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The Company was founded in December 1964 by Dr. V. L. Roveda and has expanded its activities in recent years with additional qualified staff, to satisfy the demand for services. The present **Paleoservices** office and laboratory address is.

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Client Company

STATOIL

Title

WELL 34/10-9

(1600m - 2412.2m)

NORWEGIAN OFFSHORE

PALAEONTOLOGICAL/STRATIGRAPHICAL FINAL REPORT.

Project No.

720

Stratigraphers

R.W. Meyrick. G.C. Wilkinson.

Directors: Dr. V. L. Roveda, Dr. D. D. Bayliss.

Date

August, 1980.

CONTENTS

1. INTRODUCTION.

This report presents the results of the stratigraphical and palaeontological study of samples from Well 34/10-9 drilled by Statoil in the North Sea (Norwegian offshore) during the summer of 1980.

The information presented is based on the analyses of ditch samples collected at 3m intervals from 1600m to 2410m. Forty-seven sidewall cores were analysed between 1735m and 2412.2m. Sixteen core samples were received and analysed from cores 1-6.

A total of 77 samples (35 sidewall cores, 28 ditch cuttings, 14 core samples) have been examined for palynology from the interval 1826m-2412.2m.

Petrophysical logs were provided by Statoil between the interval 1442m - 2202m. Slight discrepancies exist between some lithological tops based on sidewall cores, ditch cuttings and petrophysical logs (e.g. top Cook sands at 2083m on logs and at 2077m on ditch cuttings) but in all cases samples received are used to define lithological tops.

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

2. CONCLUSIONS.

1. The highest sample included in this study (1600-1603m) is Late Paleocene claystone.

2. The section from 1600m to 1693m comprises dominantly claystones with sands and sandy claystones of Late - ?Middle Paleocene age deposited in a marine, outer sublittoral to bathyal environment.

3. The absence of Middle and Early Paleocene fossils suggests that Late - ?Middle Paleocene rocks rest unconformably on Late Cretaceous rocks at 1693m.

4. Only the upper part of the Late Cretaceous (Maastrichtian-Campanian) is present in this well; this comprises claystones with occasional limestones and chalky limestones (1693m-1831m), deposited in a marine, outer sublittoral to bathyal environment.

5. A major unconformity exists between the Late Cretaceous (Maastrichtian-Campanian) and the Middle Jurassic (earliest Bathonian-Bajocian) at 1831m.

6. The youngest Jurassic rocks present in this well are of earliest Bathonian to Bajocian age and represent the Etive, Rannoch and Broom members of the Brent Formation (1831m-1957m). Deposition of this sequence was in a marine, nearshore environment. The consistent occurrence of the dinoflagellate Nannoceratopsis gracilis below 1945m indicates the influence of more marine conditions in the lower part of the interval.

7. The Dunlin Formation (1957m-2371m) comprises a thick sequence of claystones, sands and limestones ranging in age from Early Bajocian (=Aalenian) to probably Late Sinemurian. Deposition of this sequence was in a marine, inner sublittoral environment.

8. The Statfjord Formation is represented mainly by coarse sands with occasional organic claystones (2371m-2412.2m). It contains no age-diagnostic fossils, but is presumably no older than Early Jurassic (Sinemurian) in age on regional and palynological evidence.

3. STRATIGRAPHICAL SUMMARY.

Interval	Age	Thickness
1600 - 1693m F.S.R.	Late-?Middle Paleocene	93m
----------	UNCONFORMITY ----------	
1693 - 1711m	Late Cretaceous, Late Maastrichtian	18m
1711 - 1831m	Late Cretaceous, Maastrichtian-Campanian	120m
----------	UNCONFORMITY ----------	
1831 - 1945m	Middle Jurassic Earliest Bathonian - Bajocian	114m
1945 - 1957m	Middle Jurassic Early Bajocian (=Aalenian)	12m
1957 - 2035m	Middle - Early Jurassic Early Bajocian (=Aalenian) - Toarcian	78m
2035 - 2077m	Early Jurassic, Early Toarcian	42m
2077 - 2113m	" " Early Toarcian - Late Pliensbachian	36m
2113 - 2284m	" " Late Pliensbachian	171m
2284 - 2326m	" " Early Pliensbachian	42m
2326 - 2371m	" " Early Pliensbachian - Late Sinemurian	45m
2371 - 2412.2m L.S.R.	" " Sinemurian	41.2m

4. STRATIGRAPHY.

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

4.1 1600m F.S.R.-1693m LATE - ?MIDDLE PALEOCENE.

