



PALEOSERVICES LTD.

STRATIGRAPHICAL AND PALEONTOLOGICAL CONSULTANTS :

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Client Company	<u>STATOIL.</u>
Title	<u>WELL 34/10-11</u> <u>(1,600m - 2,155m)</u> <u>NORWEGIAN OFFSHORE.</u> <u>PALAEONTOLOGICAL/STRATIGRAPHICAL FINAL REPORT.</u>
Project No.	796.
Stratigraphers	<u>R.W. MEYRICK.</u> <u>G.C. WILKINSON.</u> Director Dr. V. L. Roveda,
Date	April, 1981.

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Fig. 1. Sedimentary History

ENCLOSURES.

1. Stratigraphic Log
(scale 1:500)
(1,600m-2,155m)



1. INTRODUCTION.

This report presents the results of the stratigraphical and palaeontological study of samples from Well 34/10-11, drilled by Statoil in the North Sea (Norwegian offshore) during 1980.

The information presented is based on the analysis of ditch samples collected at an average interval of 3m from 1,600m-2,155m. Twenty-four sidewall cores were analysed between 1,863m and 2,145.5m. Core chips were received from Cores 1-6 (1,870m-1,926.5m) and have been incorporated into this study.

A total of 51 samples (23 sidewall cores, 13 ditch cuttings and 15 core samples) have been examined for palynology from the interval 1,863m to 2,155m.

Petrophysical logs were provided by Statoil for the interval from 1,713.5m to 2,155m but in all cases the boundaries are based solely on the samples examined.

The Stratigraphical Log (scale 1:500) is presented with this report and a Sedimentary History diagram (Fig.1) is also included in the report.



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2. CONCLUSIONS.

1. The highest sample included in this study (1,600m-1,603m) is a Late Paleocene claystone.
2. The Late-?Middle Paleocene section (1,600m-1,693m) comprises dominantly claystone, with occasional sand and limestone beds, which were deposited in a marine, outer sublittoral to bathyal, environment.
3. The Late-?Middle Paleocene sediments rest unconformably on Late Cretaceous (Late Maastrichtian) sediments at 1,693m.
4. The Late Cretaceous (1,693m-1,868m) is represented only by Maastrichtian and Campanian sediments. These comprise claystone and chalk deposited in a marine, outer sublittoral to bathyal environment, influenced by oceanic currents (1,693m-ca.1,1738m) and below ca.1,738m claystone deposited in a marine, outer sublittoral to bathyal environment with more restricted circulation.
5. Late Cretaceous (Maastrichtian-Campanian) sediments rest unconformably on Early Jurassic (Early Pliensbachian-Sinemurian) sediments at 1,868m. The lower part of the Shetland Group, the Cromer Knoll and Humber Groups, Brent Formation, and upper part of the Dunlin Formation are absent.
6. Only the lowest part of the Dunlin Formation (Amundsen Member) is present and this comprises sand and claystone of Early Jurassic, Early Pliensbachian-Sinemurian age (1,868m-1,891m).
7. The Statfjord Formation (1,891m-2,029m) is represented by marine sands and marine - continental sands and claystones of Early Jurassic-?Late Triassic (Sinemurian-?Rhaetian) age.



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8. The top of the 'red beds' of the Cormorant Formation (ca.2,029m-2,155m) is tentatively taken at the sidewall core at 2,029m. Dating of these sediments is difficult but palynomorphs in the sidewall core at 2,078m indicate a Late Triassic (Rhaetian) age. Deposition of this 'red bed' sequence took place in a continental, alluvial environment.



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3. STRATIGRAPHICAL SUMMARY.

<u>Interval</u>	<u>Age</u>	<u>Thickness</u>
1,600m - 1,693m (F.S.R.)	Late - ?Middle Paleocene	93m
----- Unconformity -----		
1,693m - 1,708m	Late Cretaceous, Late Maastrichtian	15m
1,708m - 1,868m	" " Maastrichtian - Campanian	160m
----- Unconformity -----		
1,868m - 1,930.7m	Early Jurassic, Early Pliensbachian - Sinemurian	62.7m
1,930.7m- 2,078m	Early Jurassic - ?Late Triassic, Sinemurian - ?Rhaetian	147.3m
2,078m - 2,119.5m	Late Triassic, Rhaetian	41.5m
2,119.5m- 2,155m (L.S.R.)	Late Triassic, ?Rhaetian	35.5m



4. STRATIGRAPHY.

This discussion supplements the information presented on the Stratigraphical Log (Encl.1). The lithostratigraphy and biostratigraphy are described and age and depositional environments interpreted.

