



**PALEOSERVICES LTD.**

STRATIGRAPHICAL AND PALEONTOLOGICAL CONSULTANTS

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Client Company	<u>STATOIL</u>
Title	<u>Well 34/10-8</u> (1,600m-2,216m T.D.) <u>NORWEGIAN OFFSHORE</u> <u>PALAEONTOLOGICAL/STRATIGRAPHICAL FINAL REPORT.</u>
Project No.	718
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Date	29th May, 1980. (Samples received by Paleoservices Ltd. on 9th May, 1980).

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## ENCLOSURES

1. Stratigraphic Log (Scale 1:500)  
    1,600m - 2,216m T.D.



1. INTRODUCTION.

This report presents the results of the stratigraphical and palaeontological study of samples from Well 34/10-8, drilled by Statoil in the North Sea (Norwegian offshore) during 1980.

The information presented is based on the analyses of ditch samples collected at 3m intervals between 1,600m and 2,216m. Twenty six sidewall cores were analysed between 1,748m and 2,210m. Four other sidewall core bottles were either empty or contained only drilling mud. Twenty two core samples were received and analysed from cores 1 - 8.

A total of 58 samples (14 sidewall cores, 23 ditch samples, 21 core samples) has been examined for paly-nology from the interval 1,822m - 2,216m.

Interval tops are taken from sample depths, although petrophysical logs were provided by Statoil.

A stratigraphical/palaeontological log (scale 1:500) is presented with this report.



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2. CONCLUSIONS.

1. The highest sample included in this study (1,600m) is a tuffaceous claystone characteristic of the North Sea "Ash marker" which is of basal Eocene - Late Paleocene age.
2. The section 1,620m - 1,728m comprises claystone, limestone and sand ranging in age from Late to ?Middle Paleocene age. Deposition was in a marine, outer sublittoral to bathyal environment. Occasional Cretaceous foraminiferids are present in the lower part of the section, below 1,719m, but these are tentatively presumed to be reworked.
3. ?Middle Paleocene claystone rests unconformably on claystone and limestone of Late Cretaceous (Late Maastrichtian) age at 1,728m.
4. The Late Cretaceous (Maastrichtian - ?Campanian) section comprises claystone and limestone (1,728m-1,821m). Deposition was in a marine, outer sublittoral to bathyal environment influenced by open sea circulation above 1,788m becoming more restricted below.
5. There is no evidence for the presence of rocks of Late Cretaceous (Santonian-Cenomanian), Early Cretaceous or Late Jurassic age. The Late Cretaceous (Maastrichtian-?Campanian) sequence rests unconformably on the Middle Jurassic, Brent Formation, at 1,821m.



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6. The Middle Jurassic, Brent Formation, (1,821m-2,055m) is a thick, dominantly sand, sequence containing five major lithological divisions, recognisable on petro-physical logs. Palynological analyses suggest that the sequence ranges in age from Bathonian to Early Bajocian (=Aalenian). There are two major palynological markers of regional stratigraphic value within this sequence, top *Nannoceratopsis gracilis* at 1,901.82m and top consistent *Nannoceratopsis gracilis* at 2,040m. Lithological and floral evidence suggests that the Brent Formation in this well is a regressive sequence of "shallow" marine and deltaic origin.
7. The Dunlin Formation (2,055m-2,216m T.D.) comprises claystone, siltstone, limestone with a prominent sand unit at 2,130m. The unit ranges in age from Early Bajocian (=Aalenian) to the upper Late Pliensbachian. The microfauna present is typical of a marine, inner sublittoral environment.



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3. STRATIGRAPHICAL SUMMARY.

1. Chronostratigraphical Summary.

<u>Interval</u>	<u>Age</u>	<u>Thickness</u>
1,600m - 1,620m F.S.E.	Early Eocene-Paleocene	20m
1,620m - 1,719m	Late Paleocene	99m
1,719m - 1,728m	?Middle Paleocene	9m
----- Unconformity -----		
1,728m - 1,749m	Late Cretaceous, Late Maastrichtian	21m
1,749m - 1,821m	Late Cretaceous, Maastrichtian - ?Campanian	72m
----- Unconformity -----		
1,821m - 1,901.82m	Middle Jurassic, Bathonian	80.82m
1,901.82m - 2,040m	Middle Jurassic, Earliest Bathonian- Bajocian.	38.18m
2,040m - 2,055m	Middle Jurassic, Early Bajocian (=Aalenian)	15m
2,055m - 2,121m	Middle - Early Jurassic, Early Bajocian (=Aalenian)-Toarcian	66m
2,121m - 2,130m	Early Jurassic, Early Toarcian	9m
2,130m - 2,178m	Early Jurassic, Early Toarcian - Late Pliensbachian	48m
2,178m - 2,216m T.D.	Early Jurassic, Late Pliensbachian	38m

