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STATOIL WELL 6407/1-2
BIOSTRATIGRAPHY
KEROGEN ANALYSIS

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ENCLOSURE 1	Stratigraphical summary log		
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2B	" " "	2120 - 2895m	
2C	" " "	2940 - 3560m	
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SUCCESSION

<u>Top of intervals</u>	<u>Age</u>	<u>Thickness</u>
410m (top not seen)	Pleistocene, early	180m+
590m	Pliocene	840m
1430m	Pliocene - Miocene transition	150m
1580m	Miocene, late	150m
- - - - -	?Unconformity - - - - -	- - - - -
1730m	(Barren)	70m
- - - - -	Unconformity - - - - -	- - - - -
1800m	Oligocene, early-middle	80m
1880m	Eocene, middle-late	280m
2160m	Eocene, early	30m
2190m	Late Paleocene - early Eocene	30m
2220m	Paleocene, middle	10m
2230m	Paleocene, early-middle	50m
2280m	Paleocene, early	40m
- - - - -	?Unconformity - - - - -	- - - - -
2320m	Maastrichtian	27.5m
- - - - -	Unconformity - - - - -	- - - - -
2347.5m	Campanian, early	112.5m
2460m	Campanian, early - ?Santon	190m
- - - - -	?Unconformity - - - - -	- - - - -

continued

<u>Top of intervals</u>	<u>Age</u>	<u>Thickness</u>
2650m	?Cenomanian	430m
3080m	Late Albian - early Cenomanian	80m
3160m	Albian	300m
3460m	Aptian	68.5m
- - - - -	Unconformity	- - - - -
3528.5m	Ryazanian	9.5m
- - - - -	Unconformity	- - - - -
3538m	Oxfordian	123m
- - - - -	?Unconformity	- - - - -
3661m	?Bathonian	99m
3760m	Bathonian, earliest	45m
- - - - -	Unconformity	- - - - -
3805m	Aalenian - ?Bajocian	15m
3820m	Late Toarcian - Aalenian	215m
4035m	Late Pliensbachian - early Toarcian	105m
4140m	Late Pliensbachian	40m
4180m	?Pliensbachian	40m
- - - - -	?Unconformity	- - - - -
4220m (approx.)	Hettangian - ?early Sinemurian	160m
4380m	Hettangian	110m
4490m	Hettangian, early	57m
- - - - -	?Unconformity	- - - - -
4547m	Rhaetian	13m+
4560m TD		

The stratigraphical breakdown is based on uncorrected depths.
Electric logs were not made available for this study.

SUMMARY

1. This report is based on micropaleontological study of 117 ditch cuttings samples from the interval 410m to 3560m, and palynological and kerogen analysis of 241 ditch cuttings samples, sidewall cores and conventional cores from the interval 1855m to 4560m TD.

A brief lithological examination was carried out on all samples studied to support biostratigraphical interpretations.

2. Analysis commenced in sediments of early Pleistocene age at 410m consisting of sandy and silty clay deposited in an open marine shelf environment.
3. Pliocene sediments are present from 590m. A thick sequence of clay, silt and sand deposited in an open marine shelf environment represents the Pliocene sequence.
4. A transitional Pliocene-Miocene interval is identified between 1430m and 1580m. Grey mudstone and siltstone were deposited in an open marine shelf environment.
5. Late Miocene mudstone with some silt- and v.f. sandstone is present at 1580m. An open marine environment also prevailed during deposition of this interval.
6. The interval 1730m to 1800m was barren of microfossils, probably due to poor samples obtained around casing point (1789m). An unconformity separates the intervals below and above this barren interval. The exact position of this unconformity could not be located due to lack of fossil evidence.

7. At 1800m an early to middle Oligocene sequence was penetrated. Mudstone with subordinate silt and sandstone was deposited in an open marine shelf environment. Kerogen analysis shows a low to moderate terrestrial input in a low energy distal environment.
8. A middle to late Eocene sequence is present between 1880m and 2160m. Dark claystone and greenish mud were deposited in a shallow open marine shelf environment. Input of terrestrial plant debris was moderate. Dominance of agglutinated foraminiferal fauna indicates environmental stress or secondary dissolution of foraminiferal tests.
9. Red claystone of early Eocene age appears at 2160m. A low energy open shelf environment with low to moderate terrestrial input is suggested for this interval.
10. The sequence between 2190m and 2220m is given a late Paleocene - early Eocene age. Siltstone with subordinate sandstone and greenish mudstone was deposited within this interval. A slight regressive development is recorded up through this unit. Environment remained open marine.
11. A well defined middle Paleocene horizon was identified at 2220m. An open marine shelf environment was established at this horizon.
12. Sediments of early to middle Paleocene age are present between 2230m and 2320m. Dark silty mudstone and subordinate siltstone deposited in an open marine environment with high input of terrestrial plant debris is found within this interval.
13. An unconformity probably separates the early Paleocene from the underlying Maastrichtian at 2320. Deposition of dark mudstone and red claystone took place in an open marine shelf environment.

14. Another unconformity separates the Maastrichtian from the early Campanian below at 2347.5m. Grey shale and laminated claystone/silt-sandstone is present between 2347.5m and 2650m. An open marginal marine environment with low to medium input of terrestrially derived plant debris was established.

The age of the lower part of the interval is poorly defined and it may extend down into the Santonian

15. The sequence between 2650m and 3080m is also poorly defined. A Cenomanian age is suggested for this interval. Marine conditions prevailed throughout the interval with deposition of silty claystone and subordinate sandstone. Input of terrestrial plant debris was moderate.
16. Albian to early Cenomanian sediments were recorded between 3080m and 3460m. Claystone, siltstone and minor sandstone was deposited in an open marine environment.
17. Between 3460m and 3528.5m an Aptian sequence consisting of black shale, siltstone and red claystone was identified. Marine conditions also prevailed during deposition of this sequence.
18. The sidewall core at 3528.5m produced a diagnostic Ryazanian palynomorph assemblage. Unconformities are present above and below this thin interval. Siltstone and claystone were deposited in a marginal marine environment. A kerogen assemblage typical for the late Jurassic (-earliest Cretaceous) 'hot shales' was recorded.

19. An Oxfordian age is given for the sediments at 3538m. Definitely early Oxfordian sediments are present between 3580m and 3661m. The characteristic 'hot shale' facies disappears around 3560m and is replaced by a normal marginal marine assemblage. Shale dominates in the upper part of the interval while silty shale and minor v.f.sandstone are characteristic in the lower part.
20. Samples from the cored interval between 3661m and 3719m did not produce age diagnostic assemblages. The sandstones are however, regarded as a regressive continuation of the Bathonian sedimentary cycle. A hiatus is consequently inferred between the top of the sandstones at 3661m and the top core sample at 3660.5m of early Oxfordian age.
21. Early Bathonian sediments are present between 3760m and 3805m. A marginal marine environment with high terrestrial input was established.
22. Abrupt change in organic facies and appearance of stratigraphically diagnostic assemblages at 3805m suggest an unconformity at this depth. Bituminous shales of Aalenian-?Bajocian age deposited in a restricted marine or brackish low energy environment are present between 3805m and 3820m.
23. The appearance of sandstones defines the top of the interval 3820m to 4035m. This sandstone marks the termination of a Late Toarcian-Aalenian regressive development. Marginal marine environment with high terrestrial input and deposition of silty shales are suggested for the middle and lower part of the interval.