Lithostratigraphy:

1600m-1657m Claystone, green; sand, fine to medium grained and rare beds of brown limestone. Pyrite is common throughout; glauconite and siderite are occasionally present.

1657m-1693m As above, but with more sand. Siderite is abundant below 1681m.

Biostratigraphy:

Agglutinating foraminiferids are common and diverse throughout this interval and include the genera Rhabdammina, Recurvoides, Ammodiscus, Cyclammina, Pelosina, Bathysiphon, Glomospira and Trochammina. None of these taxa are age-restricted, although this association (together with the presence of Bolivinopsis spectabilis) characterises the Late-?Middle Paleocene in the northern part of the North Sea.

Diagnostic Middle and Early Paleocene fossils are absent, indicating that the Late Paleocene rests unconformably on the Late Cretaceous.

Environment:

Marine, outer sublittoral to bathyal, with restricted circulation.

4.2 1693m-1831m LATE CRETACEOUS (Maastrichtian-Campanian)

Lithostratigraphy:

Shetland Group.

1693m-1831m Dominantly claystone, grey, calcareous in the upper part;becoming less calcareous at lower levels. Interbedded chalk, white to very light brown above 1705m, and occasional beds of grey limestone at lower levels. Pyrite is present throughout, and there is occasional glauconite. Siderite (which is common at the top) is thought to be caved.

Biostratigraphy:

1693m-1711m Late Maastrichtian.

An abundant and diverse fauna of planktic and benthic foraminiferids is present throughout this interval. The association of the planktic taxa Pseudotextularia elegans, Racemiguembelina fructicosa, Rugoglobigerina rugosa, Globotruncanella havanensis and Globigerinelloides messinae indicates a Late Maastrichtian age.

1711m-1831m Maastrichtian-Campanian.

Microfauna:

The top of this interval is regionally recognised by the first downhole appearance of Reussella szajnochae, a marker within the Late Maastrichtian. In this well the highest occurrence of the planktic taxa Abathomphalus mayaroensis at 1714m confirms this age.

In lower levels of the interval planktic foraminiferids become less common and benthic agglutinating taxa become more common (especially below 1750m). As the latter are long-ranging, dating of this section is not precise but as the planktics Rugoglobigerina rugosa and Globigerinelloides messinae are present throughout this section it is definitely no older than Late Campanian and possibly no older than Maastrichtian.

Microflora:

One sidewall core at 1826m was examined from this interval. The assemblage is characterised by abundant dinoflagellate cysts which include Odontochitina operculata, Chatangiella granulifera, C. cf. microcantha, Diconodinium firmum and Deflandrea acuminata and the pollen genus Aquilapollenites. Accessory taxa are represented by bisaccate pollen, triporate pollen, the spore genus Cicatricosisporites and Palambages sp. (alga).

Such an association of palynomorphs suggests a Late Campanian age at this level.

Environment:

Marine, outer sublittoral to bathyal. Abundant planktic foraminiferids in the upper part indicate the influence of open sea currents, while the increasing numbers of agglutinating foraminiferids downhole are typical of more restricted conditions. This change may also be noted lithologically especially in the sidewall cores; e.g. SWC's at 1735m and 1750m are calcareous non-pyritic claystones with abundant calcareous foraminiferids (especially planktic taxa), while SWC's at 1815.5m and 1826m are pyritic non-calcareous claystones with only non-calcareous, agglutinating, foraminiferids. These associations may be of regional significance, the dissolution of calcareous tests in the lower part being attributable to variations in the carbonate compensation depth rather than significant variation in other features of the environment such as depth.

4.3 1831m-1957m MIDDLE JURASSIC (Bathonian-Bajocian).

Lithostratigraphy:

Brent Formation.

The top of the Brent Formation is taken at the first downhole occurrence of sands below the Late Cretaceous claystones.

1831m-1850m Sand/sandstone, fine-medium grained; below 1837m mainly fine grained, angular to subrounded. The uppermost ditch cutting sample (1831-1834m) and the sidewall core at 1834m are sandy marl/limestone, light grey, with fine black argillaceous laminae. The sidewall core at 1847m is claystone, silty and sandy, grey with some lignitic debris.

1850m-1868m (Core No.1) Sand/sandstone, fine-medium grained, angular to subangular, with abundant white and brown mica and occasional fine carbonaceous debris. There is a thin bed of coal at ca.1852m.

1868m-1927m Sand/sandstone, mainly as in the core above. Below ca. 1885m, there is often a calcareous cement, although sidewall cores 1882m and 1918m have a white non-calcareous matrix, possibly kaolinite.

