# CONOCO/TEXACO/SOCAL/PELICAN
# NORWEGIAN NORTH SEA WELL
# 9/4-3

## FINAL REPORT

R. C. Selley

21st November 1972.

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CONOCO NORWAY INC.
TEXACO OVERSEAS PETROLEUM COMPANY
CALIFORNIA ASIATIC OIL COMPANY
K/S A/S PELICAN ET COMPANY

# WELL LOCATION PLAT.

**Well : CONOCO / TEXACO / SOCAL / PELICAN 9/4-3**

Country :- Norway

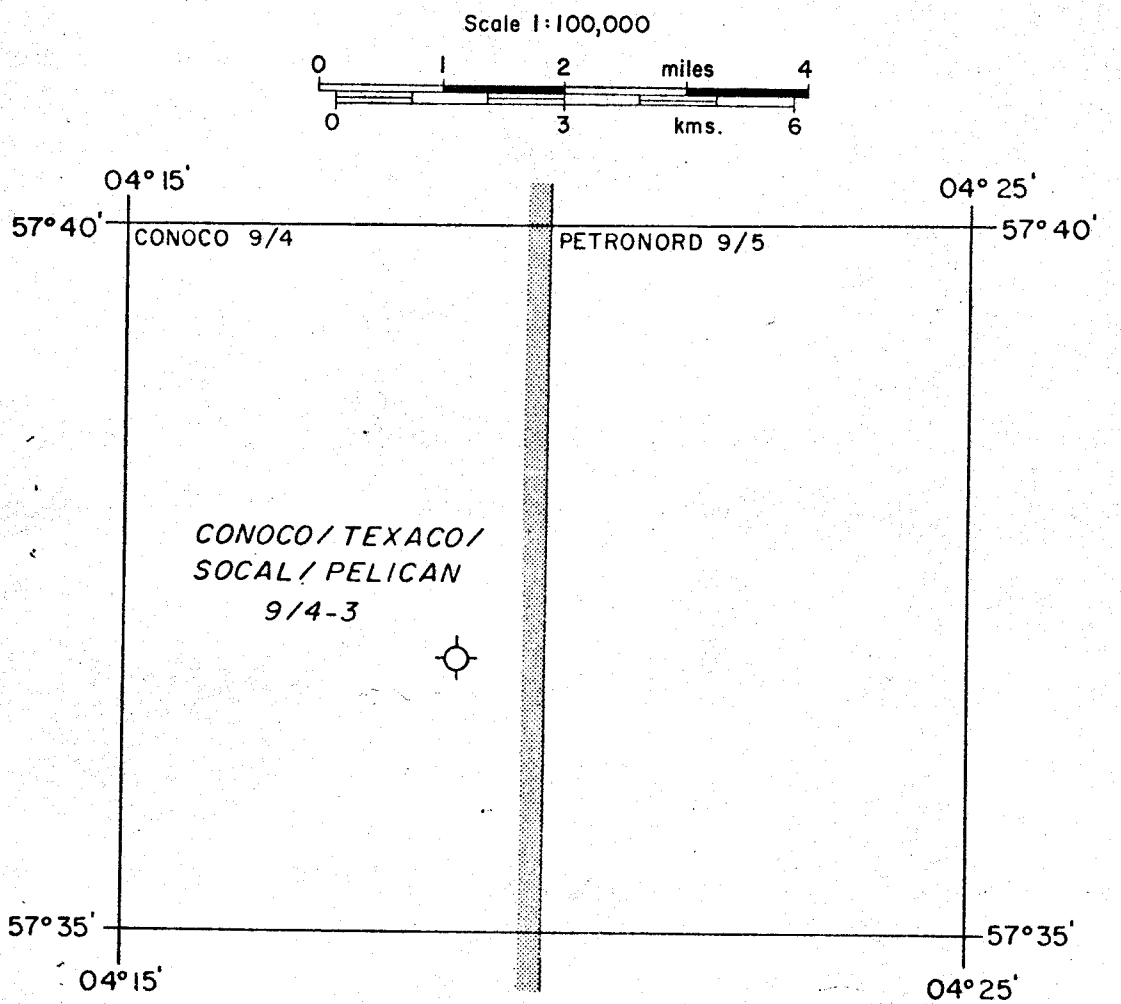
Area :- North Sea

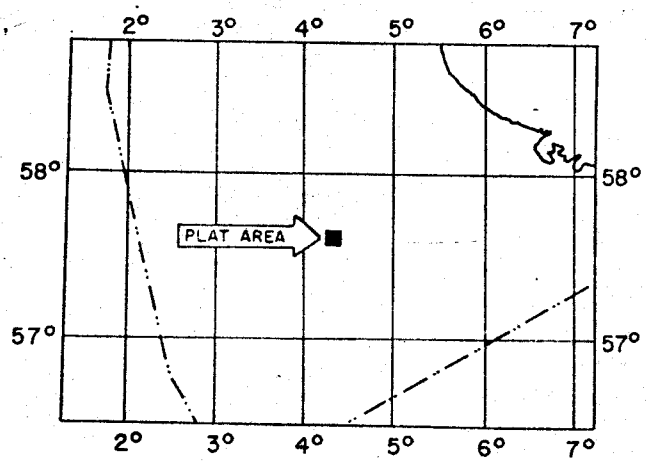
Water depth :- 237'