24. Late Pliensbachian - early Toarcian sediments are present between 4035m and 4140m. Silty shale and v.f.sandstone were deposited in a marginal marine environment. Input of terrestrial plant debris was low in the lower part increasing considerably upwards.
25. The sequence between 4140m and 4180m is given a late Pliensbachian age. Grey siltstone is probably the "in situ" sediment deposited in a restricted marginal marine environment.
26. The interval 4180m to 4220m is defined on lithological evidence. Sandstone dominates over this interval and fossil evidence is poor. A tentative Pliensbachian age is suggested. This sandstone may have been deposited during a transgressive episode at the beginning of the Pliensbachian-Toarcian sedimentary cycle. A marginal marine high energy environment is suggested for this interval.
27. A Hettangian - ?early Sinemurian continental sequence is present down to 4547m. Cyclic sedimentation of bituminous shale, coal, siltstones and sandstones took place in a top delta or coastal plain environment. Bituminous shale and coal are most abundant between 4380m and 4490m. Increased deposition of sandstones is noted towards the top of the sequence. The upper boundary of the unit is poorly defined due to low fossil productivity.
28. The well terminated in sediments of Late Triassic, Rhaetian age between 4547m and 4560m (TD). The evidence regarding facies is poor but a non-marine depositional environment is also suggested for these sediments. An unconformity probably separates the Rhaetian and Hettangian sequences.

INTRODUCTION

This report summarizes the palynological and micro-paleontological results from Well 6407/1-2 (400 - 4560m TD).

117 ditch cuttings samples were studied for micropaleontology covering the interval 410m to 3560m. The micropaleontological study was carried out by Kaare Ulleberg and Karen Luise Knudsen. Their results were presented to us in a preliminary report based on coded samples. TB is responsible for final interpretations.

241 ditch cuttings samples, sidewall cores and conventional cores were studied for palynology and kerogen analysis from the interval 1855m to 4560m TD.

A summary of the results is given in Enclosure 1. Stratigraphical distribution of foraminifera is shown in Enclosures 2A, B and C, and for palynomorphs in Enclosure 3. The results of kerogen analysis are shown in Enclosures 4 and 5.

Uncorrected depths are used for all samples.

No log information was available for the present study.

A brief lithological description was carried out on all samples below 800m to support biostratigraphical and depositional interpretations.

Results previously given from 'hot shot' analysis are incorporated in the present report.

We would like to thank STATOIL geologists at the Bergen office and at the biostratigraphical division at Forus, Stavanger, for their continued cooperation. We would also point out that the samples were received regularly during drilling period. This facilitated our possibility to follow up the biostratigraphical study.

REMARKS ON PALYNOLOGY

Palynological analysis started with two SWCs at 1855m and 1975m. Continuous examination started at 2120m.

Sample quality and palynomorph productivity showed strong variations through the sequence.

The early Tertiary sequence produced stratigraphically significant assemblages and so did the upper part of the Cretaceous sequence. The thick late to late lower Cretaceous sequence however, is poor and the stratigraphical breakdown is very broadly defined. This may reflect high sedimentation rates during limited periods of time, or may be the effect of unfavourable facies. In addition palynological examination was made difficult due to extremely large amounts of added lignite and possible smashing of poorly consolidated sediments within the Cretaceous sequence. Caving and mud contamination affect both ditch cuttings samples and sidewall cores. Especially early Tertiary and late Cretaceous material are recorded throughout the Mesozoic sequence. When organic content is low in "in situ" sediment, masking by caved material or mud contaminants is common.

REMARKS ON MICROPALAEONTOLOGY

Samples of 50g og 75g dry weight were treated by standard laboratory methods. They were disintegrated with kerosene, washed and sieved. Foraminifera in the size fraction 0.125 to 0.5mm from each sample were consentrated by floatation (mixture of C_2H_5OH and $C_2H_4Br_2$, sp.gr. 1.8).

Foraminiferal faunas from the light fractions of 0.125 - 0.5mm were examined from all samples. In addition, the heavy fractions of 0.125 - 0.5mm and 0.5 - 1mm were examined.

In the samples from 1700m to 3395m depth all foraminifera were systematically picked from both light and heavy fractions (0.125 - 0.5mm and 0.5 - 1.0mm).

In rich faunas only a part of the specimens has been picked (usually between 300 and 400 specimens), and the total faunas were extrapolated.

Results of the foraminiferal analyses are shown in three range charts, Enclosure 2A, B and C. The presence of other microfossils (radiolarians, diatoms and ostracods) are also indicated. A biostratigraphical zonation was established on the basis of foraminiferal faunas for the Tertiary.

Due to low productivity and poor stratigraphical information from the Cretaceous and late Jurassic sequence, it was decided not to examine additional samples from this interval.

In the range charts the frequencies of selected taxa of foraminifera are illustrated. Some species have been referred to groups in the diagrams, either because their stratigraphical importance is low, or because the species have been difficult to separate in the present material.

The Elphidium spp. group contains the following species:

Elphidium albiumbilicatum

Elphidium hallandense

Elphidium magellanicum

Elphidium gerthi

Elphidium macellum

Elphidium incertum

Elphidium asklundi

Elphidium bartletti

Elphidium sp. (small indeterminate specimens)

The Buccella frigida group contains the following species:

Buccella frigida

Buccella tenerrima

Buccella hannai arctica

The Cibicides lobatulus group contains the following species:

Cibicides lobatulus

Cibicides refulgens

Cibicides scaldisiensis

Nonion affine and N. barleeaanum are not separated in the present material. Down through the well we find transitional forms between typical N. affine, which is common in deeper parts of its range and the typical N. barleeaanum, which mainly occurs in the younger faunas.

Angulogerina angulosa and A. fluens are grouped together in the diagrams. A. angulosa is the dominant of these two species in the upper part, while A. fluens takes over in the deeper part of their range.

The Globigerina bulloides group contains the following species:

Globigerina bulloides

Globigerina auachitaensis subsp.

Globigerina officinalis subsp.

(the subspecies of G. praebulloides are referred to the G. praebulloides group.)

The Angulogerina gracilis group:

Angulogerina gracilis is the most common species within this group, but smooth and hispid forms are also included in the group.

The Cibicides dutemplei group contains all the biconvex Cibicides forms with affinity to C. dutemplei.

The taxonomy of the agglutinated specimens is made with a "broad brush". Due to the state of preservation and a relatively small number of specimens, many of the species present must be regarded as group-taxa. In our opinion, this does not influence the biostratigraphy seriously in this particular well. However, regional studies of the agglutinated species may possibly result in a more detailed subzonation of the agglutinated faunas.

Particular taxa-groups of the present agglutinated faunas are:

Recurvoides group: Consists of streptospiral tests, where the whorling is very difficult to distinguish. Species of Recurvoides and Thalmanammina are referred to this group.

Bathysiphon-like fragments: This group contains fragments mainly belonging to Bathysiphon spp., but also some Hyperammina are allocated here.

Trochammina globigeriniformis group: This group contains a smaller number of trochospiral tests with 3 to 5 more or less globular chambers in the final whorl.

Cystammina pauciloculata: Specimens of Praecystammina globigerinaeformis may also have been referred to this species.

The separation of Cyclammina from some specimens of Haplophragmoides has been difficult, because distinct Cyclammina - characters are not seen in all specimens of that genus. But constancy in outline, agglutination and number of visible chambers have made such a separation possible.

REMARKS ON KEROGEN ANALYSIS

Kerogen analysis was carried out on strew mounts of residue remaining after HF/HCl treatment, floatation ($ZnBr_2$, sp.gr. 2.2) and screening (20 micron net).