2. Lithostratigraphical Summary.

1,728m - 1,821m	Shetland Group	93m
----- Unconformity -----		
1,821m - 2,055m	Brent Formation	234m
2,055m - 2,216m T.D.	Dunlin Formation	161m



4. STRATIGRAPHY.

This discussion supplements the information presented on the stratigraphical log (Enclosure 1). The lithology and biota are described and the age and depositional environment interpreted.

4.1 1,600m F.S.E. - 1,620m EARLY EOCENE - LATE PALEOCENE.

Lithostratigraphy:

1,600m-1,611m. Claystone, grey and green, occasionally tuffaceous, and sideritic; limestone, grey.

1,611m-1,620m. As above with some sand, fine-medium grained, angular.

Biostratigraphy:

Agglutinating foraminiferids are present but are long-ranging and of little stratigraphic value. The diatom *Coscinodiscus* sp.1 is present and its association with tuffaceous claystone characterises the North Sea "Ash Marker" which is of Early Eocene-Late Paleocene age.

Environment:

Marine, outer sublittoral to bathyal with contemporaneous volcanic activity.

4.2 1,620m-1,728m PALEOCENE.

1,620m-1,653m. Claystone, green and grey with limestone, brown, and below 1,638m grey.

1,653m-1,683m. Limestone, grey; sand, fine-medium grained and occasional claystone, grey.

1,683m-1,728m. Sand and sandstone, fine and fine-medium grained with limestone, grey, and claystone, grey.



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Biostratigraphy:

1,620m-1,719m Late Paleocene.

Agglutinating foraminiferids characterise this interval and the downhole appearance of *Bolvinopsis spectabilis* at 1,620m indicates penetration of rocks of Late Paleocene age.

1,719m-1,728m ?Middle Paleocene.

The presence of common reticulate *Radiolaria* at 1,719m is a regional marker of probable Middle Paleocene age.

Late Cretaceous foraminiferids are present throughout, however their scarcity suggests that they are probably reworked. No fossils of Early Paleocene (Danian) age have been recorded. The ?Middle Paleocene interval probably rests unconformably on the underlying Late Cretaceous (Late Maastrichtian) sequence.

Environment:

Marine, outer sublittoral to bathyal. The fauna (above 1,717m), which is almost entirely composed of agglutinating foraminiferids, suggests restricted circulation within the basin. The grey microcrystalline limestone present throughout much of the Paleocene may be re-worked from the Early Paleocene or Cretaceous by slumping from the basin margins.

4.3 1,728m-1,821m LATE CRETACEOUS (Maastrichtian-?Campanian).

Lithostratigraphy:

Shetland Group.

1,728m-1,745m Limestone, chalky, white to very light brown and claystone, grey.

1,745m-1,821m Poor samples, dominantly cement and drilling mud additives. Claystone, grey, occasionally silty with abundant siderite below 1,791m; occasional beds of limestone, grey.





Biostratigraphy:

1,728m-1,749m Late Maastrichtian.

The top Cretaceous is taken at the highest occurrence of abundant planktic foraminiferids including *Rugoglobigerina rugosa* and *Globigerinelloides messinae*. The presence of occasional specimens of *Pseudotextularia elegans*, *Globotruncana contusa* and *Abathomphalus mayaroensis* indicates a Late Maastrichtian age for this interval.

1,749m-1,821m Maastrichtian-?Campanian.

The top of this interval is recognised regionally by the first downhole appearance of *Reussella szajnochae* and is probably within the lower part of the Late Maastrichtian.

In the lower part of the interval (below ca.1,788m) the fauna is dominated by long ranging agglutinating foraminiferids and only rare planktic taxa. Occasional specimens of *Rugoglobigerina rugosa* and *Globigerinelloides messinae* are present and these taxa suggest an age no older than Campanian.

Environment:

Marine, outer sublittoral to bathyal. Abundant planktic foraminiferids in the upper part suggest influence by open sea circulation, while the dominance of agglutinating taxa below ca.1,788m suggests more restricted conditions.



4.4 1,821m-2,055m MIDDLE JURASSIC (Bathonian - Bajocian).

Lithostratigraphy:

Brent Formation.

The top of the Brent Formation is taken at the sidewall core at 1,821m (sand, fine - medium grained, subangular, with abundant pyrite and grey claystone matrix).