1927m-1948m Sand/sandstone, as above, but occasionally coarse grained and with a brown dolomitic matrix below 1945m. Sample quality is extremely poor below 1936m, with abundant caved Cretaceous claystone.

1948m-1957m Sand/sandstone, fine-coarse, and gravel, angular to subrounded, occasionally with brown ?dolomitic cement.

Biostratigraphy:

1831m-1945m Earliest Bathonian-Bajocian.

Microflora:

Three core chips, eight sidewall cores and four ditch samples have been examined from this interval. Only one sample was suitable for palynological examination over the interval 1900m-1945m, which was a sidewall core at 1918m. The samples consistently yield palynomorph assemblages which are dominated by land-derived spores and pollen, with only rare Micrhystridium spp. and small Veryhachium spp. as possible marine indicators. On the basis of regional evidence this interval is considered to be equivalent to that between the highest appearance of Nannoceratopsis gracilis and the level of consistent N. gracilis, although the former event (highest appearance) was not recorded here.

The spore/pollen assemblages are dominated by Cyathidites spp. and Perinopollenites elatoides with common bisaccate pollen, Inaperturopollenites spp., I. turbatus, Classopollis torosus, Osmundacidites/Baculatisporites spp. and Inaperturopollenites 'hiatus'.

Accessory species present include Quadraeculina anellaeformis, Ischyosporites variegatus, Lycopodiumsporites spp., Cerebropollenites mesozoicus, Concavisporites toralis/crassexinus, C. juriensis, Coronatispora valdensis, Eucommidites troedssonii and Chasmatosporites hians/major. The sidewall core examined at 1918m yielded only rare long-ranging palynomorphs.

The spore/pollen assemblages present are composed of taxa which range throughout the Bathonian/Bajocian, with the exception of Q. anellaeformis which first appears downhole within the Bathonian. No dinoflagellates are present over this interval. In other wells in the area this flora indicates an earliest Bathonian-Bajocian age.

Microfauna:

There is no in place microfauna within this Brent Formation sequence.

1945m-1957m Early Bajocian (=Aalenian).

Microflora:

One sidewall core and one ditch sample have been examined. The top of this interval is taken at the incoming of consistent N. gracilis at 1945m. The sidewall core at 1950m is characterised by abundant N. gracilis. This is a palynoevent of widespread regional stratigraphical significance in the basal Brent Formation/Unit. The equivalent interval in other wells in the area has been dated as being Early Bajocian (Aalenian) in age.

Environment:

Shallow marine.

4.4 1957m-ca.2371m MIDDLE-EARLY JURASSIC (Early Bajocian (=Aalenian)-Early Pliensbachian/Sinemurian).

Lithostratigraphy:

Dunlin Formation.

Although there is extensive caving through this section, the top Dunlin is tentatively recognised, at 1957m, by the occurrence of claystones with agglutinating foraminiferids beneath the Broom sands of the Brent Formation.

1957m-2077m Claystone, occasionally silty, dark grey, non-calcareous, micaceous, with common pyrite and occasional glauconite. Interbedded brown and grey limestone with ?chamositic oolites at ca. 1963m. Sand, present in the samples between 2059m and 2077m, may be caved.

2077m-2167m Sand/sandstone, fine to medium grained, occasionally coarse grained, angular to subangular, becoming fine grained, angular and calcareous in the lower part, with grey claystone and siltstone. Pyrite and carbonaceous debris present throughout, but more common in the upper part.

2167m-2173m No samples.

2173m-2200m Limestone, light brown - orange, with claystone and siltstone, light grey, pyritic.

2200m-2203m Cement.

2203m-2224m Dominantly cement. 'In-place' lithologies are probably sand, fine to medium grained, and claystone, grey, often sandy or silty.

2224m-ca.2263m Claystone, dark green, occasionally sandy, with chamositic or phosphatic oolites; sample quality extremely poor in the lower part.

ca.2263m-ca.2310m Claystone, brown and grey, occasionally silty; thin beds of brown limestone.

ca.2310m-2344m Claystones as above with sandstone, very fine grained, micaceous, and claystone, sandy.

2344m-2347m No samples.

2347m-2371m Sand, fine-medium grained, angular, micaceous, together with grey claystone, often sandy.

The ditch sample at 2368m-2371m contains typical Statfjord lithologies as described below but the sidewall core at 2370m was taken in Dunlin type lithologies and contained a Dunlin type fauna. The top Statfjord Formation is therefore taken at 2371m.

Biostratigraphy:

1957m-2035m Early Bajocian (=Aalenian) - Toarcian.