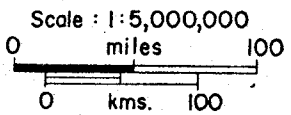
Location :- Lat : 57° 36' 54.5" N.
Long : 04° 18' 57.7" E.

K.B. elev. :- 92'

T.D. 8800'



## I. SUMMARY

The Conoco/Texaco/Socal/Pelican 9/4-3 Well was drilled in the Norwegian sector of the North Sea by the ODECO rig Ocean Tide with Conoco as operator.

The well was designed to test the hydrocarbon and reservoir potential of Tertiary and Mesozoic strata. It was located on a NW/SE trending anticlinal high faulted on its S.E. flank. The position is updip and to the southwest of a thick basinal development of Mesozoic strata.

The primary objective was the Middle Jurassic Sandstone which is well developed in the adjacent wells in the 9/4 block. Porous Triassic sands were a second potential reservoir.

The top of the Jurassic sand was found at 8,165' and a continuous porous sand section was drilled down to T.D. at 8,800' in probable Trias. No shows were observed in the whole well. Logs confirmed that the Jurassic and Triassic sands were water wet. The well was not tested.

The well was plugged and abandoned as a dry hole.

## II. WELL DATA

All details of Schlumberger logs, lithology and sidewall core descriptions are recorded on the composite log in the wallet at the back of this report.

## III. FORMATION TOPS

| | Below K.B. (Feet) | Sub-Sea (Feet) | Thickness (Feet) |
|---|---|---|---|
| K.B. elevation = +92' | | | |
| QUATERNARY | | | |
| Holocene & Pleistocene | 329(Seabed) | -237 | 651 |
| TERTIARY | | | |
| Miocene-Pliocene | 980 | -888 | 1040 |
| Oligocene | 2020 | -1928 | 1000 |
| Eocene(Upper & Middle) | 3020 | -2928 | 380 |
| Eocene (Lower) | 3400 | -3308 | 370 |
| Paleocene | 3770 | -3678 | 510 |
| CRETACEOUS | | | |
| Danian | 4280 | -4188 | 100 |
| Maestrichtian-Cenomanian | 4380 | -4288 | 2073 |
| Albian-Aptian | 6453 | -6361 | 107 |
| Barremian-Berriasian | 6560 | -6468 | 670 |
| JURASSIC | | | |
| Portlandian | 7230 | -7138 | 147 |
| Kimmeridgian | 7377 | -7285 | 620 |
| Oxfordian-Callovian | 7997 | -7905 | 168 |
| Bathonian-Bajocian | 8165 | -8073 | 405 |
| TRIASSIC | 8570 | -8478 | 230+ |
| Total Depth:- | 8800 | -8708 | |

## IV. HYDROCARBON INDICATIONS

In the Tertiary section gas readings averaged between 80-1500 ppm of Methane with erratic peaks, which attained 12,400 ppm at 2,700'.

In the top of the chalk readings averaged around 400-500 ppm declining to traces only in most of the lower part of the chalk section.

Through the lower part of the Mesozoic background gas varied from traces to only a few hundred ppm of methane.

No oil shows were found in the whole well. The top 160' of the Jurassic sand was uniformly clean with a calculated porosity from the sonic log of 25%. The lower part, and the Triassic section beneath, was shalier and had frequent shale interbeds. Calculations from log data showed a water saturation of 100%, a salinity of 250,000 ppm and an Rw of 0.018 ohms. at 163°F.

CONOCO / TEXACO / SOCAL / PELICAN 9/4-3

UPPER CRETACEOUS (CHALK)



SCHLUMBERGER

# RESISTIVITY VS POROSITY

$R_w = \frac{R_o}{F}$ When $\phi = 10\%$ $F = 100$ $P_b = 2.54$ gm/cc

$\therefore R_w = \frac{7.5}{100} = 0.075$ at 108°F

Salinity = 65,000 ppm NaCl

for $F = \frac{1}{\phi^2}$

RESISTIVITY SCALE MAY BE MULTIPLIED OR DIVIDED BY 10 FOR USE IN A DIFFERENT RANGE.