1,821m-1,899m Cuttings comprise sand, fine-medium grained, angular to subrounded. Core chips selected by Statoil geologists comprise mainly claystone and siltstone, dark grey, micaceous, carbonaceous and occasional sand, as described in the cuttings.

1,899m-1,974m Very poor cutting samples. Sand, fine-medium grained, subangular to subrounded, occasionally calcite cemented; occasional claystone, brown, waxy, with woody debris. A core sample at 1,901.82m is siltstone/claystone, light brown, with mica and fine carbonaceous debris.

1,974m-2,007m Sand/sandstone, fine-medium and occasionally coarse grained, angular to subrounded, rarely calcite cemented.

2,007m-2,046m Sand/sandstone as above, with abundant white mica and increasing amounts of calcite cement downhole.

2,046m-2,055m Sand, fine-coarse and occasional gravel, subangular to subrounded with some brown dolomitic matrix.



Biostratigraphy:

1,821m-1,901.82m Bathonian.

Microflora:

Twenty core chips and three sidewall cores have been examined from this interval. The top of the interval is taken at the incoming (downhole) of sand at 1,821m. The first palynology sample (1,822m) contains a poor assemblage but that at 1,823 (S.W.C.) and below, particularly the core samples (1,823.75m-1,896.30m) yield rich and diverse palynomorph assemblages, which are dominated by land-derived spores and pollen.

Possible marine influences are indicated by rare *Micrhystridium* spp. (at 1,857.30m, 1,860.33m and 1,866.04m) and one specimen of the dinoflagellate cyst *Nannoceratopsis gracilis* (at 1,857.30m), which is here tentatively considered to be reworked.

The spore/pollen assemblages are dominated by *Cerebropollenites mesozoicus*, *Cyathidites* spp. (common-abundant), *Classopollis torosus*, bisaccate pollen, *Lycopodiumsporites* spp. and *Inaperturopollenites turbatus*. The distinctive pollen *Callialasporites* spp. is a persistent element of these assemblages. Accessory species present include *Ischyosporites variegatus*, *Eucommidites troedssonii*, *Concavisporites toralis/crassexinus*, *Leptolepidites bossus/equatibossus*, *Neoraistrickia gristhorpensis*, *Quadraeculina anellaeformis* and *Sestrosporites pseudoalveolatus*. The freshwater alga *Botryococcus* is present in small amounts (at 1,823m (S.W.C.), 1,865.56m and 1,866.04m).

The spore/pollen taxa present with the exception of *Q. anellaeformis*, range throughout the Bathonian/Bajocian. In this area, however, such assemblages are normally characteristic of Middle to Early Bathonian sediments.



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Microfauna:

No in place microfauna.

1,901.82m-2,040m Earliest Bathonian - Bajocian.

Microflora:

One core chip, one sidewall core and ten ditch samples have been examined from this interval, the top of which is taken at the first (in situ) downhole appearance of the dinoflagellate cyst *Nannoceratopsis gracilis*, which indicates an age not younger than Earliest Bathonian.

The assemblages are generally composed of taxa which have been recorded in the overlying interval. They are dominated by abundant *Cyathidites* spp. with common *Perinopollenites elatoides*, bisaccate pollen and *Classopollis torosus*. No palynomorphs were recorded from the ditch sample at 2,028m and only *Cyathidites* spp. are present at 1,980m, whilst both had a low kerogen content.

Microfauna:

No in place microfauna:

2,040m-2,055m Early Bajocian (=Aalenian).

Microflora:

One ditch sample has been examined. The top of the interval is taken at the incoming of consistent *N. gracilis* at 2,040m. Other taxa present include common *Cerebropollenites mesozoicus*, *Cyathidites* spp. and *Classopollis torosus*. The incoming of consistent *N. gracilis* is a palynoevent of widespread regional stratigraphical significance in the basal Brent Formation. The corresponding interval in other wells in this area has been dated as being Early Bajocian (=Aalenian) in age.

Microfauna:

No in place microfauna.

Environment:

Shallow marine - 'deltaic'.



4.5 2,055m-2,216m T.D. MIDDLE-EARLY JURASSIC (Early Bajocian (=Aalenian)-Late Pliensbachian).

Lithostratigraphy:

Dunlin Formation.

The top of the Dunlin Formation is taken at the S.W.C. 2,055m; claystone, dark grey with laminated mica, carbonaceous debris, and which contains occasional foraminiferids.

