unit p2)

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

- a distinct microfaunal break with the consistent appearance of agglutinating foraminifera including Haplophragmoides cf. canui.
- the appearance of Scriniodinium crystallinum at 3457m.

LITHOLOGY

Slightly micaceous dark grey shale persists in this interval.

MICROPALAEONTOLOGY

A distinct microfaunal change in the assemblage is apparent at 3457m with the appearance and subsequently consistent occurrence of agglutinating foraminifera. The numbers of foraminifera recovered from the three samples of this section are very low and consist entirely of agglutinating forms. This association, which includes Haplophragmoides cf. canui, suggests a unit p2 (early Kimmeridgian - late Oxfordian) equivalence, although it could possibly extend into unit q sediments of Oxfordian age.

Rhaxella perforata persists as an abundant form in this interval.

PALYNOLOGY

The first downhole appearance, in an otherwise sparse assemblage, of the dinocyst Scriniodinium crystallinum at 3457m indicates an age no younger than the Leptodinium egemenii Subzone (XIA) of the early Kimmeridgian to late Oxfordian Scriniodinium crystallinum Zone (XI).

Miospores are the dominant element of the assemblage recovered, the forms Perinopollenites elatoides, Cerebropollenites mesozoicus and bisaccates being common.

Amorphous sapropel is the dominant kerogen component.

ENVIRONMENT

A shallow water inner shelf environment is suggested for these sediments by the sparse microfaunas. The consistent occurrence of foraminifera suggests that the conditions were not as restricted as in the overlying sediments, although amorphous sapropel continues to be common. Abundant miospores suggest a nearby source of terrestrial material.

INTERVAL 3466m - 3520m; UPPER JURASSIC, MIDDLE OXFORDIAN (unit q)

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

- the appearance of calcareous benthonic foraminifera which include Lenticulina cf. ectypa.

LITHOLOGY

Dark grey, slightly micaceous shales persist into this interval with the addition of small amounts of fine-grained sand; there is an increase in sand in the sample at 3517m. Limestone or siderite forms a thin bed at 3478m and yellowish grey crystalline siderite is present at 3502m.

MICROPALAEONTOLOGY

This interval is again characterised by agglutinating foraminifera but with the addition of calcareous benthonic foraminifera. Although agglutinating foraminifera predominate calcareous forms comprise a significant element of the assemblages and become particularly prominent from 3472m. The presence of species of Lenticulina, which include Lenticulina cf. ectypa, suggests a unit q-s1 (middle Oxfordian - late Callovian) connotation which in view of the subsequent palynological information can be restricted to unit q (middle Oxfordian).

The microfaunas recovered from this interval are initially low in numbers. From 3475m there is a gradual reduction in numbers and below 3508m the assemblages are very sparse.

PALYNOLOGY

There is no palynological evidence to distinguish the top of this interval, and the dinocyst species which first appear towards the top e.g. ?Scriniodinium galeritum and Stephanelytron redcliffense range into basal Kimmeridgian deposits. It does, however, coincide with a marked change of palynofacies. The kerogen content is characterised by a high proportion of inertinite. This forms a marked contrast to the overlying Jurassic, which is rich in amorphous sapropel: some sapropel is present at 3469m as cavings.

At 3504m a form referred to Acanthaulax ?spinosissima suggests a mid-Oxfordian age (Acanthaulax spinosissima Zone (XIII) or older) an age also suggested by Acanthaulax sp.1 JOHNSON and HILLS at 3519m. Microplankton abundances and diversity are similar to those in the overlying interval, but there is an increase in the abundance of microforaminiferal linings, which are relatively common, except at 3519m.

Miospores are again the dominant element of the assemblages, although there is some decrease in abundance and diversity at 3504m and 3519m. Bisaccates are the dominant forms, with Cerebropollenites mesozoicus relatively common. Perinopollenites elatoides is relatively common at 3481m and 3495m.

ENVIRONMENT

A shallow water inner shelf environment is again indicated by the microfauna. The occurrence of calcareous benthonic species suggests that the seas were more oxygenated than those of the overlying sections.

INTERVAL 3521m; UPPER JURASSIC, EARLY OXFORDIAN (unit r)

The age of this sample is based on:

- the presence of the diagnostic dinocysts Wanaea fimbriata and W. digitata.

LITHOLOGY

This sample consists of silty, sandy, micaceous, slightly carbonaceous dark grey shale with fine-grained, angular, brownish sand.

MICROPALAEONTOLOGY

This sample proved to be devoid of any microfauna.

PALYNOLOGY

Dinocysts from the core sample at 3521m form an assemblage which is diagnostic of the Wanaea fimbriata Subzone (XIVB) of the Wanaea digitata Zone (XIV). W. fimbriata and W. digitata are present and Adnatosphaeridium aemulum is common. ?Wanaea fimbriata does not occur until 3540m in ditch cuttings, where it has presumably caved. Miospores form a varied assemblage and are much more common than dinocysts.

Kerogen is dominantly humic, but there is a minor amorphous sapropel content.

ENVIRONMENT

Both the kerogen and the predominance of miospores suggest that deposition occurred in a nearshore environment, with some material being derived from a terrestrial source.

INTERVAL 3523.7m - 3528.95m; MIDDLE JURASSIC, ?CALLOVIAN (unit ?sl)

This interval has been separated essentially as sediments occurring between the disappearance of diagnostic early Oxfordian species and the appearance of Callovian (unit s2-t1) microfaunas.

LITHOLOGY

Dark grey micaceous slightly sandy and carbonaceous shales are seen in the core pieces at 3523.7m and 3525.5m. Fine-grained, light yellowish grey and micaceous sandstone occurs in the sample at 3528.95m. The ditch

cuttings samples contain abundant shale but are not considered to be necessarily representative over the cored interval.