The kerogen components were referred to the following eight categories:

finely dispersed debris, terrestrial palynomorphs, marine palynomorphs, wood fragments, inertinite, membraneous material (mainly cuticle fragments), degraded fragments and aggregates (clusters of heterogeneous composition).

The amount of each category was estimated semiquantitatively as absent, rare, common, abundant, dominating or totally dominating.

The amount of finely dispersed debris was estimated from unsieved residues relatively to all other components. The relative amount of the remaining kerogen categories were obtained from sieved residues.

The results of the kerogen analysis are shown in Enclosures 4 and 5 for ditch cutting samples (DCS) and sidewall cores (SWC) respectively.

B I O S T R A T I G R A P H YQUATERNARY

Interval 410 - 590m

Age: Pleistocene, early

Micropaleontology

Elphidium excavatum - Cassidulina teretis Zone

This zone is characterized by high frequencies of Elphidium excavatum and other species of this genus in association with Cassidulina laevigata and C. teretis. Species such as Stainforthia loeblichii, Nonion labradoricum, N. barleeaunum, Islandiella helenae and Bullimina marginata are especially abundant in the upper part of the interval between 410 and 470m.

The lower part of the interval is of early Pleistocene age. On the basis of quantitative differences the upper part of the interval between 410 and 470m may possibly be regarded as a separate unit representing a slightly younger part of the Pleistocene.

General lithology

Cuttings samples from this interval consists of poorly sorted unconsolidated mud, silt and subordinate sand.

Depositional environment

By direct comparison with recent foraminiferal faunas deposition of this interval took place in an open marine shelf environment.

TERTIARY

Interval 590 - 1430m

Age: Pliocene

Micropaleontology

Cassidulina teretis - Cibicides grossa Zone

The top of this zone is placed at the first downhole appearance of common Cibicides grossa in association with persistent occurrence of Elphidium cf. hughesi, Cassidulina pliocarinata and Ammonia beccarii. In addition Elphidiella hannai is a characteristic element of nearly all the assemblages from this zone.

Abundant Cassidulina teretis, Elphidium excavatum and other species referred to the genus Elphidium continue down from the interval above. A few specimens of Elphidium pseudolessoni and Textularia decrescens are found scattered through the interval. Bulimina aculeata also constitutes a characteristic element throughout. This species is, however, also well represented in the lower part of the interval above.

Towards the base of the interval at 1310m and 1340m rare Pullenia bulloides and Nonion pompilioides represent an older element related to the Miocene faunas below.

General lithology

The cuttings samples from this interval also consist of unconsolidated mud, silt and sand material.

From about 1250m the appearance of poorly sorted dark silt/sandstone is observed.

Depositional environment

The foraminiferal assemblage composition shows that the interval was deposited in an open marine shelf environment.

Interval 1430 - 1580m

Age: Miocene - Pliocene
transition

Micropaleontology

Nonion - Angulogerina Zone

A distinct increase in the amount of Nonion affine/barleeaunum and Angulogerina fluens occurs at the top of this interval. A.fluens, however, disappears towards the base of the zone. Stratigraphically important species like Globorotalia cf. crassaformis, G.inflata, G.continuesa, Fissurina castanea, Epistominella oveyi and Angulogerina tenuistrata, here placed within the A.gracilis group, have their first downhole occurrence within this interval.

An increase in diatoms and radiolarians is also noted within this interval.

The interval is interpreted as a transitional zone spanning the Miocene - Pliocene boundary.

General lithology

The appearance of grey, poorly sorted mudstone/siltstone with plant debris in DCS probably represents the dominating "in situ" lithology from this interval. Free quartz probably originating from the poorly consolidated sediment, is abundant. Subordinate dark mudstone are also present within this interval.

Depositional environment

This interval was deposited in an open marine shelf environment.

Interval 1580 - 1730m Age: Miocene, late

Micropaleontology

Cibicides dutemplei - Marinottiella communis Zone

The top of this interval is taken at the first downhole appearance of distinctive Cibicides dutemplei, referred to the C.dutemplei group, and Marinottiella communis. The zone is further characterized by the appearance of Sphaerodinia bulloides, Eponides umbonatus and Angulogerina tenuistrata, referred to the A.gracilis group, all characteristic of Miocene assemblages. There is a slight increase in planctonic foraminifera compared with the interval above.

Also the appearance of Bulboforma metzmacheri, B.cf.aculeata and other species of Bulboforma at the top of this interval is stratigraphically important. Their occurrence seem to be restricted to this interval.

The age of this interval is Miocene, probably the late part of the stage.

General lithology

Dark grey to brownish mudstone, poorly sorted with silt and v.f.sand dominate within this interval. Poorly sorted sandstone and abundant free quartz are also seen in the DCS.

Depositional environment

The microfossil assemblage composition shows that an open normal marine environment prevailed during the deposition of this interval.

Interval 1730 - 1800m

Age: ?

Micropaleontology

The impoverished microfossil assemblages recorded from this interval are probably the result of caving. The interval is regarded as barren of "in situ" foraminifera.

General lithology

The silty/sandy, brownish mudstone continues down into this interval and dominates completely in the DCSs.

Depositional environment

See comments.

Comments

The poor fossil recovery seen in this interval is probably due to poor sample quality in connection with casing set at 1789m. This interval also coincides with a hiatus between the early-middle Oligocene sequence below and the late Miocene above, and the poor fossil productivity may also be due to more extreme changes in facies during this geological event.

The exact position of the hiatus has not been established because of the poor fossil evidence across this interval.

The same lithology as in the interval above continues down through this interval. It may, however, not be representative for this interval.

Interval 1800 - 1880m

Age: Early-middle Oligocene

Micropaleontology

Turrilina alsatica - Rotaliatina bulimoides gr. Zone

The foraminifera assemblages from this interval are extremely poor, but contain species like Turrilina alsatica, Gyroldinoides cf. givardanus, Sigmoilina tenuis and Rotaliatina bulimoides indicating an early to middle Oligocene age.

The samples studied from 1840m to 1860m are barren of foraminifera.

Palynology

A single SWC from 1855m produced a diagnostic dinoflagellate assemblage including Deflandrea spinulosa, Glaphyrocysta intricata, Gochteodinium simplex, Phtanoperidinium amoenum, Aeroligera semicirculata and Chiropteridium dispersum.

The age of this assemblage is early Oligocene.

Kerogen analysis

The SWC at 1855m produced a kerogen assemblage dominated by finely fragmented debris, partly coherent. Abundant dinocysts and rare terrestrial palynomorphs suggest a marine origin for most of the finely fragmented debris. Rare membraneous material and common wood and inertinite show a low to moderate terrestrial input.

This kerogen composition is typical for distal open marine low energy conditions.

General lithology

Dark silty mudstone dominates this interval with subordinate light grey silt/v.f.sandstone.

A single SWC from 1855m consists of a homogeneous grey mudstone.

Depositional environment

The foraminifera fauna indicate an open normal marine shelf environment. This is supported by the palynological assemblage and kerogen analysis. Kerogen composition further shows low to moderate terrestrial input in a low energy distal environment at 1855m.

Interval 1880 - 2160m

Age: Eocene, middle - late

Micropaleontology

Haplophragmoides - Recurvoides - Spiroplectamina Zone

A distinct and abrupt change in the foraminiferal assemblage is seen at 1880m. An agglutinated fauna completely dominates this interval contrasting sharply with the assemblage recorded above. Only minor changes in assemblage composition have been recorded through this interval. On the basis of a closer study of the agglutinating species it may be possible to subdivide this interval further. Our present knowledge of these species does not, however, allow further subdivision.