| Depth ft | Pb gm/cc | Cond mmhos |
|---|---|---|
| 4284 | 2.16 | 1350 |
| 4292 | 2.11 | 1550 |
| 4324 | 2.25 | 830 |
| 4349 | 2.27 | 690 |
| 4360 | 2.47 | 340 |
| 4425 | 2.28 | 960 |
| 4474 | 2.44 | 420 |
| 4489 | 2.26 | 980 |
| 4652 | 2.26 | 950 |
| 4550 | 2.38 | 480 |

CONDUCTIVITY

RESISTIVITY ÷ 10

← $R_o = 7.5\ \Omega$

Pb gm/cc

$\phi = 10\%$
$F = 100$
$P_b = 2.54$

$\Delta t, P_b$
$\phi$
F

SCHLUMBERGER

CONOCO/TEXACO/SOCAL/PELICAN 9/4-3

# RESISTIVITY VS POROSITY

MIDDLE JURASSIC SANDSTONE/TRIASSIC SANDSTONE

$R_w = \frac{R_o}{F} = \frac{0.37}{20} = \phi 0.018$ at 163°F

gives Salinity = 250,000 ppm NaCl.

for $F = \frac{0.62}{\phi 2.15}$

RESISTIVITY SCALE MAY BE MULTIPLIED BY 10 FOR USE IN A HIGHER RANGE.

JURASSIC

| Depth ft | $\rho_b$ gm/cc | Cond mmhos |
|---|---|---|
| 8180 | 2.20 | 5000 |
| 8186 | 2.16 | 5170 |
| 8200 | 2.31 | 2350 |
| 8206 | 2.17 | 5700 |
| 8224 | 2.18 | 5230 |
| 8256 | 2.33 | 2050 |
| 8286 | 2.20 | 5100 |
| 8310 | 2.22 | 4880 |
| 8334 | 2.17 | 4700 |
| 8360 | 2.30 | 2800 |

TRIASSIC

| Depth ft | $\rho_b$ gm/cc | Cond mmhos |
|---|---|---|
| 8409 | 2.33 | 5300 |
| 8457 | 2.31 | 2800 |
| 8493 | 2.29 | 2600 |
| 8528 | 2.30 | 3400 |
| 8585 | 2.28 | 2500 |
| 8668 | 2.29 | 2900 |
| 8684 | 2.41 | 1400 |
| 8716 | 2.40 | 1000 |

CONDUCTIVITY

5000 4000 3000 2500 2000 1500 1000 500 400 300 200 150 100 50 25 10

RESISTIVITY

.2 .25 .30 .35 .40 .45 .50 .60 .70 .80 .90 1.0 1.2 1.4 1.6 1.8 2.0 2.5 3.0 4.0 5.0 6.0 8.0 10 15 20 30 40 60 100 200

← Ro

2.65 2.60 2.55 2.50 2.45 2.40 2.35 2.30 2.25 2.20 2.15

$\rho_b$ gm/cc

2.32

$\phi = 20\%$

$F = 20$

$\Delta t, \rho_b$

$\phi$

F

PTO

## V. PALEONTOLOGICAL REPORTS

A. Tertiary - Top Chalk by Paleoservices Limited.

B. Base Chalk to T.D. by Neves and Downie.

Paleontological logs from these reports are contained in the wallet at the back of this report.

PALEOSERVICES LTD.
PALEONTOLOGICAL AND LITHOLOGICAL CONSULTANTS

PARAMOUNT INDUSTRIAL ESTATE,
SANDOWN RD., WATFORD WD2 4XA
TEL.: 25678 · CABLE: PALEOSERV.
DIRECTOR: DR. V. L. ROVEDA (IT.)

12th September, 1972.

CONOCO NORWAY LTD.

Well 9/4-3

Paleontological Final Report

This report presents the results of the stratigraphical and paleontological study of samples from well 9/4-3, drilled by Conoco Norway Ltd. in the Norwegian offshore.

The samples received were represented by cuttings samples, collected every 20 feet, from a depth of 2000 feet to 4500 feet, and by 28 sidewall cores, collected at depths of 1691 feet to 3580 feet.

A copy of the Biostratigraphic Log, scale 1:2000, is enclosed with this report. One progress report has previously been sent.

## CONCLUSIONS

1. The topmost samples received (1691', 1692'), are probably Miocene in age.

2. The well bottomed at 4500' in the Upper Cretaceous (Maestrichtian).

3. The thickness of the intervals drilled are summarised as follows:

| Interval | Age | Thickness |
|---|---|---|
| 1691'-c.1800' | Upper Miocene ? | 108' ? |
| c.1800'-c.2020' | Lower & Middle Miocene | c.220' |
| 2020'-2400' | Upper Oligocene | 380' |
| 2400'-3020' | Middle Oligocene | 620' |
| 3020'-3400' | Middle & Upper Eocene | 380' |
| 3400'-3600' | Lower Eocene | 200' |
| 3600'-4280' | Middle & Upper Paleocene | 680' |
| 4280'-4380' | Lower Paleocene (Danian) | 100' |
| 4380'-4500' | Upper Cretaceous (Maestrichtian) | 120' |

4. The sequence comprises a Maestrichtian-Danian carbonate interval (Chalk), conformably overlain by a Paleocene to Miocene marine argillaceous section with minor arenaceous intervals.