MICROPALAEONTOLOGY

The poor agglutinating foraminiferal assemblages recovered from this interval (3523.7m and 3528.95m) were originally considered to be of Callovian to Bathonian age (units s2-t2). However, now that we have been able to analyse the entire Jurassic interval it is considered that these sediments lie above the incoming of unit s2-t2 assemblages. No firm conclusion is possible on these microfaunas except to suggest an early Kimmeridgian - Bathonian (units p2-t2) age.

PALYNOLOGY

Miospores dominate the palynomorph assemblages as 3523.7m and 3525.5m and are the only elements recovered at 3528.95m.

The poor palynomorph assemblages recovered at 3523.7m and 3525.5m suggest only a general mid Callovian - Bathonian age, although the presence of several specimens of the genus Meiourogonyaulax at 3525.5m tends to suggest a Callovian age.

ENVIRONMENT

The continued presence of humic kerogen and the dominance of miospores suggest that deposition occurred in a paralic to marginal marine environment. The sparse microfauna suggests nearshore, inner shelf conditions.

INTERVAL 3531m - 3537m; MIDDLE JURASSIC, MIDDLE CALLOVIAN - LATE BATHONIAN (units s2-t1)

The age and upper limit of these sediments are based on:

- a distinct microfaunal change with the reappearance of common Haplophragmoides canui.

LITHOLOGY

Fine to medium-grained, angular, fairly uniform light brown-stained sand is present at 3531m, and becomes slightly coarser at 3534m. Light yellowish brown and yellowish grey siderite occurs at 3537m.

MICROPALAEONTOLOGY

A distinct microfaunal change occurs at 3531m with a minor influx of agglutinating foraminifera. The assemblages from this interval consist entirely of agglutinating foraminifera, and include common Haplophragmoides canui.

This resurgence of agglutinating microfaunas usually characterises units s2-t2 (Callovian - Bathonian) sediments,but on the evidence from the underlying section this can tentatively be restricted to units s2-t1. By comparison to other areas of the North Sea, however, the s2-t1 interval is unusually thin when compared to the thick t2 section.

PALYNOLOGY

A core sample at 3531.55m yielded an assemblage rich in miospores and with only rare dinocysts. The miospore assemblage suggests only a general Middle Jurassic age.

Kerogen in this sample is dominated by humic material.

ENVIRONMENT

Nearshore inner shelf conditions are suggested for these deposits by the agglutinating foraminiferal assemblages.

INTERVAL 3540m - ?3648m; MIDDLE JURASSIC, ?BATHONIAN (unit ?t2)

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

- the appearance of coarse-grained agglutinating foraminigera.

LITHOLOGY

Fine grained, white sand is the dominant lithology between 3540m - 3564m. There is a large influx of dark grey to black shale at 3567m and this persists in the ditch cuttings samples to 3582m. Coarse, angular to well rounded sand persists through 3526m - 3582m, although the two core samples from this interval, at 3612.75m and 3620.6m, consist of fine-grained, angular sandstone.

Fine-grained, angular sand persists in the ditch cuttings down to 3618m. The two core pieces at 3571.85m and 3626.65m consist of light yellowish grey slightly carbonaceous shale and dark grey sandy shale respectively.

There is an increase in the amount of shale in the samples between 3627m - 3648m and coal fragments occur at 3627m.

Light yellowish brown sphaerosiderite occurs at 3540m.

MICROPALAEONTOLOGY

The microfaunas recovered from this section are essentially highly impoverished. However, at 3540m and from 3573m to 3582m and 3627m - 3636m slightly less impoverished assemblages have been recovered from the ditch cuttings samples. The appearance of foraminifera with slightly coarser grained tests at 3540m suggests the possibility that from this point the sediments are of unit t2 connotation, Bathonian age. This is supported to a certain extent by the occurrence of ? Verneuilinoides sp. 1. The microfauna from 3573m - 3582m is of a general Callovian - Bathonian aspect (units s2-t1) whilst the appearance of Ammobaculites coprolithiformis and coarse grained agglutinating forms at 3627m - 3636m provides added support for a unit t2 determination. We have therefore assigned a tentative unit t2 (Bathonian) determination to the entire interval although it is unusually thick and the basal part, 3639m - 3648m, contains no in situ microfauna.

PALYNOLOGY

With the exception of 3556.55m the core samples from the interval contain rich palynomorph assemblages, dominated by miospores, but also with varied and locally common dinocysts, indicating persistent marine influences through this section. Sample 3556.55m is relatively impoverished in both miospores and dinocysts, and is enriched in inertinite compared with the other samples which are vitrinite dominated.

Evidence from the dinocyst content suggests that this interval may be no older than middle Bathonian, as the forms Adnatosphaeridium aemulum. Leptodinium aff. regale, Dichadogonyaulax stauromatos and the D. gochtii/sellwoodi/kettonensis plexus have not yet been recorded from North Sea early Bathonian deposits, although the last two forms have been recorded from the late Bajocian in the Southern North Sea. The absence of Nannoceratopsis gracilis suggests that the Bajocian has not been penetrated.

ENVIRONMENT

The dominance of miospores and large quantities of vitrinitic material indicate proximity to a substantial source of terrestrial debris, such as that encountered in a deltaic situation. However, the marine influences as demonstrated by the presence of microplankton suggest a distal location.

At 3356.55m some winnowing is suggested, selectively removing the lighter elements and enriching the denser inertinitic fraction.

INTERVAL ?3651m - 3726m; MIDDLE JURASSIC, ?BATHONIAN - ?BAJOCIAN

The age and upper limit are based purely on the lithology.

LITHOLOGY

Much cleaner mainly medium-grained sand, which also contains coarse, angular and fine grains appears at 3651m. This persists to 3666m, below which black brittle coal is seen and shale occurs. Coal persists with variable amounts of dark grey and yellowish brown waxy shale and dark brown siderite occurs at 3681m - 3693m. Amounts of sand in the samples between 3678m - 3711m are variable, but below 3705m sand increases; traces of coarse sand are present at 3720m.

MICROPALAEONTOLOGY

No in situ microfauna has been recovered from these sediments.