The most important species and species group are Recurvoides spp., Bathysiphon related fragments, Glomospira corona, G.irregularis, G.charoides, Haplophragmoides spp., Cyclamina placenta, C.cancellata, C.amplectus, Ammodiscus incertus and Trochamina globigeriniformis group.

The first downhole appearance of Spiroplectamina spectabilis and Cystamina pauciloculata is recorded at 2020m and 2060m respectively. The appearance of these species shows a late Eocene age for this horizon.

The homogeneous composition of the assemblages recorded and the contrast with the overlying interval, suggest that the interval represents a continuous sedimentary sequence, and that the age is probably middle to late Eocene.

Palynology

A single SWC at 1975m was analysed. A diagnostic late Eocene assemblage containing Areosphaeridium dichtyoplokus, Deflandrea heterophlycta and Arosphaeridium fenestratum was recorded.

Palynological analyses of ditch cuttings samples started at 2120m. Dinoflagellate assemblages from 2120m, 2140m and 2160m containing Deflandrea speciosa, Thalassiphora pelagica, Diphyes colligerum, Rhomboidinium draco, Spiniferites cornutus, and Kisselovia edwardsii are consistent with a middle Eocene age.

Kerogen analysis

The SWC at 1975m produced a kerogen assemblage dominated by finely fragmented debris, partly coherent, Dinocysts are relatively common. Terrestrially derived debris is relatively rare.

Kerogen analysis of DCSs started in the lower part of this interval at 2120m. The samples at 2120m, 2130m and 2140m show abundant to dominating finely fragmented debris. Terrestrial palynomorphs are rare, while marine palynomorphs, mainly dinoflagellates, are common. Wood fragments are abundant to dominating, inertinite is common to abundant. Membraneous material is rare.

Although some of the wood and inertinite may be derived from added lignite, this assemblage composition indicates an open normal marine environment with moderate terrestrial input under oxydizing conditions.

General lithology

Dark claystone is characteristic in the upper part of the interval. Greenish, poorly consolidated mud appears at 1920m and becomes dominating from 1980m.

Light grey sandstone is present in DCSs around 1960 - 1980m and 2100m.

A single SWC at 1975m consists of brownish silty claystone.

Depositional environment

The foraminiferal fauna indicates environmental stress by the dominance of agglutinated foraminifera.

The kerogen assemblage composition however, shows an open normal marine environment with moderate terrestrial input. A shallow open shelf environment is suggested from the available evidence.

Interval 2160 - 2190m

Age: Early Eocene

Micropaleontology

Globigerina linaperta Zone

A distinct change in microfossil fauna is recorded at 2160m. Planctonic species like Acaririna pentacamerata, A. soldadoensis, Pseudohastigerina wilcoxensis are present in association with the benthic calcareous species Cibicides ungerianus, Canoris subcornicus, Eponides plummerae, Melonis nobilis, Lenticulina cultrata and Turrilina brevispira. This association gives an early Eocene age. The presence of Coscinodiscus spp. is also characteristic of this interval.

The fauna is typically red stained.

Palynology

The appearance of Hystrichocolpoma eisenackii and Dracodinium varielongituda at 2160m and Wetzeliella cf. solida at 2180m further support an early Eocene age for this interval. Azolla sp, appears at 2160m indicating a change in sedimentary environment from the interval above.

Kerogen analysis

Kerogen assemblages from the DCSs at 2160m and 2180m contain abundant finely dispersed debris, rare to common terrestrial palynomorphs and common to abundant marine palynomorphs. Wood fragments are reduced from the interval above from dominating to abundant, while inertinite is still common to abundant.

The representativity of these assemblages is again questionable due to poor control with caving and mud additive, but a careful interpretation suggests an open marine, low energy oxydative environment with moderate to low terrestrial input.

General lithology

Red mudstone appearing at 2160m(DCS) and reaching a maximum at 2180m (DCS) is the dominating "in situ" lithology within this interval. Considerable amounts of sediments caved from the intervals above are also present in the DCSs.

Depositional environment

Open marine shelf environment with low energy and oxygenated conditions is suggested. The area occupied a distal position with low to moderate terrestrial input.

Interval 2190 - 2220m

Age: Late Paleocene -
early Eocene

Micropaleontology

Haplophragmoides - Spiroplectamina Zone

This zone marks a return to an agglutinated fauna. Rare stained calcareous species are regarded as caved from the interval above. The fauna shows strong similarity with that recorded above the Globigerina linaperta Zone. The zone is sandwiched between the early Eocene above and the middle Paleocene below. A late Paleocene to early Eocene is therefore assigned to this interval.

Palynology

The top of this zone is marked by the appearance of abundant Caryapollenites simplex and other early Tertiary pollen species, showing a change in facies from the intervals above, which reflects an increase in terrestrially derived plant debris.

Kerogen analysis

Two SWCs were examined from this interval. At 2191.5m the kerogen assemblage is dominated by finely dispersed debris and terrestrial palynomorphs, all other kerogen categories being rare. At 2115m the organic productivity is extremely low and the significance of this assemblage is uncertain. The assemblage is dominated by finely dispersed debris, the

particulate debris is very rare and quantification is not reliable. All categories are characterized as rare. In the DCS at 2200m finely dispersed debris is dominating. Terrestrial palynomorphs shows a slight increase to common, but the full effect of the increase is not seen until the sample at 2220m.

Marine palynomorphs are abundant at 2200m and so are wood and inertinite fragments.

The kerogen assemblage from 2191.5m shows a maximum terrestrial input in the upper part of the interval. This increase is, however, not recorded until 2220m in the DCSs. The kerogen composition thus indicates a regressive development through this interval with an increase in terrestrial input within the framework of a distal to marginal open marine environment.

General lithology

Poorly sorted dark/light grey siltstone with occasional sandy patches appears at the top of this interval and probably represents the "in situ" lithology. Red mudstone is still abundant at 2200m but considerably reduced downwards. Greenish mud is present as a minor constituent. Sediments caved from higher intervals are common.

Grey silty claystone is present in the SWC at 2191.5m. The SWC at 2215m consists of greenish grey, highly silty mudstone.

Sedimentary environment

Open normal marine conditions prevailed throughout the deposition of this interval. Increased terrestrial input upwards suggests a development from a distal position to a more marginal environment. This seems to be reflected by the sediments observed in SWCs with greenish mud in the lower part and grey siltstone with sandy patches in the upper part.

The dominance of agglutinated foraminiferal fauna again suggests either environmental stress or possibly secondary dissolution of calcareous foraminifera. It may be interesting to note that the impoverished foraminiferal fauna between 1880m and 2160m also coincides with greenish mud sediments.

Interval 2220 - 2230m

Age: Middle Paleocene

Micropaleontology

Globigerina triloculinoides Zone

An abrupt and distinct faunal change occurs at 2220m with the appearance of abundant Globigerina triloculinoides and G. triangularis. In addition the persistent presence of Bulimina midwayensis and rare Globigerina pseudobulloides and Globorotalia compressa suggest a middle Paleocene age.

Palynology

The assemblage recorded from the DCS at 2220m was extremely poor and yielded no age diagnostic assemblage.

Kerogen analysis

No SWC was available from this interval. It is also very difficult to assess the influence of this thin interval on the assemblages from the DCS.

General lithology

Only small lithological changes are noted within this interval from the DCSs. Dark to light grey poorly sorted siltstone is still dominating the samples with subordinate greenish mud and red claystone caved from the intervals above.