## STRATIGRAPHICAL DESCRIPTION - ZONATION

The following section presents a description of the stratigraphical units recognised in the section, detailing their lithology and faunas, and including a determination of their probable age, together with their environment of deposition.

1691'-c.1800' Upper Miocene ? Unzoned

Lithology: This interval is represented only by three sidewall cores, which are only smears of clay with limestone fragments.
Fauna: Sparse foraminifera, including Asterigerina sp., Ehrenbergina serrata and Spiroplectammina carinata.
Environment: Marine.
Age: Uncertain; all fossils may be contaminants. A possible Middle-Upper Miocene age is suggested.

c.1800'-c.2020' Lower & Middle Miocene. Asterigerina staeschei interval

Lithology: The main part of this interval (1800' to 2000') is represented only by one sidewall core (at 1801'). This is a very micaceous highly glauconitic clayey silt. Samples from 2000' to 2020' are clayey micaceous silts with limestone bands.
Fauna: None at 1801'. From 2000' to 2020' foraminifera are common, chiefly Asterigerina staeschei and A. gurichi, with Uvigerina hosiusi and U. tenuipustulata, Hoeglundina elegans and Cibicides spp.
Environment: Moderately deep marine, well-oxygenated. The glauconitic silt at 1801' suggests very slow deposition in a fairly deep environment.
Age: The glauconitic level at 1801' is most probably correlative of the 'Glauconite Clay' of Jylland (Denmark), which forms the top of the Middle Miocene and can be recognised in other North Sea wells. The interval below contains Middle Miocene index-fossils, but Lower Miocene cannot be separated off due to the lack of samples and probable caving.

c.2020'-2400' Upper Oligocene. Asterigerina guerichi interval

Lithology: Micaceous clayey silt with layers of argillaceous limestone.
Fauna: An abundant and diverse foraminiferal fauna is present, including Asterigerina guerichi, Nonion affine, Spiroplectammina carinata, Sphaeroidina bulloides, Sigmomorphina regularis, Pararotalia fallax and Gyroidina soldanii. Diatoms (Coscinodiscus spp.) are common at some levels.
Environment: Fairly deep marine, well-oxygenated.
Age: The top of this interval is marked by the introduction of several Oligocene markers, and by the great increase in abundance of Asterigerina guerichi, which typifies the Upper Oligocene.

2400'-2620' Middle Oligocene. Rotaliatina bulimoides & Cassidulina carapitana interval

Lithology: Micaceous clayey silts, becoming very glauconitic below 2500'.
Fauna: An abundant fauna of calcareous benthonic foraminifera is present, including Rotaliatina bulimoides, Cassidulina carapitana, Cibicides dutemplei, Ammobaculites humboldti, Hoeglundina elegans and Alabamina tangentialis.
Environment: Fairly deep marine, well-oxygenated. The high glauconite content again suggests slow or interrupted deposition.
Age: This interval yields a well-characterised Middle Oligocene (Rupelian) fauna, very similar to faunas of the same age in North Germany and Belgium.

2620'-2780' Middle Oligocene. Unzoned

Lithology: Fine silty sand (begins above 2600' in the sidewall cores) passing down into micaceous silts.
Fauna: Almost no 'in situ' microfauna is present.
Environment: Probably fairly shallow marine.
Age: Middle Oligocene, by consideration of the intervals above and beneath.

2780'-3020' Middle Oligocene. Interval with rare fossils

Lithology: Micaceous silt and clayey silt.
Fauna: Foraminifera are not common; they include Hoeglundina elegans, Rotaliatina bulimoides, Pullenia bulloides, Ceratobulimina contraria and Gyroidina soldanii.
Environment: Fairly deep marine.
Age: Middle Oligocene markers are still frequent in this interval.

3020'-3180' Upper Eocene. Uvigerina eocaena, Marginulina decorata & Globigerapsis index interval

Lithology: Pale brown mudstone, with abundant phosphatic 'coprolitic' pellets.
Fauna: Abundant foraminifera are present, mainly calcareous benthonic types, including Uvigerina eocaena, Marginulina decorata, Pullenia spp., Arenobulimina ? sp., Lenticulina multiguttata. Planktonic forms are represented by Globigerina spp. and scarce Globigerapsis index. Scattered agglutinated foraminifera include Rhabdammina sp. and Glomospira charoides.
Environment: Fairly deep marine, well-oxygenated, with open-sea connections.
Age: The planktonics indicate an Upper Eocene age, and this is supported by the benthonic fauna, which includes forms familiar in the Upper Eocene elsewhere in the North Sea.