PALYNOLOGY

A core sample at 3671.85m contains an extremely sparse miospore assemblage of no age diagnostic value. Ditch cuttings samples are rich in miospores, but also contain dinocysts which are obviously caved, thus suggesting that most of the flora has caved from the richly palyniferous overlying deposits.

ENVIRONMENT

A marginal marine or fluviatile/deltaic environment is suggested for these sediments on the basis of the lithology.

INTERVAL 3729m - 3735m; ?LOWER JURASSIC

The presence of very light grey shale with isolated sand grains and waxy light grey slightly sandy shale suggests that Lower Jurassic sediments have been penetrated.

No palynological or microfaunal evidence was found.

LITHOLOGY

Very light grey to slightly buff waxy shale containing scattered angular medium or fine sand grains occurs in the samples from this interval in association with fine and medium-grained, angular white sand.

MICROPALAEONTOLOGY

No in situ microfauna has been recorded in this section.

PALYNOLOGY

A ditch cuttings sample from 3735m contains a miospore and dinocyst assemblage composed of elements originating from Upper and Middle Jurassic sources. There are no forms present which can be regarded as in situ.

ENVIRONMENT

A similar environment to that of the preceding interval is tentatively suggested for this section on the basis of the lithology.

VII

PALAEOENVIRONMENTAL SUMMARY

The oldest sediments examined in this well consist of light grey shales and white sand of questionable Lower Jurassic age which were probably laid down in a marginal marine or fluviatile/deltaic environment.

After a period of non-deposition or deposition with subsequent erosion, sands with minor shales of ?Bajocian - ?Bathonian age accumulated under marginal marine or fluviatile/deltaic conditions. Similar lithotypes and conditions persisted into the questionable Bathonian although slightly stronger marine influence is apparent at the end of this period. Towards the end of the Middle Jurassic, in the late Bathonian - middle Callovian, an inner shelf environment was established which continued throughout the remainder of the Middle into the Upper Jurassic. Deposition of sands with minor shales persisted to the end of the Middle Jurassic and into the Upper Jurassic, extending until the base of the middle Oxfordian interval.

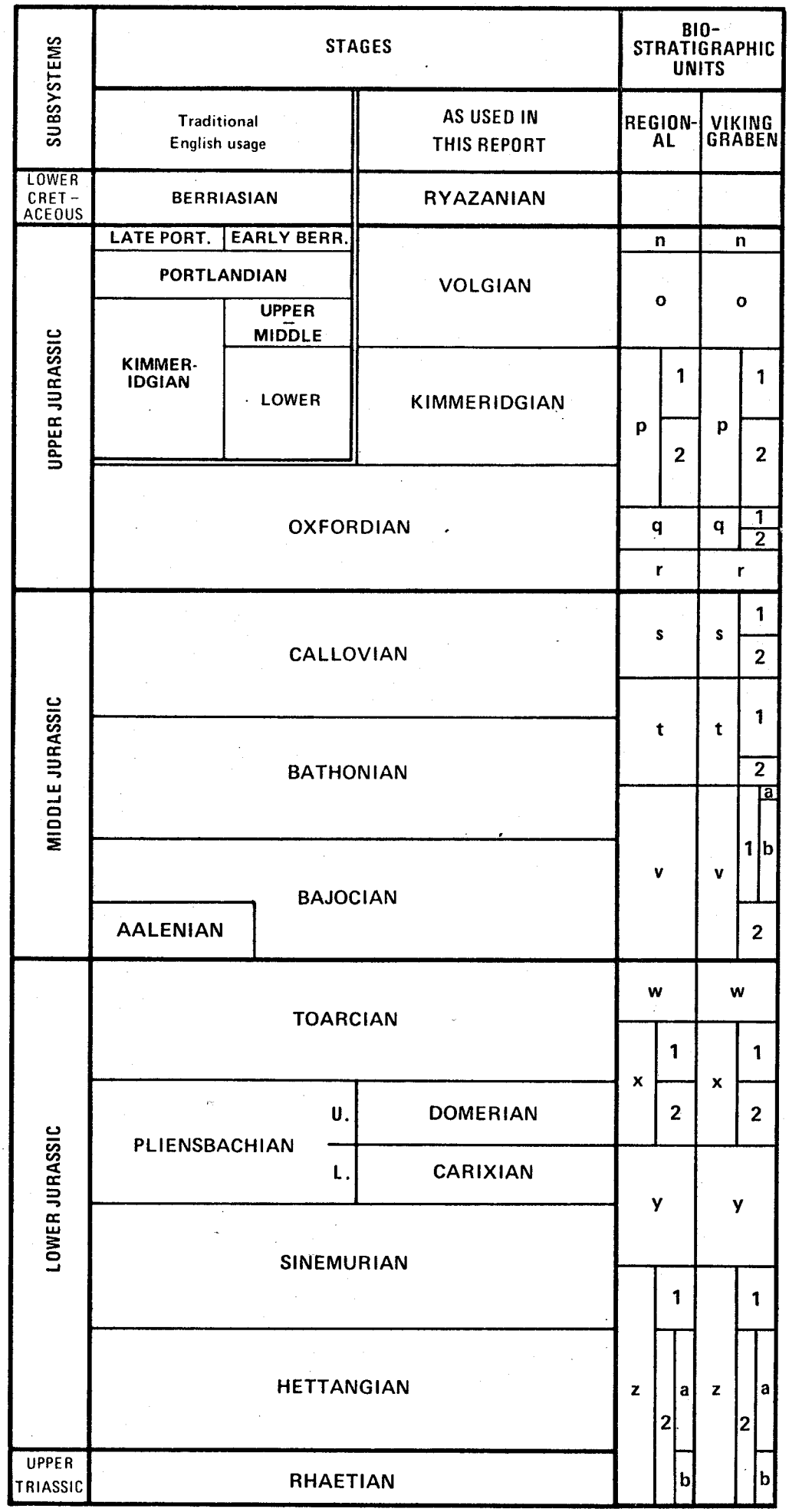
In the middle Oxfordian a lower energy environment became established resulting in the deposition of grey shales. The addition of calcareous benthonic foraminifera to the microfaunas suggests that conditions were more fully marine. Similar conditions and sediments occurred in the succeeding late Oxfordian - early Kimmeridgian interval. An inner shelf regime, with the deposition of dark grey - black shales persisted throughout the late Kimmeridgian - middle Volgian, although the palaeontological evidence suggests that conditions were restricted.