4.1 1,600m (F.S.R.)-1,693m LATE-?MIDDLE PALEOCENE

Lithostratigraphy:

Rogaland Group (Lista Formation).

1,600m-1,624m Claystone, grey-green; occasional grey marl/limestone in the lowest part; pyrite and siderite common below 1,615m. Poor samples.

1,624m-1,648m Claystone, as above, with sandy claystone; thin beds of grey limestone. Rare fragments of white chalk occur but are presumed to be reworked.

1,648m-1,654m Limestone, grey-white, micro-crystalline, with claystone as above.

1,654m-1,681m Claystone, grey-green, sandy claystone, and sand, fine-medium grained, subangular to subrounded.

1,681m-1,693m As above, together with limestone, grey (no samples from 1,684m-1,690m).

Biostratigraphy:

This interval is characterised by a diverse assemblage of agglutinating foraminiferids which includes the genera *Rhabdammina*, *Ammodiscus*, *Glomospira*, *Trochammina*, *Bathysiphon*, *Cyclammina*, *Haplophragmoides* and *Pelosina*. Large specimens of *Bolivinosia spectabilis* are present throughout much of the sequence and these are known to characterise rocks of Late - ?Middle Paleocene age below the "Ash Marker" in the North Sea.



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Rare calcareous foraminiferids, including *Globigerina triloculinoides* and *Pullenia aff. cretacea* are present in the upper part of the interval and possibly reworked.

No rocks of definite Middle - Early Paleocene age are present. The Late - ?Middle Paleocene probably rests unconformably on the Late Cretaceous (Late Maastrichtian) at 1,693m.

Environment:

Marine, outer sublittoral to bathyal. The fauna of agglutinating foraminiferids is typical of a 'deepwater' environment with restricted circulation. Sands in this interval may have been introduced by turbidity currents.

4.2 1,693m-1,868m LATE CRETACEOUS (Maastrichtian-Campanian).

Lithostratigraphy:

Shetland Group.

Ditch cuttings are extremely poor through this interval and between 1,720m and 1,735m comprise mainly drilling mud additives and cement.

1,693m-1,702m Claystone, grey, calcareous; with chalk, white.

1,702m-1,708m No samples.

1,708m-1,868m Claystone, grey, calcareous in the upper part; with thin beds of limestone, grey and light brown. Pyrite is present throughout but common below 1,822m; siderite is present throughout but is presumed to be caved from the Paleocene except below 1,852m where it is common; glauconite is present but rare.

Three sidewall cores were received from the basal part of this interval (1,863m, 1,865m, 1,866m). These comprise grey claystones, with occasional silty laminations; they are pyritic and non-calcareous.



Biostratigraphy:

1,693m-1,708m Late Maastrichtian.

This interval contains an abundant and diverse fauna of planktic and benthic foraminiferids including *Pseudotextularia elegans*, *Globigerinelloides messinae*, *Heterohelix* spp., *Praeglobotruncana havanensis*, *Gavelinella whitei*, *Arenobulimina obliqua* and *Osangularia lens*. This fauna indicates a Late Maastrichtian age.

The absence of *Globotruncana contusa* and the scarcity of *Pseudotextularia elegans* suggest that the topmost Maastrichtian is missing in this well.

1,708m-1,868m Maastrichtian - Campanian.

Microfauna:

The top of this interval is recognised by the first downhole appearance of *Reussella szajnochae*, which is a regionally consistent marker in the lower part of the Late Maastrichtian.

Below ca.1,738m the lithology is less calcareous, and the fauna is dominated by long-ranging agglutinating foraminiferids. Rare specimens of *Rugoglobigerina rugosa* continue through most of the sequence indicating an age not older than Campanian.

Microflora:

Palynological analyses were only carried out in the lowest part of this interval, where three sidewall cores were examined which yielded rich and diverse assemblages of dinoflagellates, pollen and spores. The presence of the dinocysts *Palaeohystrichophora infusorioides* (at 1,863m), *Diconodinium* sp. (from 1,863m) and *Odontochitina costata* (from 1,865m), and the pollen genus *Aquilapollenites* (from 1,865m) together indicate a Campanian age for the base of the interval.