3180'-3260' Middle/Upper Eocene. Bulimina truncana and Planulina cocoaensis interval

Lithology: Pale brown mudstone with abundant 'coprolitic' pellets.
Fauna: Scarcer benthonic foraminifera, including Bulimina truncana, Planulina cocoaensis and Spiroplectammina carinata. Planktonics are almost absent.
Environment: Fairly deep marine, well-oxygenated.
Age: The microfauna still indicates a Middle/Upper Eocene age.

3260'-3400' Middle Eocene. Pseudohastigerina wilcoxensis interval

Lithology: Grey-green clays, very glauconitic in places.
Fauna: Common foraminifera, including Pseudohastigerina wilcoxensis, Uvigerina farinosa, Cibicides spp.
Environment: Fairly deep marine, with periods of non-sedimentation.
Age: The presence of Pseudohastigerina wilcoxensis indicates a Lower or Middle Eocene age. In view of the dating of the underlying intervals, a Middle Eocene age is considered most likely.

3400'-3560' Lower Eocene. Radiolaria interval

Lithology: Grey-green clays.
Fauna: Spherical radiolaria (Cenosphaera) are very abundant, together with a few arenaceous foraminifera and sponge spicules.
Environment: Fairly deep marine, probably poorly oxygenated sea-bed, but with a rich planktonic fauna.
Age: This interval is correlated with the 'Lower Eocene 4' interval of North Germany, which has an identical fauna and lithofacies.

3560'-3600' Lower Eocene. Bulimina buchiana calebra & Globigerina triangularis interval

Lithology: Grey and red clays.
Fauna: A diverse fauna of benthonic and planktonic calcareous foraminifera is present, including Anomalina grosserugosa, Turrilina brevispira, Bulimina buchiana calebra, Marginulina decorata, Globigerina triangularis.
Environment: Fairly deep marine, well-oxygenated, with open sea connections.
Age: This interval is correlable with the 'Lower Eocene 3' of Germany; the planktonics confirm its Lower Eocene age.

3600'-3700' Upper Paleocene. Coscinodiscus interval

Lithology: Grey tuffaceous mudstones, with a band of brown dolomitic limestone at the top.
Fauna: Few foraminifera are present, but pyritised diatoms (Coscinodiscus sp.) are abundant.
Environment: Probably fairly deep marine, with a poorly oxygenated sea-bed but a rich planktonic fauna. Nearby vulcanicity is indicated by the tuffaceous material in the sediments.
Age: This interval with tuff and pyritised diatoms is conventionally dated as Upper Paleocene in the North Sea, and this dating is retained here. However, it is now evident that it corresponds to the Mo clay series of Denmark, of Lower Eocene age.

3700'-3940' Middle/Upper Paleocene. Arenaceous foraminifera & Bulimina trigonalis interval

Lithology: Grey mudstones with two thin levels of very fine glauconitic sandstone. A glauconite-rich level at the base.
Fauna: Abundant arenaceous foraminifera in the upper part, including Bathysiphon sp., Ammodiscus glabratus, Cyclammina sp., 'Plectina' sp., and lower down, sparse calcareous forms including Bulimina trigonalis and Nonion sp.
Environment: Fairly deep marine, mostly poorly oxygenated.
Age: The faunas present are typical of the upper part of the Paleocene in the North Sea.

3040'-4100' Middle/Upper Paleocene. Discorynopsis parvula & Bulimina midwayensis interval

Lithology: Grey mudstones.
Fauna: Abundant calcareous benthonic foraminifera, including Discorynopsis parvula, Cibicides spp., Bulimina midwayensis.
Environment: Fairly deep, well-oxygenated.
Age: The fauna is typical of parts of the Middle/Upper Paleocene of the North Sea.

4100'-4280' Middle/Upper Paleocene. Allomorphina trigona, Osangularia lens & Globigerina triloculinoides interval

Lithology: Grey mudstones passing down into grey marls.
Fauna: A rich and diverse fauna of foraminifera is present, including Allomorphina trigona, Osangularia lens, Pullenia sp., Gavelinella sp., Arenobulimina sp., Globigerina triloculinoides. Ostracods are also present.
Environment: Fairly deep marine, well-oxygenated, with open sea connections.
Age: This fauna, and the planktonics in particular, are characteristic of the Middle Paleocene of the North Sea.