After a period of non-deposition, or deposition with subsequent erosion, ranging from the late Volgian - Valanginian, sedimentation recommenced in an inner shelf environment of Hauterivian - Barremian age. Slightly greater water depths prevailed in the Barremian with the establishment of an inner to outer shelf environment which had strong open marine connections whilst more restricted and shallower inner shelf conditions returned in the Aptian - early Albian. Shales with limestones were deposited throughout the Lower Cretaceous interval and into the Indeterminate section, for which a general shelf environment is postulated.

VIII

SELECTED REFERENCES

ARKELL, W.J.	1933	The Jurassic System in Great Britain. Oxford.
BARTENSTEIN, H. et al	1962	Leitfossilien der Mikropaläontologie, Gebrüder Borntraeger, Berlin.
FINSTAD, K.G. & SELLEY, R.C. (Editors)	1976	Jurassic Northern North Sea Symposium 1975: Norwegian Petroleum Society Publication.
WOODLAND, A.W. (Editor)	1975	Petroleum and the Continental Shelf of northwest Europe, Vol. 1. Geology. Inst. Petrol.
ROBERTSON RESEARCH INTERNATIONAL LIMITED	1976/1977	"The Jurassic of Northwest Europe: Offshore Project".



THE BIOSTRATIGRAPHIC UNITS OF THE JURASSIC AS ESTABLISHED BY ROBERTSON RESEARCH INTERNATIONAL LIMITED

JAN. 1977

APPENDIX II

NORIAN - BARREMIAN DINOCYST ZONES

(In part from Riley, 1977)

GEOLOGICAL AGE		"STANDARD" AMMONITE ZONES	SPEETON CLAY LITHO-UNITS	DINOCYST ZONATION	
				ZONE	SUBZONE
BARREMIAN	L		UPPER B	SIRMIODINIUM GROSSI I	ASTROCYSTA CRETACEA IA
	M		CEMENT BEDS		DOIDYX ANAPHRISSA IB
	EARLY		LB1 LB2 LB3 LB4 LB5 A-D		KLEITHRIASPHAERIDIUM CORRUGATUM IC
HAUTERIVIAN	LATE	SIMBIRSKITES BEDS	LB5 E LB6 C1 C2 C3 C4 C5 C6 C7	SUBTILISPHAERA TERRULA II	ADNATOSPHAERIDIUM VETUSCULUM IIA
					CANNINGIA cf. RETICULATA IIB
	EARLY	ENDEMOCERAS BEDS	C8 C9 C10 C11 D1 D2 A-D	OLIGOSPHAERIDIUM NANNUM III	CHLAMYDOPHORELLA TRABECULOSA IIIA
					KLEITHRIASPHAERIDIUM SIMPLICISPINUM IIIB
VALANGINIAN	L		BASAL D2 D	PHOBEROCYSTA NEOCOMICA IV	MUDERONGIA EXTENSIVA IVA
	E		D2 E D3 D4 D5		TUBOTUBERELLA APATELA IVB
					ENDOSCRINIUM PHARO IVC
RYAZANIAN	L	ALBIDUM STENOMPHALUS ICENII	D6 - D7 A-E	DINGODINIUM SPINOSUM V	? PROLIXOSPHAERIDIUM TORYNUM VA
					DICHADOGONYAULAX SPP. VB
	E	KOCHTI RUNCTONI			CANNOSPHAEROPSIS SP. A. VC
VOLGIAN	L	LAMPLUGHI PERICOMPHALUS PRIMITIVUS OPPRESSUS		IMBATODINIUM VILLOSUM VI	EGMONTODINIUM SP. A VIA
					unnamed subzone VIB
	M	GIGANTEUS GOREI ALBANI EPIPALLASICERAS SP. ROTUNDA SP. PALLASIOIDES PAVLOVIA SP.		MUDERONGIA SIMPLEX VII	DICHADOGONYAULAX PANNEA VIIA
					DICHADOGONYAULAX CULMULA VIIB
					GLOSSODINIUM DIMORPHUM VIIC
	E	PECTINATUS HUDLESTONI WHEATLEYENSIS SCITULUS ELEGANS		PAREODINIA MUTABILIS VIII	GONYAULACYSTA PENNATA VIIIA
					GONYAULACYSTA JURASSICA VIIIB
				GONYAULACYSTA LONGICORNIS IX	EGMONTODINIUM POLYPLACOPHORUM IXA
KIMMERIDGIAN		AUTISSIODORENSIS EUDOXUS MUTABILIS CYMODOCE			FROMEA WARLINGHAMENSIS IXB
				GONYAULACYSTA CLADOPHORA X	
		BAYLEI		SCRINIODINIUM CRYSTALLINUM XI	LEPTODINIUM EGEMENII XIA
OXFORDIAN	LATE	PSEUDOCORDATA DECIPIENS CAUTISINGRAE TRANSVERSARIUM PLICATILIS	?	SCRINIODINIUM GALERITUM XII	STEPHANELYTRON REDCLIFFENSE XIB
				ACANTHAULAX SPINOSISSIMA XIII	
	E	CORDATUM MARIAE		WANAEA DIGITATA XIV	GONYAULACYSTA SCARBURGHENSIS XIVA
					WANAEA FIMBRIATA XIVB
CALLOVIAN	L	LAMBERTI ATHLETA			MENDICODINIUM "EGALITUM" XIVC
	M	CORONATUM JASON		POLYSTEPHANEPHORUS PARACALATHUS XV	KALYPTEA STEGASTA XVA
	E	CALLOVIENSE MACROCEPHALUS			NANNOCERATOPSIS PELLUCIDA XVB
					DICHADOGONYAULAX GOCHTI XVIA
BATHONIAN		DISCUS ASPIDOIDES RETROCOSTATUM MORRISI SUBCONTRACTUS PROGRACILIS ZIGZAG		PAREODINIA CERATOPHORA XVI	WANAEA ACOLLARIS XVIB
			?		GONYAULCYSTA FILAPICATA XVIC
BAJOCIAN	L	PARKINSONI GARANTIANA SUBFURCATUM		NANNOCERATOPSIS SPICULATA XVII	
	M	HUMPHRIESIANUM SOWERBYI			
	E	CONCAVUM MURCHISONAE SCISSUM OPALINUM		NANNOCERATOPSIS GRACILIS XVIII	POLYSPHAERIDIUM DEFLANDREI XVIIIA
TOARCIAN		LEVESQUEI THOUARSENSE VARIABILIS BIFRONS FALCIFERUM TENUICOSTATUM			unnamed subzone XVIIIB
					SPHAEROMORPHS / SPHERIPOLLENITES XVIIIC
PLIENSBACHIAN	L	SPINATUM MARGARITATUS			LUEHNDEA SPINOSA XVIIID
	E	DAVOEI IBEX JAMESONI		POLYSPHAERIDIUM LANGII XIX	unnamed subzone XIXA
SINEMURIAN	L	RARICOSTATUM OXYNOTUM OBTUSUM			PAREODINIA 'FUSIFORMIS' XIXB
	E	TURNERI SEMICOSTATUM BUCKLANDI			unnamed subzone XIXC
HETTANGIAN		ANGULATA LIASICUS PLANORBIS	?		DAPCODINIUM PRISCUM XIXD
RHAETIAN ?				RHAETOGONYAULAX RHAETICA XX	CLEISTOSPHAERIDIUM MOJSISOVICSII XXA
NORIAN	L	SUESSI			SVERDRUPIELLA SPP. XXB
	M	COLUMBIANUS RUTHERFORDI MAGNUS			unnamed subzone. XXC
	E	DAWSONI KERRI			