In general terms, these assemblages are characterised by the occurrence of common *Chatangiella* spp. displaying a range of morphological diversity, of which *C. victoriensis* is the most readily identifiable. Further notable elements of these assemblages include the dinocysts *Palaeoperidinium cretaceum* (from 1,863m) and *Isabelidium* cf. *pellucida* (common at 1,866m).

Environment:

Marine, outer sublittoral to bathyal. The association of a diverse assemblage of calcareous and agglutinating foraminiferids in the upper part (above ca.1,738m) suggests the influence of 'open sea' currents. More restricted conditions (below ca.1,738m) are indicated by the dominance of agglutinating foraminiferids. This change is of regional significance, and probably attributable to variations in the carbonate compensation depth.

4.3 1,868m-1,891m EARLY JURASSIC, (Early Pliensbachian-Sinemurian).

Lithostratigraphy:

Dunlin Formation.

The top of the Dunlin Formation, in this well (sidewall core at 1,868m), is recognised by the association of claystones and fine sandstones with a characteristic microflora.

Ditch cuttings throughout the Dunlin Formation are extremely poor and dominated by drilling mud additives. Some fine sand is present and presumed to be the 'in place' lithology.

Two sidewall cores were received from this interval:

1,868m Claystone, laminated, grey, non-calcareous, with sand, very fine, angular.

1,882m Claystone and siltstone, grey, non-calcareous.



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Cores were cut through much of this interval (1,870m-1,891m) but only the following eleven samples were sent for palaeontological/paly-nological analyses:

1,870.67m Claystone, grey, micaceous and sand, fine grained, angular with clay matrix.

1,871.6m-1,872.7m Laminated, fine grained angular, non calcareous and claystone, grey, silty. Fine lignitic debris throughout.

1,874.56m Sandstone, fine grained angular, very micaceous, claystone matrix, occasional lignitic debris.

1,877.40m Claystone, grey, micaceous, and sand, fine grained, angular, clay matrix, 'sticks' of pyrite.

1,878.10m As above but bioturbated and poorly laminated.

1,879.72m Claystone, grey, silty and sandy, slightly calcareous.

1,887.9m, 1,889.65m Siltstone and grey sand, fine - medium grained, occasionally coarse and claystone, sandy, grey.

1,888.35m Claystone, grey, silty and sandstone, fine angular, with occasional floating subrounded gravel grains, fine lignitic debris throughout, disturbed/bioturbated bedding.

1,889.30m As above, with partially decalcified bivalve and gastropod shells.

The lithologies presented in the core are typical of those of the Amundsen Member of the Dunlin Formation in this area.



Biostratigraphy:

Microfauna:

The sands and claystones in this interval are mainly non-calcareous and contain a very sparse fauna. Eleven core chips and two sidewall cores were processed, but only three yielded microfossils.

At 1,878.10m the agglutinating foraminiferid Ammodiscus 'incertus' occurred and at 1,879.72m the calcareous foraminiferid Lenticulina varians and the ostracod Ogmoconchella aff. danica. The core chip at 1,889.3m yielded the most abundant fauna, with gastropods, bivalves (including ostreids) and the foraminiferids Lenticulina varians and Dentalina sp. (Int. sp. EJA).

The ostracod Ogmoconchella aff. danica is the only age-restricted fossil. This typically occurs in the Amundsen Member of the Dunlin Formation, within the age range Early Pliensbachian - Late Sinemurian.

Microflora:

Four core and two sidewall core samples have been examined from this interval. These samples yield rich and diverse assemblages which are dominated by pollen and spore taxa but also contain marine microplankton.

The assemblages, as outlined below, are regionally characteristic of sediments of Late Pliensbachian to Sinemurian age. Additionally, the significant absence of Nannoceratopsis gracilis indicates in this region an age not younger than Early Pliensbachian.



The assemblages throughout this interval are characterised by common/abundant *Classopollis torosus* and bisaccate pollen. Other notable elements include *C. thiergartii* (common at 1,868m, 1,870.67m, 1,887.90m and 1,889.65m), *C. mesozoicus*, *Chasmato-sporites* spp., *Osmundacidites/Baculatisporites* spp., *Quadraeculina anellaeformis*, and *Micrhystridium stellatum* (marine microplankton - present throughout but common at 1,887.90m and 1,889.65m). Accessory taxa include *Lycopodiumsporites* spp., *Contignisporites problematicus*, *Inaperturopollenites 'hiatus'*, *Deltoidospora* spp., *Stereisporites* spp., *Lycopodiacidites rugulatus*, *Perinopollenites elatoides*, *Eucommidites troedssonii* (at 1,889.65m), *Crassosphaera* sp. (marine microplankton) and *Botryococcus* sp. (alga with freshwater affinities).