2,055m-2,079m. Poor samples with abundant caved sand. Probable in place lithologies are claystone and occasional siltstone, grey, pyritic and sideritic and limestone, brown.

2,079m-2,130m. Claystone, and occasional siltstone, grey, pyritic, sideritic and glauconitic; frequent beds of limestone/dolomite, brown.

2,130m-2,169m. Sand/sandstone, fine-medium grained occasionally coarse, angular to subangular, occasionally calcite cemented, common pyrite coated sand grains at 2,157m.

2,169m-2,172m. No sample.

2,172m-2,208m. Sand/sandstone, as above, but mainly fine grained, angular with calcite cement; occasional claystone/siltstone, grey and brown as in sidewall core 2,200m.

2,208m-2,216m. As above with limestone/marl, light brown.

Biostratigraphy:

2,055m-2,121m. Early Bajocian (=Aalenian)-Toarcian.

Microfauna:

The top of this interval is taken at the highest occurrence of agglutinating foraminiferids (S.W.C. 2,055m) a consistent regional marker below the



Brent Formation. Below 2,067m the fauna includes *Nodosaria regularis*, *Ammodiscus 'incertus'*, *Haplophragmoides kingakensis*, *Camptocythere parvula*, *C. cf. gr. foveolata* and *C. aff. toarciana* indicating that the interval ranges in age from Early Bajocian (=Aalenian)-Toarcian.

Microflora:

Four sidewall cores and four ditch samples have been examined from this interval. The resulting variable assemblages include the dinoflagellate cysts *Nannoceratopsis gracilis*, Plankton Type 2 (Schulz and Mai in Doring et al. 1966) from 2,064m and below, *Comparodinium aff. punctatum* from 2,076m and below, Dinoflagellate Type C (internal species) from 2,088m and below and Dinoflagellate Type 4 (internal species) from 2,100m and below. This association is characteristic of the Early Bajocian (=Aalenian) to Late Toarcian.

The presence of Dinoflagellate Type 3 (Thusu) in the ditch sample at 2,109m is a palynoevent of potential significance in local correlation. Its appearance (downhole) is usually close to the incoming of the ostracod *Kinkelinella intrepida*, which is normally taken to indicate the penetration of strata of Early Toarcian age (see section below), although rare specimens of *Callialasporites* spp. occur in the sidewall core at 2,120m and this species is more characteristic of the Late Toarcian at this level.

2,121m-2,130m Early Toarcian.

Microfauna:

The first downhole occurrence of *Kinkelinella intrepida* at 2,121m is a regional marker of Early Toarcian age.



Microflora:

One ditch sample has been examined from this interval. It contains an assemblage similar to those in the overlying interval and includes *Nannoceratopsis gracilis*, Plankton Type 2 (Schulz and Mai), Dinoflagellate Type 4 (internal species), *Micrhystridium* spp., *Cyathidites* spp., *Lycopodiumsporites* spp. and *Classopollis torosus*.

2,130m-2,178m Early Toarcian-Late Pliensbachian.

Microfauna:

No in-place age diagnostic microfauna.

Microflora:

Three sidewall cores and three ditch samples have been examined from this interval. The six samples yield rich and diverse palynomorph assemblages which are dominated by *Cyathidites* spp., bisaccate pollen, *Classopollis torosus*, *Chasmatosporites hians/major* and *N. gracilis*.

The dinoflagellate cyst *Mancodinium semitabulatum*, which first appears downhole at 2,139m is considered by Morbey (1978) to be a characteristic element of Late Pliensbachian strata. Abundant *Spheripollenites/Exesipollenites* spp. occur from 2,139m to 2,160m. The abundance of these small spherical pollen (otherwise referred to as small *Inaperturopollenites* spp.) is of regional significance in the recognition of the Early Toarcian.



2,178m-2,216m T.D. Late Pliensbachian.

Microfauna:

The highest occurrence (2,178m) of the ostracod genus *Ogmoconchella* is a regional marker consistently used by Paleoservices Ltd. to indicate the top Late Pliensbachian.

The association of *Ogmoconchella aequalis* (large form) and gastropods (2,208m) is another correlatable level within the Late Pliensbachian.

Microflora:

Three sidewall cores and four ditch samples have been examined from this interval. *Nannoceratopsis gracilis* is not reported to range below the Late Pliensbachian. It occurs throughout this interval and is abundant in the sidewall cores at 2,200m and 2,210m. Its presence suggests this interval is not older than Late Pliensbachian. The assemblages are also characterised by common to abundant *Classopollis torosus* and bisaccate pollen, with *Cerebropollenites mesozoicus*, *Chasmatosporites hians/major* and *Kraeuselisporites reissingeri* at 2,202m and below. *Cerebropollenites cf. thiergartii* is present throughout this interval; this species is typical of the Pliensbachian although it can range higher.