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

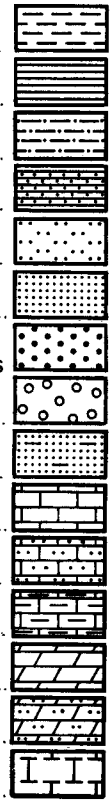
Silty/sandy limestone

Argillaceous limestone

Dolomite

Silty/sandy dolomite

Chalk



Calcareous sediments

Dolomitic sediments

Carbonaceous sediments

Anhydrite

Salt

Coal/lignite

Undifferentiated volcanics

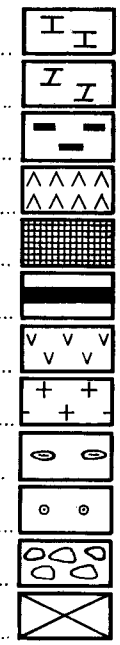
Basement (undifferentiated)

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 (Samples unsuitable for good stratigraphic analysis)	tu

PALAEONTOLOGICAL SYMBOLS

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

ENCLOSURE 1

(for further abbreviations see Enclosure 2)

GENERALISED LITHOLOGY

DRILLED DEPTH (Metres) CASING
CORES SIDEWALL SAMPLES

STRATIGRAPHIC UNITS

SYSTEM SERIES: INDETERM-INATE | LOWER CRETACEOUS | MIDDLE JURASSIC | UPPER JURASSIC

STAGE: EARLY ALBIAN | BARR. BARREM | HAUT. — IAN APTIAN | EARLY VOLGIAN — MIDDLE KIMMERIDGIAN | OXFORDIAN | CALL. BATH. | BATHONIAN

MICROFAUNAL ASSEMBLAGES: GLOMO-SPIRA | H.INFRA-CRETACEA | POLYM. | UVIG. | RADIOLARIA / RHAXELLA | LENTICULINA MUENSTERI | H.CANUI | A.COP. | A.COP.

PALYNOFLORAL: VIIA | VIIIB | X | XIA | XIII | XIV

COMMENTS:
- RED STAINED FORAMS
- INFLUX OF HEDBERGELLA
- WHITE STAINED FORAMS
- MASSIVE LOWER CRETACEOUS CAVING
- ABUNDANT RHAXELLA
- GENERALLY VERY POOR MICROFAUNAS
- MINOR INFLUX OF AGGLUTINATING FORAMS
- COARSE GRAINED AGGLUTINATING FORAMS
- MINOR INFLUX OF AGGLUTINATING FORAMS

ENVIRONMENT: CONTINENTAL | LACUSTRINE FLUVIATILE | DELTAIC | TRANSITIONAL | LITTORAL | MARINE | INNER SHELF | OUTER SHELF | BATHYAL

DOMINANT KEROGEN COMPONENTS (20 μ)
Agglutinated
Calcareous benthonic
Planktonic
0% — 100%