There is a significant decrease in microfloral frequency and diversity in the samples examined below 1,889.65m.

Environment:

Marine, littoral to inner sublittoral. The sandstones with 'floating' pebbles in the lowest part of the interval are considered to represent the transgressive base of the Dunlin Formation.

4.4 1,891m-2,155m EARLY JURASSIC - LATE TRIASSIC. (Sinemurian-Rhaetian).

Lithostratigraphy:

Statfjord and Cormorant Formations.

The top of the Statfjord Formation is recognised by the downhole appearance of 'clean' poorly sorted sandstones, in the ditch cutting sample 1,891m-1,894m.

The following core samples selected by Statoil geologists were used in this study:

1,893.30m Sand, very fine grained, angular; and silty claystone, micaceous.



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1,899.99m Lignified wood, black.

1,903.20m Sand, fine and occasionally medium grained, angular, with some brown claystone matrix, pyrite.

1,909.10m Sand, fine-medium grained, angular to subangular.

1,909.50m Sand as above, together with 50% lignite.

1,921.30m Lignitic debris with some sand, fine and occasionally medium grained, with abundant mica.

1,922.50m Claystone, medium brown-grey, occasional sand grains.

1,925.00m Claystone, medium grey, occasionally silty, rare sand grains, very fine mica.

Lithology for the interval based on ditch cuttings and sidewall cores:

1,891m-1,924m Sand, fine to medium and occasionally coarse grained, subangular, 'clean'. Poor sample with abundant drilling mud additive.

1,924m-1,930m Claystone with brown-grey ?siderite and sand, fine to coarse, angular to subangular.

1,930m-1,933m As above together with claystone, brown and dark grey with lignitic debris.

1,933m-1,948m Claystone with abundant light brown sphaerosiderite, and beds of sand, fine to occasionally medium grained.

1,948m-1,954m Claystone, brown, lignitic; with sand, poorly sorted fine to coarse grained and gravel, angular to subrounded.

1,954m-1,966m Sand, fine to coarse grained, and gravel, angular to subrounded.

1,966m-1,999m Sand, as above, occasionally well cemented. Sidewall cores shot in claystones, light grey, sandy (1,976.5m, 1,982m, 1,986.7m).



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1,999m-2,008m Claystone, grey, with abundant sphaeroiderite, occasional claystone, red and sand as above.

2,008m-2,029m Sand, fine-coarse grained, angular to subangular; occasional claystone, purple, green and red with anhydrite.

2,029m-2,080m Claystone, red, purple, yellow and grey, non-calcareous, micaceous, calcareous concretions especially below 2,068m, occasional anhydrite; beds of sand, fine-medium grained.

2,080m-2,086m Sand, fine-medium grained, angular to subangular, white ?kaolinitic cement.

2,086m-2,155m Claystone, red, purple, yellow and grey, non to slightly calcareous, occasional calcareous concretions and anhydrite; occasional sand (especially 2,107m and 2,128m) fine to medium grained, angular.

The position of the top of the Cormorant Formation is uncertain, but is tentatively placed at the top of the main 'red-bed' sequence (2,029m).

Biostratigraphy:

Microfauna:

Barren.

Microflora:

1,891m-1,930.7m Early Jurassic, Sinemurian.

The top of this interval is taken at the lithological break at 1,891m. Eleven core samples and one side-wall core sample have been examined from this interval. The microflora is similar to that of the overlying interval but is now significantly reduced in frequency and diversity. The assemblages remain dominated by *Classopollis torosus* and bisaccate pollen but marine microplankton in the form of *Micrhystridium stellatum* are now rare, being present only at 1,899m.



The base of this interval is taken at the lowest occurrence of *Cerebropollenites mesozoicus* in the sidewall core at 1,930.7m, since this species has not been reported from below the Sinemurian.

Remarks:

The palynological evidence suggests an age for this interval of not older than Sinemurian. However, regional lithostratigraphical evidence suggests a Sinemurian age at 1,891m, thus giving a Sinemurian age for the interval 1,891m to 1,930.7m.

1,930.7m-2,078m Sinemurian-?Rhaetian.