Microfauna:

The uppermost part of this interval (1957m-1969m) contains only long-ranging agglutinating foraminiferids, but the fauna is consistent regionally and is probably of Early Bajocian (=Aalenian) age. At and below 1969m the downhole appearances of the foraminiferids Nodosaria regularis, Haplophragmoides kingakensis and Lenticulina clathrata, and the ostracods Camptocythere cf. gr. foveolata, C. parvula and C. aff. toarciana suggest that this interval ranges in age from Early Bajocian (=Aalenian) to Toarcian.

Microflora:

Four sidewall cores and five ditch samples have been examined from this interval. The assemblage includes the dinoflagellate cyst Nannoceratopsis gracilis, with Plankton Type 2 (Schulz and Mai in Doring et al. 1966) and Comparodinium aff. punctatum from 1966m and below, Dinoflagellate Type C (internal species) from 1975m and below, Dinoflagellate Type 4 (internal species) from 1984m and below and Susadinium sp. A (internal species) from 2000m and below. This association is characteristic of the Early Bajocian (Aalenian) to Late Toarcian. The presence of rare specimens of Callialasporites spp. at 2000m suggests an age no older than Late Toarcian at this level.

2035m-2077m Early Toarcian.

Microfauna:

The top of this interval is recognised by the first downhole appearance of Kinkelinella intrepida, an ostracod restricted, in onshore successions in England, to the Early Toarcian (Whitbian).

Microflora:

Two sidewall cores and two ditch samples have been examined from this interval. It is characterised by an assemblage similar to that in the overlying interval and includes Nannoceratopsis gracilis and Susadinium sp. A (internal species) in all four samples, Comparodinium aff. punctatum at 2059m (DC) and 2076m (SWC), Dinoflagellate Type C (internal species) at 2059m (DC) and the first downhole appearance of Cf. 'Comparodinium cf. koessenium' sensu Willie and Gocht at 2050m (SWC).

The presence of Dinoflagellate Type 3 (Thusu) is normally regarded as 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 above). However, in this well the only occurrence of Dinoflagellate Type 3 (Thusu) is at 2059m, which is at a significantly lower level than the incoming of K. intrepida at 2035m.

Pollen and spores dominate these assemblages, which are characterised by abundant bisaccate pollen (at 2050m) and Classopollis torosus (at 2059m) with common Cyathidites spp., Spheripollenites/Exesipollenites spp. and Chasmatosporites hians/major (at 2076m).

2077m-2113m Early Toarcian-Late Pliensbachian.

Microfauna:

This interval appears to lack any in-place fauna.

Microflora:

Five core chips, three sidewall cores and one ditch sample have been examined from this interval. These samples yield rich and diverse palynomorph assemblages which are dominated by Nannoceratopsis gracilis, bisaccate pollen, Classopollis torosus, Cerebropollenites mesozoicus and Chasmatosporites hians/major/apertus.

A single specimen of Mancodinium semitabulatum was found at 2094.46m (core) and this species is considered by Morbey (1978) to be a characteristic element of Late Pliensbachian strata. Abundant Spheripollenites/ Exesipollenites spp. occur from 2085.5m to 2096.17m. The abundance of these small spherical pollen grains is of regional significance in the recognition of the Early Toarcian. Cerebropollenites cf. thiergartii, which first appears downhole at 2101.22m, is generally considered to be a typical Pliensbachian element although it can range higher.

2113m-2284m Late Pliensbachian.

Microfauna:

The first downhole occurrence of common specimens of the ostracod genus Ogmoconchella (2113m) has been consistently used as a convenient indicator for the top Late Pliensbachian, although the genus does range into the lowest Toarcian in onshore sections.

Other microfaunal markers present within the Late Pliensbachian of this sequence are:-

2173m top Ogmoconchella aequalis (large form) and gastropods.
2212m top Ogmoconcha amalthei (large forms)
2224m top Dentalina matutina
2239m top Wicherella semiora

Microflora:

Four core chips, nine sidewall cores and nine ditch samples have been examined from this interval.

Nannoceratopsis gracilis is not reported to range below the Late Pliensbachian. In this well it has not been positively recorded below 2200m (the single specimen found in the ditch cutting at 2242m may well be caved from an overlying interval). Its presence suggests an age not older than Late Pliensbachian at 2200m. Rare specimens of Cf. Comparodinium sp. and Cf. 'Comparodinium cf. koessenium' sensu Willie and Gocht are recorded at 2137m.

These assemblages are dominated by abundant bisaccate pollen, Chasmatosporites hians/major/apertus and Classopollis torosus with common Osmundacidites/ Baculatisporites spp. Accessory species include Acanthotriletes cf. varius, Ceratosporites spinosus, Anaplanisporites cf. echinatus and Convolutispora cf. klukiformis sensu Schulz. Cerebropollenites cf. thiergartii and C. mesozoicus are present throughout this interval.