The appearance of light grey, homogeneous mudstone at 2220m may represent the "in situ" lithology.

Depositional environment

The microfossil fauna recorded shows that this interval was deposited in an open normal marine shelf environment. This interval may represent a more distal marine part of the same sedimentary cycle as the interval above. The light grey mudstone suggested to be the "in situ" lithology, represents a more favourable environment for the microfossil productivity, either due to primary or secondary processes.

Interval 2230 - 2280m

Age: Early to middle Paleocene

Micropaleontology

Haplophragmoides - Spiroplectamina Zone

Again a return to an agglutinated fauna is observed. There are no distinct changes from similar faunas above. First downhole appearance of Spiroplectamina navarroana is recorded from this zone.

Palynology

The assemblage recorded from SWC 2232m again shows dominance of Caryapollenites simplex. The appearance of Sequoiapollenites cf paleocenicus at 2232m and Deflandrea speciosa, Apectodinium augustum and Eisenackia rugolirata at 2240m and 2260m is diagnostic for the Paleocene. The interval is, however, sandwiched between the middle Paleocene and the early Paleocene below and the age is consequently late early to middle Paleocene.

Kerogen analysis

Two SWCs were examined from this interval. At 2232m finely dispersed debris is totally dominating. Terrestrial palynomorphs are dominating the particulate debris, all other components being rare.

The SWC at 2269m differs completely from this composition. Finely dispersed debris is reduced to common and terrestrial

palynomorphs to rare. Marine palynomorphs are nearly absent while wood fragments are now totally dominating the assemblage.

The kerogen assemblages from DCSs differ considerably from those seen in the SWCs. Finely dispersed debris varies between abundant and dominating. Both terrestrial and marine palynomorphs are common and wood and inertinite is abundant. Added lignite probably affects the amount of wood and inertinite observed.

The more reliable information from the SWCs suggest an open marginal marine environment with considerable terrestrial input. The differences in kerogen composition between the two SWCs is interpreted as the result of a more oxydative environment in the lower part of the interval unfavourable for the preservation of organic material which may be more easily destroyed by oxydation. This may partly explain the relative dominance of wood material here.

General lithology

Poorly consolidated silty and sandy mudstone is the dominating lithology within this interval. The SWC at 2232m presents two distinct lithologies, a brownish silty mudstone and a dark grey mudstone.

At 2269m there are greenish and brownish claystone. The DCSs over this interval are dominated by light grey sandy siltstone and free quartz apparently originating from this sediment, and greenish mudstone showing a maximum in the lower part at 2260m. A dark grey laminated mudstone/siltstone dominating the DCS at 2280m also partly originates from this interval.

Depositional environment

The presence of typically agglutinated foraminifera and abundance of terrestrially derived pollen at 2232m and wood debris at 2269m suggest a relatively high terrestrial input. The sequence was probably deposited in a marginal open shallow marine environment.

Interval 2280 - 2320m Age: Early Paleocene

Palynology

The top of this interval is defined by the appearance of Eisenackia crassitabulata, Fibrocysta bipolare, Alisocysta sp. and Paleoperidinium pyrophorum at 2280m DCS and 2281m SWC. This assemblage is diagnostic of the early Paleocene.

Micropaleontology

The agglutinated fauna recorded above continues down into this zone. Apart from the appearance of a species probably belonging to the species Plectina conversa at 2280m no new elements enter the assemblage over this interval.

Kerogen analysis

The two SWCs from the upper part of the interval are both dominated by finely dispersed debris. Terrestrial palynomorphs are abundant in both samples while marine palynomorphs are abundant in the upper sample and rare in the lower, varying

inversely with wood fragments. Inertinite is abundant in the upper sample and reduced to common in the lower.

The DCS at 2280m is probably heavily influenced by material originating from the interval above. At 2300m an assemblage with common finely dispersed debris, rare terrestrial palynomorphs, abundant marine palynomorphs and common to abundant wood and inertinite was recorded.

General lithology

Dark grey, silty mudstone with siltstone laminae appears at the top of this interval becoming dominating at 2300m. Light grey silty mudstone is present as an additional element.

The SWC at 2281m consists of homogeneous greenish grey, poorly consolidated claystone. In the SWC at 2290.2m dark grey claystone is present.

Depositional environment

Deposition of this interval took place in an open marine environment with considerable terrestrial input. Energy regime was mainly low. Poor microfossil assemblages may either be due to environmental stress or secondary dissolution.

CRETACEOUS

Interval 2320 - 2347.5m

Age: Maastrichtian

Palynology

The appearance of Paleocystodinium benjamini and Deflandrea diebli at 2320m (DCS) and Fibulapollis sp., Triprorhynchus unicus, Aquilapollenites sp. and Danea mutabilis in 2330.5m (SWC) and 2340m (DCS) characterizes this interval. This assemblage suggests a Maastrichtian age for the interval. Cyclonephelium sp. of Molander dominating in the SWC at 2327.5m is characteristic for Maastrichtian sediments in some NW European localities.

Species typical for the late Cretaceous such as Dicodinium psilatam and Alterbia acuminata, also appear within this zone further suggesting that the Tertiary - Cretaceous boundary has been penetrated.

Micropaleontology

Several planctonic calcareous species appear at the top of this zone. Globigerinelloides aspera dominates the assemblages in association with Biglobigerinella multispira and rare Praeglobotruncorea cf. havanensis, Heterohelix globulosa and H. lata. Among the calcareous benthonic species Gavelinella cf. umbilicata, G. laevigata, Globorotalites micheliamus and Gyroidionides nitidus are characteristic.

Kerogen analysis

The three SWCs from the upper part of the interval are all extremely poor in organic debris. The SWC at 2323m did not produce any workable assemblage, the two others are dominated by finely dispersed debris. The sample at 2327.5m was dominated by inertinite in the particulate fraction. Relative amounts of particulate debris could not be established due to low productivity. They produced however, rare dinocysts and pollen.

Due to low organic productivity in the "in situ" lithologies as seen in the SWCs, the true kerogen assemblage composition is regarded to be masked by caved material in the DCSs over this interval.

General lithology

The DCS at 2340m is dominated by the dark grey silty mudstone seen above. A distinct maximum in brick red claystone probably represents the dominating "in situ" lithology within this interval. Light grey silty mudstone are also present in considerable amounts.

The SWC at 2323m consists of red claystone with some greenish inclusions, while that at 2327.5m consists of dark greenish mudstone. The SWC at 2330.5m is again showing red claystone.

Depositional environment

Open normal marine shelf environment is indicated by the foraminiferal fauna from this interval.

Kerogen analysis shows low terrestrial input in a highly oxydative environment.

Interval 2347.5 - 2460m

Age: Early Campanian

Palynology

The top of this interval is defined by the appearance of characteristic late Cretaceous dinoflagellates in the ditch cuttings samples at 2347.5m and 2360m. Here Raphidodinium fucatum, Odontochitina costata, Paleostomocystis fragilis, Paleohystrichophora infusoroides, Paleoperidinium cretaceum, Chatangiella verrucosa group, Chatangiella vnigrii and Trithyrodinium cf. suspectum are recorded, species which range up into the early Campanian.

In ditch cuttings sample at 2420m and sidewall core at 2454.1m the appearance of Cicatricosisporites spp., Xenascus ceratoides, Hystrichodinium voigtii, Canningia colliveri, Cyclonephelium distinctum, Odontochitina operculata, Oligosphaeridium complex, Integricorpus conspicuum and Chatangiella microarma is further evidence for an early Campanian age.