Foraminiferal Association

FORAMINIFERA
1 Barren of in situ foraminifera
2
3 Lenticulina sp.
4 Spiroplectammina spectabilis C
5 Glomospira gordialis *
6 Glomospira sp.
7 Haplophragmoides sp.
8 Recurvoides sp.
9 Ammodiscus sp.
10 Plectorecurvoides sp.
11 ?"Lingulogavelinella" gyroidinaeformis
12 Ammobaculites sp.
13 Pelosina sp.
14 Valvulineria gracillima
15 Bathysiphon sp.
16 Hedbergella delrioensis
17 Hedbergella infracretacea *
18 Polymorphinids
19 Reophax sp.
20 Dentalina sp.
21 Verneuilinoides neocomiensis
22 Uvigerinammina mosesiana *
23 Marssonella cf. trochus
24 Marssonella haueriviana *
25 Auloctortus (Spirillina) neocomiana *
26 Gavelinella sp.
27 Trochammina cf. labetica
28 Haplophragmoides cf. canui
29 Haplophragmoides cf. infracallovienis
30 Lenticulina cf. actypa *
31 Haplophragmoides canui *
32 Ammobaculites sp.
33 Pseudoglandulina sp.
34 Haplophragmoides infracallovienis *
35 Lenticulina quenstedti
36 Lenticulina major *
37 Epistomina cf. parastelligera
38 Trochammina cf. squamata
39 ?Bulbobaculites maynci *
40 Trochammina globigeriniformis
41 ?Verneuilinoides sp. 1
42 Glomospira sp.
43
44
45 Apteodictyon simulana
46 Ponticypretta sp.
47 Macrocypris sp.
48 Bairdia sp.
49 Protocythere triplicata
50 Cytheralla sp.
51 Cytheralla pyriformis
52
53
54 Bisaccates
55 Cerebropollenites mesozoicus
56 Cyathidites minor
57 Callialasporites dampieri
58 Cicatricosisporites spp.
59 Campenia sp.
60 Vitreisporites pallidus
61 Lycopodiumsporites spp.
62 Deltoidospora spp.
63 Baculatisporites/Osmundacidites group
64 "Circumpolles" group
65 Perinopollenites elatoides
66 Staplinisporites caminus group
67 Klukisporites sp.
68 Araucariacites australis
69 Densoisporites velatus
70 Dictyophyllidites harrisii
71
72
73 Echinoderm debris
74 Bone fragments
75 Cenosphaera spp.
76 Rhaxella perforata
77 Lithostrobus spp.
78 Ammonoids
79 Bivalves
80 Gastropods
81 Fish teeth

OSTRACODA

MIOSPORES

O. FOSSILS

ROBERTSON RESEARCH INTERNATIONAL

WELL: 15/9 — 1
LOCATION: NORWEGIAN NORTH SEA
CLIENT: STATOIL

DEPTH: 3300 — 3600m
SHEET 1a OF 2
ANALYST: JWC, CND, JU, CWH.

DRAWING NO: 316/1240/4015 SCALE 1 : 2,000
DATE: DECEMBER 1977 ENCLOSURE 2

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

DRILLED DEPTH (Metres)

PALYNOFLORAL ASSEMBLAGES

COMMENTS

DOMINANT KERogen COMPONENTS (20 µ)

MICROPLANKTON

KEROGEN

3300
3350
3400
3450
3500
3550
3600

VIIA
?? VIIIB
?? X
XIA
XIII
XIV

D. cf. cerviculum
E. pharo. G. "neocomica"
Amorphous sapropel
G. dimorphum
S. jurassica D. pannea
G. jurassica
? S. luridum
L. egemenii
S. crystallinum
? S. galeritum
S. redcliffense
A. ? spinosissima
Acanthaulax sp. 1 J&H
D. cf. stauromatos

VITRINITE | INERTINITE | AMORPHOUS SAPROPEL

1 Spiniferites ramosus group
2 Cleistosphaeridium polypes
3 Canningia spp.
4 Microforaminifera
5 Cleistosphaeridium spp.
6 Leiospheres
7 ?Kleithriasphaeridium sp.
8 Apteodinium ?granulatum
9 Cribroperidinium edwardsi
10 Hystrichodinium pulchrum
11 ?Callaiosphaeridium asymmetricum
12 Kerminonium campanula
13 Gonyaulacysta cretacea/ferrata
14 Heliodinium voigti
15 Siliciphaera sp.
16 Oligosphaeridium anthophorum
17 Odontochitina operculata
18 ?Isosphaeridium varielaminum
19 Oligosphaeridium spp.
20 Sirmiodinium grossi
21 Pseudoceratium pelliferum
22 Dingodinium cf. cerviculum *
23 Chlamydophorella nyei
24 Gonyaulacysta aff. "neocomica" *
25 Caseiculosphaerida magna
26 Necrobroomea longicornuta
27 Cyclonephelium distinctum
28 Gonyaulacysta helicoidea
29 Pterospermopsis ?aureolata
30 Heterotonia heterotonensis
31 Endoscrinium pharo *
32 Oligosphaeridium pulcherrimum
33 Cribroperidinium cf. muderongense
34 Dingodinium albertii
35 Acanthomorph acritarchs
36 Tenua spp.
37 Tasmanitids
38 Pterospermopsis aureolata
39 Pterospermopsis spp.
40 Pareodinia spp.
41 Muderongia simplex
42 Tubotuberella apatela
43 ? Pareodinia sp.
44 Wallodinium krutzschi
45 Glossodinium dimorphum *
46 Chorate cysts indet.
47 Scriniodinium bicuneatum
48 Senoniasphaera jurassica *
49 Dichadogonyaulax pannea *
50 Pareodinia ceratophora
51 Gonyaulacysta spp.
52 Scriniodinium sp.
53 ?Systematophora areolata
54 Pareodinia cf. verrucosa
55 Prolixosphaeridium ?deirense
56 Leptodinium spp.
57 Dictyopytidis ovula
58 Cleistosphaeridium polyacanthum
59 ?Senoniasphaera jurassica
60 Tenua ?tridulti
61 ?Pareodinia muehlia
62 Leptodinium cf. asteronium
63 Gonyaulacysta jurassica
64 Gonyaulacysta ?cladophora
65 Lepodinium egemenii *
66 Systematophora areolata
67 ?Gonyaulacysta jurassica
68 ?Scriniodinium luridum
69 ?Scriniodinium inritibilum
70 Pareodinia borealis
71 Scriniodinium crystallinum *
72 Gonyaulacysta cladophora
73 Meiourogonyaulax sp.
74 Scriniodinium luridum
75 Scriniodinium dictyotum
76 ?Scriniodinium galeritum *
77 Taenophora lunciapina
78 Stephanelytron redcliffense *
79 Ballisphaeridium whitei
80 Scriniodinium galeritum *
81 Athastosphaeridium demulum
82 Acanthaulax ?japonosissima *
83 Acanthaulax spp.
84 Nannoceratopsis pellucida
85 Scriniodinium oxfordianum
86 ? Pareodinia groenlandicum
87 Epiplosphaera sp.
88 Crassosphaera sp.
89 Acanthaulax sp. 1 J & H *
90 Chytroeisphaeridia sp.
91 Gonyaulacysta scabrugenae
92 ?Wanaea fimbriata
93 Surculosphaeridium vestitum
94 Dichadogonyaulax sp.
95 Meiourogonyaulax sp.
96 Dichadogonyaulax cf. stauromatos
97 Kalyptea jurassica
98 Valensiella ovulum
99 Pareodinia ?evitti
100 Gonyaulacysta dangeardi
101 ?Cleistodinium ornatum
102 Stephanelytron scarburgense
103 Chytroeisphaeridia "gigantea"
104 Kalyptea stegasta
105
106
107
108
109
110 Inertinite
111 Vitrinite
112 Sporopollenin
113 Amorphous sapropel
114
115
116
117
118
119