4280'-4380' Lower Paleocene (Danian). Globigerina pseudobulloides interval

Lithology: White chalk.
Fauna: Abundant bryozoa and echinoderm debris. Globigerina triloculinoides and G. pseudobulloides are common, with Ammodiscus and Bathysiphon sp.
Environment: Fairly deep marine, well-oxygenated, with no clastic deposition but in a carbonate environment.
Age: The planktonic foraminifera indicate a Danian age.

4380'-4500' Upper Cretaceous (Maestrichtian). Unzoned

Lithology: White chalk.
Fauna: Rather sparse foraminifera including Stensioina pommerana, Pseudotextularia elegans, Praebulimina sp. and Globotruncana contusa.
Environment: As indicated for the Danian.
Age: The fauna indicates an Upper Maestrichtian age.

GEOLOGICAL HISTORY

During Upper Maestrichtian and Danian times chalk deposition took place; there is no evidence of any unconformity at the Cretaceous/Tertiary boundary.

At the end of Danian times chalk sedimentation ceased, and clastic sedimentation began, at first still in a rather calcareous facies, and in a fairly deep marine environment. Mudstone deposition continued throughout the Paleocene, with slight sand intercalations, until at the end of Paleocene times a volcanic episode deposited tuffs in the area.

Throughout Eocene times argillaceous sedimentation persisted in a similar environment, with generally slow deposition (evidenced by the condensed nature of the succession) and at times non-deposition.

Although no Lower Oligocene sediments have been recognised, there is little evidence of a major break in sedimentation at this time. Middle Oligocene sediments are again argillaceous, though somewhat coarser-grained, and were deposited still in a relatively deep environment. Slight shallowing may be indicated by a sandy episode in Middle Oligocene times. This is followed by renewed argillaceous deposition, at first slow and interrupted, and similar sedimentation persisted into Miocene times.

The general picture in the Tertiary is of a fairly deep sea receiving little sediment in the Paleocene and Eocene, but rather more in the Oligocene and Miocene, and usually well-oxygenated.

V.L. Roveda

C. King

# Norwegian Off-shore Well 9/4-3

## Palynology of the Lower Cretaceous and Jurassic

by

C. Downie and R. Neves

Sheffield,
September, 1972.

## 1. Summary

The following stratigraphic units have been recognised on the basis of their palynological content:

| | | |
|---|---|---|
| TURONIAN-CENOMANIAN | White, chalky limestone: Marine. | 6000-6320 feet |
| APTIAN-ALBIAN | Grey marlstone and clays: Marine. | 6480 feet |
| BARREMIAN-BERRIASIAN | Alternating dark and light grey clay and shale: Marine, open sea. | 6560-7230 feet |
| PORTLANDIAN | Dark grey shale: Marine, open sea. | 7230-7380 feet |
| KIMMERIDGIAN | Dark grey/black carbonaceous and bituminous shales: Marine, open but restricted circulation. | 7380-7995 feet |
| OXFORDIAN-CALLOVIAN | Grey shales and mudstones: Marine, inshore. | 7995-8090 feet |
| BATHONIAN-BAJOCIAN | White and brown sandstones, siltstones, thin coals, shales, rootlet beds: Deltaic. | 8090-8570 feet |
| AGE NOT DETERMINED | Grey, green and brown sandstones and siltstones. | 8580-8790 feet |


## 2. Nature of Samples

Cuttings samples were available at approximately 30 foot intervals from 6000 feet to terminal depth (8800 feet). In addition some 36 sidewall cores had been obtained, mainly located below 8000 feet. 46 horizons were examined - 20 sidewall cores and 26 cuttings levels - and are indicated on Figure 1.

The quality of the cuttings down to approximately 8000 feet was generally good with caving at a minimum. The consistent Kimmeridge caving below this depth was partially compensated by the availability of a good selection of sidewall cores.

Lithologies encountered in this section are fairly clearly defined with Cenomanian chalk, overlying (6480 feet) Albian/Aptian grey marl, passing down into grey Lower Cretaceous shales (6510-7230 feet) which in turn gives way to increasingly carbonaceous and finally bituminous shales of the Portlandian/Kimmeridgian interval (7230-7995 feet). The lower Kimmeridge bituminous shales are particularly evident (and palynologically distinct) between 7880 and 7980 feet. A short interval(7995-8090 feet) of grey Oxfordian/Callovian shales overly substantial sequence of middle Jurassic rocks comprising white and brown, micaceous sandstones with thin coals and rootlet beds which can be traced down with certainty to the sidewall core at 8550 feet. Below this level, sidewall cores demonstrate the presence of a wide variety of sandstones which contain no palynological taxa.