Reworked palynomorphs are present in the form of striate bisaccate pollen at 2155m (Late Carboniferous - Triassic), Tripartites sp. at 2209.9m (Late Visean - Early Namurian), monosaccate pollen at 2242m (Carboniferous - Permian) and a single densospore specimen at 2278.5m (Carboniferous).

2284m-2326m Early Pliensbachian.

Microfauna:

The ostracod Gammacythere ubiquita which first occurs at 2284m is restricted in numerous European onshore sections to the Early Pliensbachian.

Microflora:

Two sidewall cores and two ditch samples have been examined from this interval. No age - significant changes in the microflora occur within this interval. The assemblages are dominated by bisaccate pollen with lesser amounts of Classopollis torosus, Chasmatosporites spp. and Inaperturopollenites spp.

2326m-2371m Early Pliensbachian-Late Sinemurian.

Microfauna:

The top of this interval has been consistently recognised by the top occurrence of ostracods of the genus Kinkelinella and although they are not specifically identifiable they approach the K. foveolata group whose main range is within the Late Sinemurian. The continued presence of common ostracods of Ogmoconcha amalthei group and Ogmoconchella cf. danica is more typical of the Early Pliensbachian.

Microflora:

Two sidewall cores and two ditch samples have been examined from this interval. The assemblages are still dominated by bisaccate pollen, Classopollis torosus and Chasmatosporites spp. No age-significant changes in the microflora occur within this interval. A single specimen of Zebrasporites cf. interscriptus was recorded at 2370m. A rare dinoflagellate cyst which may have an affinity to the genus Comparodinium is present at 2370m.

Reworked palynomorphs are present as single densospore specimens at 2350m and 2376.1m respectively (Carboniferous) and a striate bisaccate pollen at 2370m (Late Carboniferous - Triassic).

Environment:

Marine, inner sublittoral.

4.5 ca.2371m-2412.2m L.S.R. EARLY JURASSIC (Sinemurian).

Lithology:

Statfjord Formation.

Sands, fine-coarse grained, subangular to sub-rounded, rarely calcite cemented; occasional claystone, dark brown, sometimes silty, abundant fine mica and carbonaceous debris.

These lithologies are first encountered in the ditch sample at 2368m-2371m but the top of the Statfjord Formation is taken at 2371m as the sidewall core at 2370m is in more typical Dunlin lithologies.

Microfauna:

Ostracods and foraminiferids in this interval are presumed caved.

Microflora:

Two core chips, three sidewall cores and two ditch samples have been examined. No age-significant taxa appear downhole in this interval and there is no apparent change in the overall composition of the assemblage in relation to those of the overlying interval.

The presence of specimens of Cerebropollenites mesozoicus in the sidewall core at 2412.2m would normally be taken to suggest an age not older than Sinemurian at this level.

Environment:

Marine, dominantly high energy, probably nearshore with occasional low-energy clay deposition in a ?lagoonal environment with a strong continental influence.

5. REFERENCES.

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

S T A T O I L	ANALYSTS: R. W. M. G. C. W.	PROJECT No: 720	DATE: AUGUST 1980	ENCLOSURE No: 1

WELL 34/10-9

1600 m. — 2412·2 m.

NORWEGIAN OFFSHORE

STRATIGRAPHIC LOG

SCALE 1:500

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

LEGEND

CLAY/CLAYSTONE, SANDSTONE (F M C), LIMESTONE, SHALE, CONGLOMERATE, CHALK, MARL - CALCAREOUS SHALE, VOLCANICS LAVAS/TUFFS, DOLOMITE, SILTSTONE/SILT, UNDIFFERENTIATED BASEMENT, CEMENT, SAND (F M C), NO DITCH SAMPLES, ANHYDRITE/GYPSUM

MEGAFOSSILS, G GLAUCONITE, MICA, CHERT, S SIDERITE, CORES, PYRITE, LIGNITE/COAL, SIDEWALL CORES, P.S. POOR SAMPLES

SIGNIFICANT FAUNA

SIGNIFICANT FLORA

Boundary

Unconformity

T.D. (Total depth)

Partial or interrupted sequence

F.S.E. First sample examined

L.S.R. Last sample received

FOSSILS AND ACCESSORY MINERALS: Abundant, Common, Rare

FOSSILS IN SIDEWALL CORES: Abundant, Common, Rare

PALYNOLOGICAL ANALYSES: Ditch cuttings, Core, S.W.C.