ROBERTSON RESEARCH INTERNATIONAL

WELL : 15/9-1
LOCATION: NORWEGIAN NORTH SEA
CLIENT : STATOIL

DEPTH : 3300 – 3600m
SHEET 1b OF 2
ANALYST : CND

DRAWING NO. : – 316/1240/4015
DATE : DECEMBER 1977

SCALE 1 : 2,000
ENCLOSURE 3

For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

GENERALISED LITHOLOGY

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

3650

3700

STRATIGRAPHIC UNITS

SYSTEM SERIES: MIDDLE JURASSIC

STAGE: BATHONIAN - ?BAJOCIAN - ?BATHONIAN

ASSEMBLAGES: MICROFAUNAL — A. COP. t_2 — PALYNOFLORAL

?LOWER JUR.

?BAJOCIAN

COMMENTS

GENERALLY VERY POOR OR NO MICROFAUNAS

MINOR INFLUX OF AGGLUTINATING FORAMS.

SPHAEROSIDERITE

MIOSPORE DOMINATED PALYNOMORPH ASSEMBLAGES

DINOCYSTS PROBABLY CAVED

ENVIRONMENT: CONTINENTAL — TRANSITIONAL — MARINE

TERRESTRIAL, LACUSTRINE FLUVIATILE, DELTAIC, LITTORAL, INNER SHELF, OUTER SHELF, BATHYAL

DOMINANT KEROGEN COMPONENTS (20 μ)

V I T R I N I T E

Foraminiferal Association

Agglutinated.....

Calcareous benthonic.....

Planktonic.....

FORAMINIFERA

1 Barren of in situ foraminifera
2 Ammodiscus sp.
3 Haplophragmoides sp.
4 Haplophragmoides canui *
5 Ammobaculites sp.
6 Ammobaculites coprolithiformis *
7 Vernuilinoides sp.
8 Textulina sp.
9
10
11
12
13 Meiourogoyaulax sp.

MICROPLANKTON

14 Microforaminifera
15 Gonyaulacysta jurassica
16 Pareodinia ceratophora
17 Botryococcus sp.
18 Adnatosphaeridium semilum
19 Gonyaulacysta cladophora
20 Scriniodinium galeritum
21 Acanthomorph acritarchs
22 Valensiella ovulum
23 Gonyaulacysta dangeardi
24 Nannoceratopsis pellucida
25
26
27
28
29
30
31

MIOSPORES

32 Cerebropollenites mesozoicus
33 Baculatisporites 'Osmundacidites group
34 Perinopollenites elatoides
35 Deltoidospora spp.
36 Cycadopites spp.
37 Cyathidites minor
38 Callialasporites dampieri
39 Duplexisporites sp.
40 Cyathidites australis
41 Araucariacites australis
42 Callialasporites turbatus
43 Dictyophyllidites harrisii
44 Neoraistrickia sp.
45 Densosporites sp.
46 Charmasporites spp.
47 Klukisporites sp.
48 Concavissimisporites sp.
49 Todisporites sp.
50 Klukisporites variegatus
51 Callialasporites trilobatus
52
53
54
55
56