3. Palynological Assemblages

Marine microplankton is both diversified and abundant in the section between 6000 and 8000 feet, providing a fairly complete record from Cenomanian to (Oxfordian) Kimmeridgian. The general Lower Cretaceous depositional environment is considered open marine with only small amounts of land derived palynological taxa. A progressive increase in the latter assemblage component characterises the Portlandian to Oxfordian section and this is also associated with a lithological change involving an increase in general carbonaceous and bituminous detritus.

The underlying Bathonian/Bajocian assemblages are dominated by spores and pollen which are clearly associated with deltaic environment indicated by the sandstone, coal rootlet bed sequence. Bathonian marine phases clearly terminated the deltaic conditions and are indicated by the Bathonian/Lower Callovian microplankton recovered from 8100-8127 feet.

No indigenous palynomorphs were obtained from below 8551 feet where the sidewall cores were essentially arenaceous and cuttings yielded caved taxa only.

The recorded ranges of individual taxa are shown on Figure 1, which also summarises age and environment conclusions. The following section is intended to provide comments on critical taxa and general composition characteristics of the assemblages, both of which are used in age/environment conclusions.

Interval: 6000 to 6450 feet

Horizons Sampled: 6000, 6320

Lithology: White/grey, soft limestone

Assemblages:

Restricted microplankton obtained from both horizons indicates some caving from the overlying Tertiary. The presence of Cyclonephelium eisenacki in some abundance in the upper sample and Apteodinium granulatum and Heliodinium voigti in the lower, are considered against the background assemblage as indicative of Turonian and Cenomanian respectively.

Pollen and spores were virtually absent from the upper horizon, and constituted only a minor part of the lower assemblage. Of particular interest are the species of Appendicisporites and Trilobosporites.

Age: Turonian-Cenomanian

Environment: Marine, chalk sea.

Interval: 6450-6510 feet

Horizons: 6480

Lithology: Pale grey/green marl

Assemblage:

Dominantly a marine assemblage with disaccate pollen recorded rarely. The microplankton is rich and the presence of Gonyaulacysta edwardsi, Thalisophora sp., Gonyaulacysta cassidata and Astrocysta cretacea in particular indicate an Aptian/Albian age with some emphasis on the latter.

Age: Aptian/Albian

Environment: Marine, open sea.

Interval: 6560–7230 feet

Horizons: 6560, 6660, 6720, 6840, 6930, 7110, 7170.

Lithology: Dark and light grey, shale/clay alternations.

Assemblages:

Assemblages taken at approximately 100 foot intervals are rich in microplankton species which indicate a fairly complete lower Cretaceous succession from Berriasian to Barremian. The following species are considered of particular value:

Dingodinium cerviculum (Haut-Apt)

Broomea longicornuta (Haut-Barr)

Gonyaulacysta cretacea (Haut)

Dingodinium alberti (Barr)

Apteodinium ciliatum (Haut)

Pseudoceratium gochti (Haut-Barr)

Heliodinium patricae (Valang-Haut)

Tenua hystrix (Neocomian)

Significant flucturations in abundance are apparent and enable closer determination of age where a pattern is recognised.

Spores are rare throughout the interval and disaccate pollen, whilst consistently present, is never common.

Age: Lower Cretaceous; the following stage 'tops' are suggested Barremian (6510), Hauterivian (6680), Valanginian (6800) and Berriasian (7000).

Environment: Marine, open sea.

Interval: 7230-7380 feet.

Horizons: 7260, 7370, 7376 (SWC).

Lithology: Dark grey shale, some bituminous layers.

Assemblages:

Microplankton continues to dominate the assemblages and certain species such as: Imbatodinium villosum, I. krondratjevi, Tenua eminula, Epiplosphaera varicosa, Gonyaulacysta scolea, G. sarjeanti are considered to be characteristic of uppermost Jurassic age.

Terrestrially derived elements are more frequent than in the lower Cretaceous section and particularly disaccate pollen is often a major element. The sporadic occurrence of the spore element confirms a generally marine sequence.

Age: Portlandian.

Environment: Marine, some current influence.

Interval: 7380-7980 feet.

Horizons: 7470, 7510 (SWC), 7680, 7702 (SWC), 7830, 7866 (SWC), 7950, 7980.

Lithology: Dark grey, black shale; highly bituminous, particularly towards base.

Assemblage:

The palynological assemblages continue to be dominated by a large microplankton component which is diversified and strongly diagnostic of the age. Disaccate pollen is common generally and at certain horizons i.e. 7980 feet assumes an equal dominance with the microplankton. The spore element of the assemblages is minor although those species recorded are compatible with the microplankton dating.

Some of the diagnostic hystrichosphere/dinoflagellate taxa are: Ascodinium neophytense, Taeniophora sp. A (Stavrinos), Tapeinosphaeridium pericompsum, Gonyaulacysta cladophora, G. Sp. B (Gitmez), Cyclonephelium downei, Scriniodinium luridum, Pareodinia ceratophora, Heliodinium angelicum, Leptodinium antigonium, Cleistosphaeridium polyacanthum.