There is no palynological evidence which suggests the penetration of strata older than Late Pliensbachian in age.

Environment:

Marine, mainly inner sublittoral.





5. REFERENCES.

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MORBAY. S.J. 1978. Late Triassic and Early Jurassic subsurface palynostratigraphy in northwestern Europe. Palinologia, 1, 355-365.



# WELL 34/10-8

1600 m. - 2216 m. T.D.  
NORWEGIAN OFFSHORE

## STRATIGRAPHIC LOG

SCALE 1:500

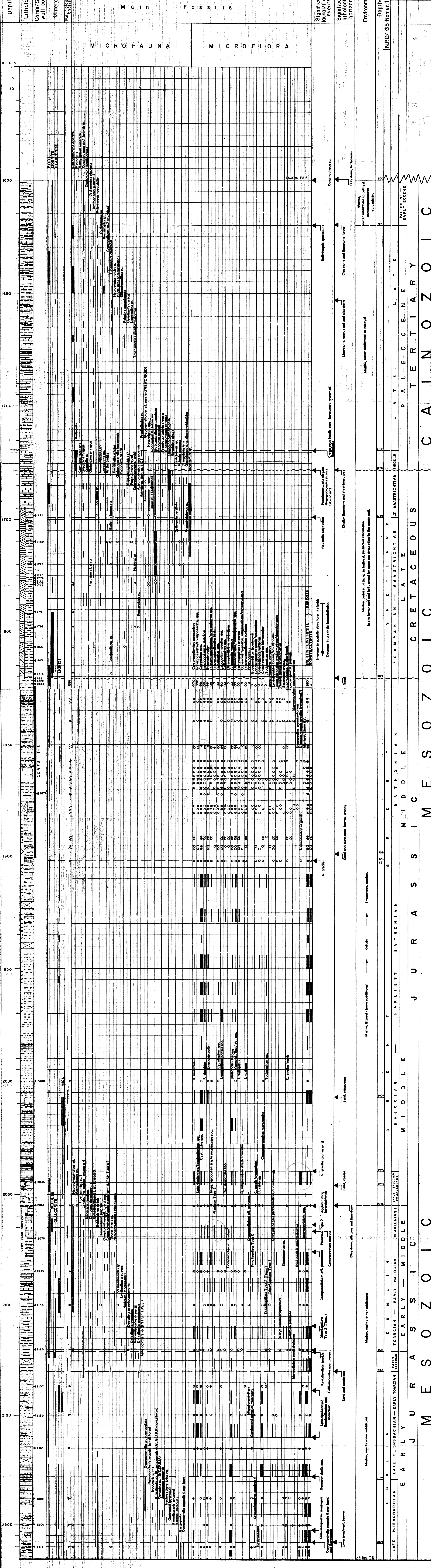


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### LEGEND

- CLAY/CLAYSTONE
- SHALE
- MARL - CALCAREOUS SHALE
- SILTSTONE/SILT
- SAND
- MEGAFOSSILS
- CHERT
- PYRITE
- SANDSTONE
- CONGLOMERATE
- VOLCANICS LAVAS/TUFFS
- UNDIFFERENTIATED BASEMENT
- NO DITCH SAMPLES
- GLAUCONITE
- SIDEWALL CUTTINGS
- LIGNITE/COAL
- LIMESTONE
- CHALK
- DOLOMITE
- CEMENT
- ANHYDRITE/GYPSUM
- MICA
- SIDEWALL CORES
- POOR SAMPLES

- Boundary
- Unconformity
- TD (Total depth)
- Partial or interrupted sequence
- F.S.R. First sample received
- L.S.R. Last sample received
- Fossils and accessory minerals
- Abundant
- Common
- Rare
- Fossils in sidewall cores/cores
- Ditch cuttings
- Core
- SWC
- PALYNOLOGICAL ANALYSES



Age

Depths

Environment

Significant lithological horizons

Significant faunal/floral events

Main Fossils

Microfauna

Microflora

MAASTRICHTIAN

DANIAN

EARLY CRETACEOUS

MIDDLE CRETACEOUS

LATE CRETACEOUS

PALEOCENE

EARLY PALEOCENE

VERY POOR SAMPLES

POOR SAMPLES

VERY GOOD SAMPLES

Core

SWC

PALYNOLOGICAL ANALYSES