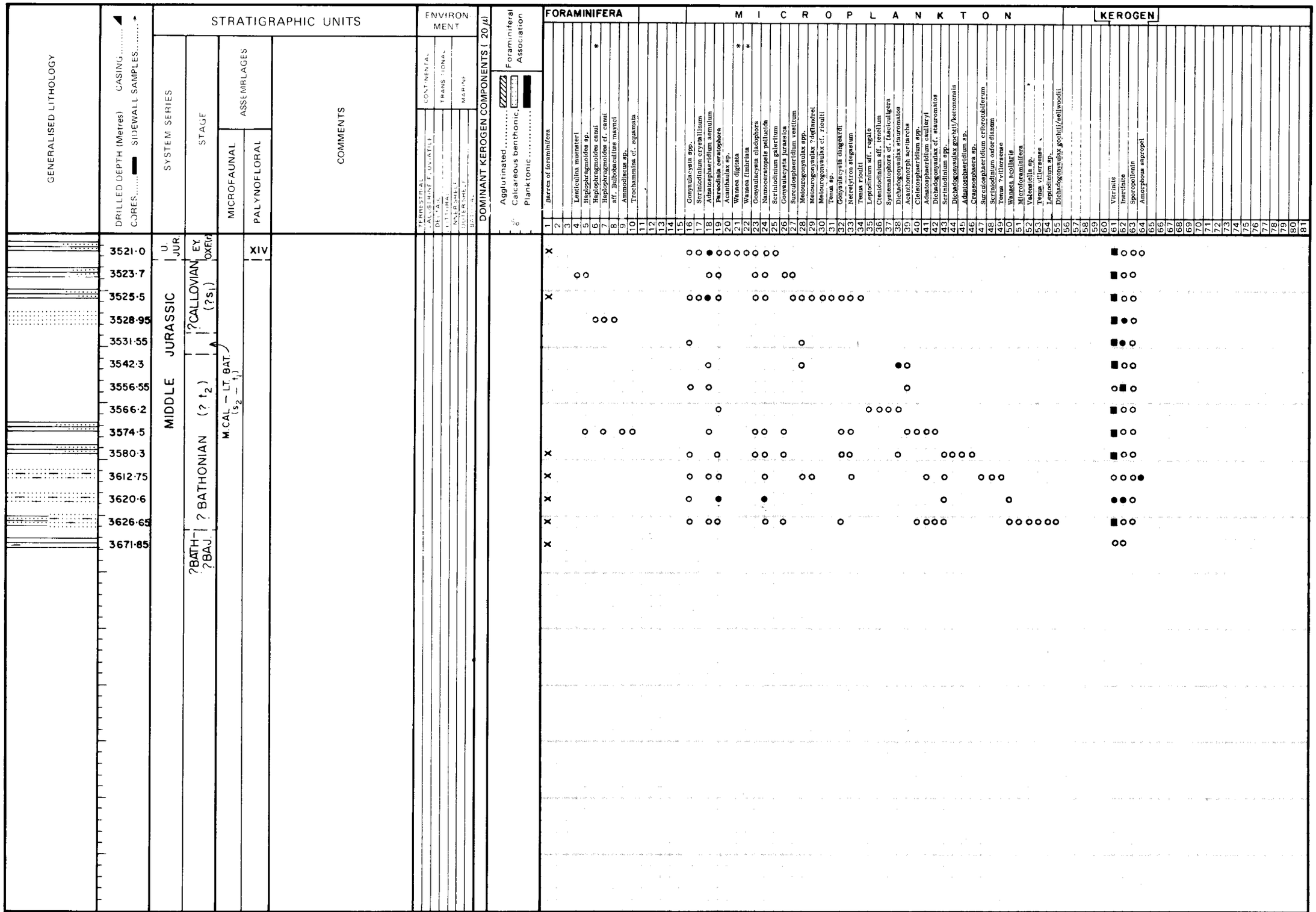
KEROGEN

57 Inertinite
58 Vitrinite
59 Sporo-pollenin
60 Amorphous sapropel

O. FOSSILS

61
62
63
64
65
66 Ammonoids
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81

ROBERTSON RESEARCH INTERNATIONAL	WELL : 15/9-1 LOCATION: NORWEGIAN NORTH SEA CLIENT : STATOIL	DEPTH : 3600 - 3735 m. SHEET 2 OF 2 ANALYST: JWC, CND, JU,	DRAWING NO : 316/1240/4015 SCALE 1 : 2,000 DATE : DECEMBER 1977 ENCLOSURE 4 *For legend see Enclosure 1*	BIOSTRATIGRAPHICAL ANALYSIS CHART



ROBERTSON RESEARCH INTERNATIONAL

WELL: 15/9 – 1
LOCATION: NORWEGIAN NORTH SEA
CLIENT: STATOIL

CORES
SHEET 1a OF 1
ANALYST JWC, CND, JU.

DRAWING NO 316/1240/4015
DATE DECEMBER 1977 ENCLOSURE 5
For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

DRILLED DEPTH (Metres)	PALYNOFLORAL ASSEMBLAGES	COMMENTS
3521·0	XIV	
3523·7		
3525·5		
3528·95		
3531·55		
3542·3		
3556·55		
3566·2		
3574·5		
3580·3		
3612·75		
3620·6		
3626·65		
3671·85		

DOMINANT KEROGEN COMPONENTS (20 μ)

MIOSPORES

1	Callialasporites dampieri
2	Bisaccates
3	Baltisphaeridium/Impunctosphaeridium group
4	Lycopodiumsporites austroclavidites
5	Cerebropollenites mesozoicus
6	Dehesdospora spp.
7	Araucariacites australis
8	Verrucosisporites spp.
9	Permopollenites elaloides
10	Callialasporites turbatus
11	Callialasporites triobatus
12	Vitreisporites pallidus
13	Cyathidites australis
14	Converrucosisporites sp.
15	Densoisporites velatus
16	Kraeuselisporites spp.
17	Cyathidites minor
18	Lycopodiumsporites spp.
19	"Circumpollen" group
20	Dictyophyllidites harrisii
21	Stereisporites pseudoalveolatus
22	Classopollis torosus
23	Duplexisporites problematicus
24	Lycopodiacidites rugulatus
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	
61	
62	
63	
64	
65	
66	
67	
68	
69	
70	
71	
72	
73	
74	
75	
76	
77	
78	
79	
80	
81	
82	
83	
84	
85	
86	
87	
88	
89	
90	
91	
92	
93	
94	
95	
96	
97	
98	
99	
100	
101	
102	
103	
104	
105	
106	
107	
108	
109	
110	
111	
112	
113	
114	
115	
116	
117	
118	
119	

ROBERTSON RESEARCH INTERNATIONAL

WELL 15/9-1
LOCATION: NORWEGIAN NORTH SEA
CLIENT: STATOIL

CORES
SHEET 1b OF 1
ANALYST: CND

DRAWING NO. 16/1240/4015
DATE: DECEMBER 1977
ENCLOSURE 6
For legend see Enclosure 1

BIOSTRATIGRAPHICAL ANALYSIS CHART

ROBERTSON RESEARCH INTERNATIONAL LIMITED

SUMMARY LOG 15/9-1

AREA : NORWEGIAN NORTH SEA — SPUD DATE : FEB 24, 1977

COMPANY : STATOIL — COMPLETION DATE : MAY 30, 1977

INTERVAL STUDIED : 3301 m - 3732 m — T. D. 3734 m

Dr. No. 316/1240/4015 — SCALE 1 : 5000 — Date : Dec. 1977

▌ Cored Interval ◣ Casing Shoe

ENCLOSURE 7