Micropaleontology

The foraminiferal fauna is poor over this interval. It reflects either a return to a Haplophragmoides - Spiroplectamina fauna, or it may possibly be a result of caving. The stratigraphical significance is therefore uncertain.

Kerogen analysis

The kerogen assemblages recorded from the DCSs over this interval show dominating finely dispersed debris in the uppermost part probably due to caving, rare at 2370m and 2380m and abundant from 2400m. Terrestrial palynomorphs are rare to common while marine palynomorphs are abundant. Wood fragments and inertinite vary between common and abundant in most samples. Membraneous material is present only in small amounts.

One SWC at 2454.1m was examined. Finely dispersed debris is dominating, terrestrial palynomorphs are rare and marine abundant. Wood fragments are common while inertinite is abundant. Rare membraneous material and aggregates were recorded.

General lithology

Dark grey shale, occasionally silty, is the dominating lithology within this interval. Red claystone is still abundant at 2347.5m, but is rapidly reduced downwards.

Light grey sandy siltstone to v.f.sandstone occurs as a persistent subordinate lithology throughout the interval.

A SWC from the lower part of the interval at 2454.1m consists of laminated claystone/light grey silt to v.f.sandstone.

Depositional environment

This sequence was deposited in an open shallow marine environment with moderate terrestrial input under oxydative conditions. Energy regime was low to medium.

Interval 2460 - 2650m : Age: Early Campanian - ?Santon

Palynology

This interval is defined by the appearance of Dinogymnium cf longicornis, D.acuminatum and Hexagonifera chlamydata in the DCS at 2460m and SWC at 2461.3m. Lithosphaeridium siphoniferum and Coronifera oceanic were also recorded at or near the top of this interval. Further down in the SWCs at 2490.9m and 2522m the appearance of Triporoletes reticulatus and T. radiatus is noted.

This zone is probably a continuation of the early Campanian sequence above, possibly extending down into the Santonian.

Micropaleontology

No age diagnostic assemblages recorded.

Kerogen analysis

Six SWCs were examined from this interval. They show considerable variation in the amount of finely dispersed debris, in the upper part being dominating, in the lower reduced to rare.

Terrestrial palynomorphs are rare in all SWCs except one at 2601.2m where they are common. Marine palynomorphs are abundant in all samples except that at 2601.2m where they are reduced to common. Wood fragments are common in most

samples, again the assemblage at 2601.2m is an exception with an increase to abundant for this kerogen category. Inertinite is abundant in all assemblages except for that at 2490.9m where a reduction to common is observed. Membraneous material is rare throughout the interval.

The DCSs produced somewhat different kerogen assemblages regarding finely dispersed debris and wood fragments. This is probably due to added lignite. The information from the SWCs is regarded as the most representative, and our interpretation is based on this information.

The appearance of greyish, coherent finely fragmented debris in the DCS at 2610m may however, be of importance.

General lithology

Light grey sandy siltstone to v.f.sandstone now become the dominating lithology. The sediments are poorly consolidated and free quartz grains are abundant in the DCSs.

From 2600m the quality of the samples is reduced consisting of mud and sand grains. Abundant added lignite further reduces the sample quality for palynological analysis.

The SWCs at 2461.3m, 2490.9m, 2522m, 2540.2m and 2639.1m all consist of laminated dark grey silty sandstone/white silt to v.f.sandstone. The SWC at 2601.2m consists of homogeneous silty claystone.

Depositional environment

The sequence covered by this interval was deposited in an open marginal marine, oxydative environment with low to medium terrestrial input. Energy regime was intermediate.

Interval 2650 - 3080m Age: ?Cenomanian

Palynology

The top of this zone is placed at a distinct change in facies taking place between 2630m and 2650m. This is seen palynologically by the appearance of Kalyptea halosa and algal colonies possibly related to Botryococcus in the DCS at 2660m.

A Cenomanian age is suggested for the interval based on the appearance of the distinctive spore species Impardecispora trioreticulosus and I. marylandensis at 2680m (DCS) and 2747m (SWC) respectively. In addition the appearance of Aequitriradites baculatus at 2687m (SWC), Appendicisporites spp. and questionable specimens of Ovoidinium verrucosum at 2747m (SWC) also suggests that Cenomanian sediments have been penetrated at this depth.

Very few stratigraphically important species appear further down in the interval. We may however, point out the appearance of Pareodinia sp. at 2850m (DCS) and Cerebropollenites mesozoicus at 2860m (DCS). These species may have been reworked from Jurassic sediments, but are regarded to range as high as the Cenomanian. Cicatricosisporites skalmaricus

recorded at 2940m (DCS) belongs to the same spore/pollen suite as Impardecispora known from the Albian - Cenomanian of eastern North America.

The sample quality from this interval was extremely poor due to large amounts of added lignite and relatively low productivity.

Micropaleontology

No age diagnostic assemblages recorded.

Kerogen analysis

The kerogen assemblages obtained from seven SWCs through this interval show a remarkable stability. All assemblages contain only rare finely dispersed debris. Terrestrial palynomorphs are common in the upper part of the interval, but reduced to rare in the lower. Marine palynomorphs are rare to common in all samples, but at 3070m increase to abundant. Wood fragments are rare to common while inertinite is abundant to dominating. Membraneous material is rare or absent from the assemblages.

The kerogen assemblage data from the DCSs is unreliable due to added lignite.

General lithology

Sample quality is still extremely poor in the upper part of the interval and the "in situ" lithology is very difficult to interpret from these samples. From 2700m dominance of light grey silty sandstone probably represents the "in situ" lithology. Occasional v.f. sandstone is seen in most samples over the interval.

The SWC at 2687m consists of dark grey claystone with siltstone patches. At 2724m, 2747m, 2782.1m, 2831m and 3000.4m a dark grey claystone with rare silt is present in the SWCs. The SWC at 3070m consists of poorly consolidated v.f. quartz sandstone with coal clasts.

Sedimentary environment

The sequence was deposited in an open marine environment with moderate terrestrial input. Energy regime was intermediate. Increased sorting of terrestrial debris and deposition of v.f. sandstone recorded at 3000.4m is regarded to be a result of current activity rather than more shallow conditions, because of increase in marine palynomorphs at the same horizon.

Interval 3080 - 3160m

Age: Late Albian -
Early Cenomanian

Palynology

The top of this interval is defined by a lithological break between 3070m and 3080m with the appearance of Cauca parva and Hystriochodinium amphiacanthum at 3085m (DCS). Wallogdinium lunum appearing at 3115m (DCS) further supports a late Albian - early Cenomanian age for this interval.

Micropaleontology

No age diagnostic species recorded.

Kerogen analysis

Two SWCs from the upper part of the interval at 3083m and 3092m were examined. Kerogen assemblages are very similar to those recorded from the interval above. Finely dispersed debris is rare, terrestrial palynomorphs are rare to common while marine palynomorphs are common. Wood fragments are common and inertinite is dominating the assemblages. Membraneous material remains rare.

DCSs from this interval is unfortunately heavily contaminated by added lignite making quantification unreliable.

General lithology

Grey to light grey silty mudstone dominates totally the DCSs over this interval.

Two SWCs were examined from this interval. The SWC from 3083m consists of laminated grey claystone/dark grey claystone. At 3092m a dark grey and brownish claystone with silty patches is found.

Sedimentary environment

Both kerogen analysis and lithology suggest a similar sedimentary environment to that of the interval above. An open distal marine oxygenated environment with intermediate energy regime and moderate terrestrial input is suggested.