Eleven sidewall core and eight ditch samples have been examined from this interval. There is a reasonable recovery of palynomorphs from the sidewall cores at 1,942.2m, 1,982m and 1,986.7m; the assemblages are characterised by common bisaccate pollen with *Classopollis torosus*, *Osmundacidites/Baculatisporites* spp., *Lycopodiumsporites* spp. and *Deltoidospora* spp. *Cerebropollenites thiergartii*, *Chasmatosporites* spp. and *Quadraeculina anellaeformis* are recorded from the sidewall core at 1,942.2m only, this being their lowermost occurrence in the well.

The occurrence of ornamented miospores such as *Conbaculatisporites mesozoicus* is a significant regional event which is known to occur in sediments of Hettangian/Sinemurian age (Lund 1977). In this well, consistent *Conbaculatisporites mesozoicus* occurs between 1,982m and 1,986.7m.

All samples examined from 1,986.7m to 2,078m are either barren or yield impoverished assemblages containing only rare pollen and spores.



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This interval is defined in relation to the overlying Sinemurian sediments and the underlying Rhaetic sediments at 1,930.7m and 2,078m respectively. The possibility of Rhaetian age sediments occurring above 2,078m (see below) gives an overall age for this interval of Sinemurian to ?Rhaetian.

Remarks:

The sideritic claystone at 1,933m is a distinctive and regional lithological marker within the Statfjord Formation. The top of "red beds" and the Cormorant Formation is tentatively taken at sidewall core 2,029m.

2,078m-2,119.5m Late Triassic, Rhaetian.

Four sidewall core and two ditch samples have been examined from this interval. The sidewall core sample at 2,078m yields a rich assemblage of pollen and spores characterised by abundant *Classopollis torosus* with common *Riccisporites tuberculatus*, *Ovalipollis ovalis* and *Rhaetipollis germanicus*. Accessory taxa include bisaccate pollen, *Cycadopites* spp., *Inaperturopollenites* spp., *Punctatisporites globosus* sensu Pedersen and Lund, *Apiculatisporis* cf. *ovalis* and *Botryococcus* sp. (alga). The occurrence of *R. tuberculatus*, *O. ovalis* and *R. germanicus* at 2,078m indicates the penetration of sediments of Late Triassic, Rhaetian age. Furthermore, the presence of common *R. germanicus* suggests that these sediments may be of a Middle Rhaetian age at this level. This suggests the possibility that sediments of Rhaetian age are present above 2,078m. This cannot be confirmed because of the poor recovery of palynomorphs from the interval 1,986.7m to 2,078m (see above).

No age-diagnostic palynomorphs have been recorded below 2,119.5m.



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Remarks:

The first palynological evidence for the penetration of sediments of Rhaetian age in this region is normally indicated by the first (rare) downhole appearance of the pollen *Riccisporites tuberculatus*. Regional evidence shows that this event normally takes place above the top of the 'red beds'. However, in this well, presumably due to unfavourable lithologies for the recovery of palynomorphs, *R. tuberculatus* is not recorded until 2,078m, some 49m below the estimated top of the 'red beds'.

2,119.5m-2,155m (L.S.R.) Late Triassic, ?Rhaetian.

Two sidewall core and three ditch samples have been examined from this interval. The sidewall core samples (2,127.5m and 2,145.5m) were found to be barren whilst the ditch samples are considered to contain taxa which have mostly been caved from higher in the well.

A Rhaetian or older age for these sediments cannot be confirmed since no age-diagnostic palynomorphs have been recorded from this interval.

Environment:

1,891m-ca.1,924m Marine, inner sublittoral to littoral.
ca.1,924m-ca.2,029m Transitional, continental - marine, including alluvial 'red beds'.
ca.2,029m-2,155m Continental, mainly alluvial, 'red beds'.



5. REFERENCES.

LUND, J.L. 1977. Rhaetic to Lower Liassic Palynology of the onshore south-eastern North Sea Basin. Geological Survey of Denmark. II. Series No. 109, 128 pp.



34/10-11
1-HNC

S T A T O I L

ANALYSTS: R.W.M. G.C.W. PROJECT No: 796 DATE: APRIL 1981 ENCLOSURE No: 1

WELL 34/10-II
1600m—2155m.