The individual ranges and fluctuations in overall abundance permit a clear subdivision of this interval into lower and upper units.

Age: Upper to Lower Kimmeridgian.

Environment: Marine; with increasing amounts of terrestrially derived organic matter and poor current circulation.

Interval: 7995-8090 feet.

Horizons: 8037 (SWC), 8040.

Lithology: Grey shales and mudstones.

Assemblage:

The presence of microplankton throughout the interval is indicative of overall marine conditions. However, the spore/pollen content is high and sub-dominant.

Stratigraphically useful taxa are: Gonyaulacysta jurassica, Scriniodinium cristallinum, Valensiella ovulum, Ctenidodinium ornatum and Pterospermopsis harti.

Age: Lower Oxfordian/Callovian.

Environment: Marine; inshore, high land influence.

Interval: 8100-8570 feet.

Horizons: 8100, 8127, 8160 (SWC), 8190, 8230 (SWC), 8364 (SWC), 8370 (SWC), 8373 (SWC), 8385, 8390 (SWC), 8393 (SWC), 8400, 8402 (SWC), 8430, 8460, 8551 (SWC).

Lithology: Brown and white sandstones, siltstones; grey and dark shales; coals.

Assemblage:

With the exception of the assemblages from 8100 and 8370 feet, no indigenous microplankton was recorded in this interval. The taxa present at these two horizons are indicative of a middle Jurassic age and include: Valensiella vermiculata, Leptodinium subtile pectinigerum, Valensiella ovulum, Pareodinia ceratophora and Valensiella ampulla.

The microflora is both abundant and diagnostic with such elements as: Perinotriletes rugulatus, Inaperturopollenites dettmani, Matonisporites phlebopteroides, Lygodioisporites perverrucatus, Dictyophyllum rugosum, Staplinisporites sp. A (Brora), Osmundacidites wellmanni, Klukisporites variegatus and Corrugatosporites anagramminensis.

Certain other elements are typically abundant and characterise the depositional setting, i.e. Cerebropollenites mesozoicus, Araucariacites australis, Cyathidites spp., Callialasporites spp. and disaccate pollen.

Age: Bathonian to Bajocian.

Environment: Deltaic; regressive marine phase in the upper part.

Interval: 8580-8756 feet.

Horizons: 8580, 8602 (SWC), 8667 (SWC), 8716 (SWC), 8735 (SWC), 8756 (SWC), 8760, 8790.

Lithology: Grey, green and brown sandstones and siltstones.

Assemblage:

The five sidewall core samples were brown and green sandstones with silty micaceous partings - palynologically unfavourable lithologies, but prepared in view of their borehole occurrence.

Thin sections demonstrated the presence of large amounts of chlorite (particularly 8602 feet) otherwise the sandstones were sub-angular, micaceous, waterlaid type.

Palynologically barren.

Three cuttings samples were prepared to check overall lithology in the section and these yielded abundant microfloras none of which were older than Middle Jurassic, i.e. Bajocian. The presence of younger plankton in the assemblages raises the possibility of a totally caved assemblage, particularly in view of the barren nature of the associated sidewall cores. Consequently the age of this lower interval is not determined.

Age: Indeterminate.

Environment: Waterlaid sandstones; contemporaneous erosion of igneous/metamorphic suite.

## 4. Stratigraphical Conclusions

The principal conclusions regarding the age of the section between 6000 feet and terminal depth, together with observations on depositional environment based on lithological variation and the palynological content, are shown in Figure 1.

Several observations are considered worthy of note:

i. The Aptian-Albian section immediately below the Cenomanian chalk phase, is markedly brief and difficult to sub-divide into the two component stages.

ii. A complete sequence of Lower Cretaceous stages is present between 6560 and 7230 feet. Elements indicating Barremian, Hauteivian, Valanginian and Berriasian have been recognised in a succession which compares closely with those present in 9/11-1 and 8/12-1.

iii. The Cretaceous/Jurassic boundary is considered conformable and is placed near 7260 feet. A recognisable Portlandian association being recorded between 7260 and 7470 feet.

iv. The Kimmeridge section also appears complete and represented entirely by an argillaceous succession. No sandy facies of Lower Kimmeridgian/ Upper Oxfordian has been detected. A non-sequence may occur at this level.

v. The presence of Lower Oxfordian/Callovian clays between 8000 and 8090 feet is probably a time sediment zone not recorded in 9/11-1,8/12-1 or 7/9-1.

vi. The Bathonian-Bajocian sandstone/shale sequence between 8100 and 8551 feet is comparable with adjacent wells in the area although clearly thicker in the current section. Marine shale interleaves, in an essentially deltaic sequence, are probably present.