Interval 3160 - 3460m

Age: Albian

Palynology

The top of this interval is defined by the appearance of Apteodinium grande at 3160m (DCS), Hapsocysta dictyota at 3167m (SWC) and Steptodinium coronatum at 3182m (SWC). Paleohystrichophora infusoroides becomes common to abundant at 3160m (DCS). Of stratigraphical importance is also the presence of Dorocysta litotes at 3220m (DCS) and Ovoidinium scabrosum at 3260m (DCS). Rare Scriniodinium campanulum is present throughout the interval together with several long ranging species.

Micropaleontology

No age diagnostic assemblages were recorded from this interval.

Kerogen analysis

Eight SWCs have been examined from this interval. Finely dispersed debris is still poorly represented being rare in all assemblages except for the two at 3430.5m and 3446.1m where it is common. Terrestrial palynomorphs are rare in all assemblages except near the top of the unit at 3167m. Here they are common. Marine palynomorphs are common in the middle and upper part of the interval, but reduced to rare in the lower part. Wood fragments are abundant at 3167m and near the base of the interval at 3446.1m, in the other assemblages they are rare to common. Inertinite are abundant to dominating throughout. Membraneous material is rare.

General lithology

Grey to light grey silty mudstone dominates the interval. At 3280m and 3300m a distinct maximum in white silt/mud is observed. Grey v.f.sandstone is observed below 3400m. The SWC at 3167m consists of laminated dark mudstone/subordinate v.f.sandstone. At 3182m, 3335m, 3360m, 3391m, 3404m, 3430.5m and 3446.1m dark grey homogeneous claystone is seen in the SWCs.

Depositional environment

The open distal marine oxygenated environment also dominates this interval. Terrestrial input was moderate and the environment was well oxygenated. Possible slightly increased terrestrial input is noted at 3167m.

Interval 3460 - 3528.5m Age: Aptian

Palynology

The top of this interval is defined by the appearance of Lithosphaeridium conispinum/arundum at 3460m (DCS) becoming common to abundant at 3487.5m (SWC) and 3500.2m (SWC). At 3487.5m (SWC) stratigraphically important species such as Subtilisphaera terrula, Aptea attadalica, Pseudoceratium pelliferum, Pterodinium cf aliferum s. Davey, Batioladinium jaegerii s.s., Kleithriasphaeridium eoinodes and Cleistosphaeridium huguonioti appear. Odontochitina operculata is also a characteristic element.

These assemblages define an Aptian age for this interval.

Micropaleontology

No age diagnostic species recorded.

Kerogen analysis

Five SWCs were examined from this interval. Low organic productivity is typical for these sediments. The assemblage recorded at 3481.9m is dominated by wood and inertinite fragments, all other types of debris being absent.

At 3487.5m and 3500.2m finely dispersed debris is rare, terrestrial palynomorphs are common, while marine palynomorphs are rare to common. Both assemblages are dominated by wood and inertinite.

The sample at 3520.5m produced wood debris only and the sample at 3526m did not produce any workable assemblage.

The DCSs show decrease in finely dispersed debris and palynomorphs and dominance of wood material. Inertinite is common in assemblages from DCSs over this interval. The appearance of common aggregates at 3500m and 3520m is unique to this interval.

General lithology

Light grey siltstone dominates at 3460m. Dark grey shale also makes up a large portion of the sample. These lithologies continue down through the interval. In DCS at 3480m abundant red claystones appear. The appearance of abundant laminated sandstone at 3520m also represents an "in situ" lithology.

Five SWCs were examined from this interval. At 3481.9m and 3520.5m red claystone is found. Black shale is present at 3487.5m and 3500.2m.

The SWC at 3526m consists of a light grey to white ?marl.

Depositional environment

This interval was deposited in a highly oxydative marine environment.

Interval 3528.5 - 3538m

Age: Ryazanian

Palynology

This thin interval has been recorded from one sample only, the SWC at 3528.5m. A diagnostic assemblage containing Occisucysta sp. A of Davey, Gochteodinia villosa, Adnatosphaeridium caulleryi, Egmontodinium expiratum, Batioladinium pomum, Sirmioidinium grossi and Egmontodinium torynum has been recorded from this sample.

This assemblage is diagnostic of the Ryazanian.

Micropaleontology

No age diagnostic assemblage recorded.

Kerogen analysis

The SWC at 3528.5m produced a kerogen assemblage with common finely dispersed debris. Terrestrial palynomorphs are rare, while marine palynomorphs are common. Wood fragments are abundant and inertinite common in this assemblage. The appearance of abundant degraded debris separates this assemblage from all those recorded above.

General lithology

The SWC at 3528.5m representing this interval consists of light grey siltstone and dark grey claystone.

Depositional environment

This interval was deposited in a proximal marine environment with high terrestrial input. Degradation of organic debris was intense but not completed, forming the characteristic kerogen assemblage. This is interpreted as a result of stagnant conditions just below sediment surface.

Comments

The upper boundary marking a considerable stratigraphical break, is located between the SWCs 3526m and 3528.5m. The lower boundary is also representing a hiatus located between 3528.5m and 3538m (see below).

The kerogen assemblage recorded is typical for late Jurassic (- earliest Cretaceous) shales. The relationship between organic facies and gamma-activity shows that a 'hot shale' has been penetrated.

JURASSIC

Interval 3538 - 3661m Age: Oxfordian

The top of this interval is poorly defined palynologically. The SWC at 3538m did not produce any identifiable species. However, the kerogen assemblage contrasts with that of the intervals above and on the other hand shows great similarity with that of the samples below.

At 3546m (SWC) and 3550m (SWC) the appearance of Systematophora orbifera, Adnatosphaeridium aemulum and Hystrihogonyaulax cladophora shows that Oxfordian sediments have been penetrated. At 3564m (SWC) the characteristic Oxfordian species Scriniodinium crystallinum makes its first downhole appearance. The appearance of Acanthaulax senta at 3580m (DCS) shows that early Oxfordian is present from this depth. An Early Oxfordian age for the lower part of the interval is further supported by the presence of Chytroeisphaeridium cerastes at 3660m (DCS).

The uppermost sample from the cored interval at 3661m produced an assemblage containing Adnatosphaeridium aemulum, Hystrihogonyaulax cladophora, Scriniodinium crystallinum, Acanthaulax senta and Chytroeisphaeridia chytroides. The age is early Oxfordian.

Micropaleontology

No "in situ" assemblage was recorded.

Kerogen analysis

Five SWCs from the uppermost part of the interval between 3538.5m and 3564m were examined. Finely dispersed debris is abundant to dominating in these assemblages. Terrestrial palynomorphs show a distinct increase downwards from rare to abundant at 3550m. Marine palynomorphs are rare except in the sample at 3564m where they are abundant. Wood fragments are also rare in the uppermost samples becoming abundant at 3564m. Inertinite is common in the uppermost sample at 3538.5m and abundant in the other assemblages down to 3564m. Degraded debris varies inversely with the other components. It is dominating at 3538.5m and reduced to abundant and common towards 3564m.

The kerogen assemblages obtained from DCSs clearly shows the same development. Finely dispersed debris is abundant between 3540m and 3580m and reduced to rare below 3600m. Palynomorph productivity is low in the upper part of the interval, but a distinct increase in productivity is observed from 3620m. Both terrestrial and marine palynomorphs become abundant towards the base of the interval. Wood fragments and inertinite are recorded as abundant in all assemblages except at 3640m where wood fragments are reduced to common, while inertinite shows an increase to dominating. Degraded debris appears at 3540m, shows a maximum at 3560m and is then rapidly reduced, disappearing at 3600m.