NORWEGIAN OFFSHORE
STRATIGRAPHIC LOG

SCALE 1:500



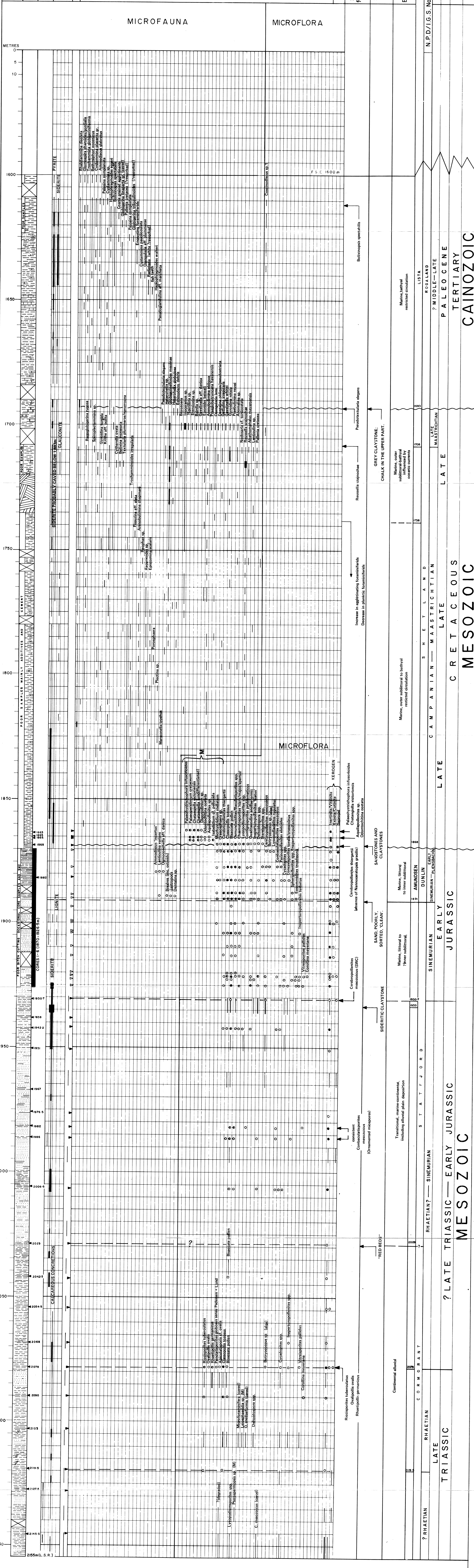
UNIT 15, PARAMOUNT INDUSTRIAL ESTATE,
SANDOWN ROAD, WATFORD, WD2 4XA, ENGLAND.

LEGEND

- [Symbol] CLAY/CLAYSTONE
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- [Symbol] LIMESTONE
- [Symbol] SHALE
- [Symbol] CONGLOMERATE
- [Symbol] CHALK
- [Symbol] MARL - CALCAREOUS SHALE
- [Symbol] VOLCANICS LAVAS/TUFFS
- [Symbol] DOLOMITE
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- [Symbol] ANHYDRITE/GYPSUM
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- [Symbol] GLAUCONITE
- [Symbol] SIDERITE
- [Symbol] LIGNITE/COAL
- [Symbol] PYRITE
- [Symbol] FOSFILLS AND ACCESSORY MINERALS
- [Symbol] Abundant
- [Symbol] Common
- [Symbol] Rare
- [Symbol] Abundant
- [Symbol] Common
- [Symbol] Rare
- [Symbol] FOSFILLS IN SIDEWALL CORES
- [Symbol] M
- [Symbol] INDICATES PALYNOFORMS OF MARINE ORIGIN

Boundary
Unconformity
T.D. (Total depth)
Partial or interrupted sequence
F.S.R. First sample received
L.S.R. Last sample received

Depth Lithology Cores/Side-wall cores Minerals Petrological analyses Main Fossils Kerogen Significant faunal/floral events Significant lithological horizons Environment Depths N.P.D./I.G.S. Nomen 1977 Age



2155 (L.S.R.)
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SEDIMENTARY HISTORY®

CLIENT: **STATOIL**

WELL NO: **34/10-II**

FIGURE: **I** DATE: **APRIL 1981**

PROJECT NO: **796** ANALYST: **R.W.M., G.C.W.**

- KEY:
- Missing section
 - Open marine circulation
 - Restricted circulation
 - Mainly coarse clastics (sand)
 - Mainly fine clastics (silt, clay)
 - Carbonates
 - Evaporites
 - Volcanics
 - Regressive Sequence
 - Transgressive Sequence
- * Vail et al. 1980



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