By considering the information from both SWCs and DCSs it is seen that degraded debris shows a delayed appearance due to caving effects. The decrease in this type of debris observed in the SWCs from the uppermost part of the interval is also observed in the DCSs and is there shown to be permanent.

General lithology

Bituminous grey to brownish shale dominates in the upper part of the interval. Dark to light grey v.f. sandstone appears at 3580m and reaches a maximum at 3600m and is again reduced downwards with the increase of dark grey silty shale.

The SWCs at 3538.5m, 3546m, 3550m and 3560.5m consist of black shale with brown patches. At 3564m the same lithology is present with light grey silt patches.

Depositional environment

This interval was deposited in proximal marine environment with high terrestrial input. In the upper part of the interval abundant degraded debris is evidence of intense but not completed, degradation of the debris probably resulting from partly stagnant bottom conditions. Further down increased circulation created more normal marine conditions.

Comments

From the kerogen assemblage composition gamma-activity is expected to decrease considerably below 3560m.

Interval 3661 - 3760m

Age: ?Bathonian

Palynology

Samples from the cored interval 3661m to 3719m produced extremely poor assemblages. Rare Deltoidospora minor, D.australis, Osmundacidites sp., Lycopodiumsporites sp. and Chasmatosporites apertus s.Vigran were recorded. These assemblages are not age diagnostic.

The appearance of Quadraeculina anellaeformis and Callialasporites turbatus in the DCS at 3700m may be regarded as the first downhole appearance of the Middle Jurassic spore/pollen associations fully developed within the interval below.

Quadraeculina anellaeformis has been used to define the Bathonian in the North Sea, but has a reported range up into the Cretaceous.

Also appearing at 3700m (DCS) are rare Ctenidodinium ornatum and Dinocyst spp. B/C of de Vains, both characteristic elements of the Bathonian. A possible reworking of these species must however be considered.

Pareodinia "tabulata" and Dinocyst sp. 21552 of de Vains appearing at 3720m (DCS) and 3740 (DCS) are characteristic for the Bathonian.

Kerogen analysis

Eight core chips were examined between 3661.05m and 3719m. Organic productivity was extremely low in all these samples, making quantification difficult. All assemblages are however, dominated by inertinite. Wood fragments and rare terrestrial palynomorphs are also present.

The results from DCSs are probably not representative for this interval due to caving.

General lithology

This interval is dominated by medium to coarse micaceous sandstone as seen from cores. DCSs over this interval appear to be dominated by caved sediments.

Depositional environment

A high energy oxydative non marine environment is suggested for this interval from the kerogen analysis.

Interval 3760 - 3805m

Age: earliest Bathonian

Palynology

This interval is characterized by the appearance of diverse spore and pollen assemblages. At 3760m (DCS) Callialasporites trilobatus, Neoraistrickia cf. taylorii, Classopollis simplex and Callialasporites microvelatus make their appearance together with Pareodinia evittii.

At 3780m, 3790m and 3800m (DCS) the spore and pollen flora is fully developed with the appearance of Klukisporites variegatus, Leptolepidites rotundus, Classopollis classoides, Pollen sp. C of Vigran, Osmundacidites wellmanii group, Contignisporites cooksonii, Tripartina variabilis, Sestrosporites pseudoalveolatus and Araucariacites australis.

In association with the spore and pollen assemblages Dinocyst spp. B/C of de Vains is present, becoming common to abundant in the lower part of the interval from 3790m and Dinocyst sp. 21552, becoming common at 3805m. In addition Mendicodinium groenlandicum, Ctenidodinium sp., Gonyaulacysta cf. pectinigera, Nannoceratopsis pellucida, Pareodinia tripartita and Kylindrocysta spinosa are present between 3780m and 3805m (DCS).

These assemblages define an earliest Bathonian age for this interval.

Kerogen analysis

The DCSs over this interval are thought partly to reflect the "in situ" sedimentary sequence. Finely dispersed debris is rare at 3760m and rare to common between 3780m and 3805m. Terrestrial palynomorphs are common in the upper part and common to abundant from 3790m. Marine palynomorphs are common in all assemblages except at 3790m where they are rare. Wood fragments are abundant in the upper and abundant to dominating in the lower part of the interval, while inertinite is abundant in all assemblages. Other components are either rare or absent.

General lithology

Grey to light grey sandy siltstone dominates in the DCSs over this interval and probably represents the "in situ" lithology. Dark grey silty shale and sand is probably caved from the overlying intervals.

Depositional environment

A marginal, normal marine environment with high terrestrial input was established during the deposition of this interval.

Interval 3805 - 3820m

Age: Aalenian - ? Bajocian

Palynology

The top of this zone is marked by a distinct change in organic facies with the appearance of Botryococcus colonies at 3805m (DCS) becoming abundant at 3810m (DCS). Nannoceratopsis gracilis and Phallocysta eumekes appear at the top of the interval in association with several characteristic spore and pollen species like Leptolepidites paverus, Quadraeculina sp. (large var.), Birctisporites potonieii, Caytonipollenites pallidus, Lycopodiacidites rugulatus, Duplexisporites probelmaticus, Manumia irregularis, Chasmatosporites apertus, Staplinisporites caminus, Lycopodiumsporites semimuris and Perinopollenites elatoides.

These assemblages define an Aalenian or possibly Bajocian age for this interval.

Comments

The DCS at 3805m shows a mixed assemblage where the Bathonian and the Aalenian -?Bajocian intervals are both well represented. This may be explained either by considerable caving from the overlying Bathonian interval, or by assuming that the boundary between the two intervals is so close that the interval represented by the sample is actually covering the transition between the two units.

Kerogen analysis

DCSs from this interval produced rare finely dispersed debris. Terrestrial palynomorphs are abundant at 3805m and reduced to rare at 3815m, while marine palynomorphs are common in all assemblages. Wood fragments show a decrease from abundant at 3805m to common at 3815m, inertinite being abundant throughout.

Botryococcus colonies appear at 3805m becoming abundant at 3810m. Abundant aggregates are recorded at 3815m.

General lithology

Dark bituminous shale represents the "in situ" lithology over this interval.

Depositional environment

The development in kerogen composition observed through this interval is regarded as a result of reduced effect of caving downwards. The most representative assemblage is probably that observed at 3815m.

A restricted marine or brackish low energy environment is suggested for this interval.

Interval 3820 - 4035m

Age: Late Toarcian - Aalenian

Palynology

The top of this unit is defined lithologically by the appearance of sandstone approximately at 3820m.

Palynomorph productivity is drastically reduced and only rare elements also recorded from the interval above is present. Their presence may therefore be due to caving. Rare Baltisphaeridium spp. recorded at 3840m may indicate that the sandstones were deposited in a marginal marine environment.

The appearance of Mancodinium semitabulatum at 3860m (DCS) and Nannoceratopsis "triangularis" at 3900m (DCS) is the first evidence of the assemblages fully developed in the lower part of the interval.

At 3982m (SWC) the appearance of Parvocysta sp. B of Bjærke 1980, Eyachia prisca, Parvocysta contracta and Comparodinium sp. defines a late Toarcian age for this horizon.

Palynomorph productivity of DCSs remain extremely low.

The late Triassic and early Jurassic species Limbosporites lundbladii and Deltoidospora toralis were recorded at 3982m (SWC) suggesting reworking of sediments of this age.

Kerogen analysis

DCSs produced kerogen assemblages with rare to common finely dispersed debris in the upper part increasing to common and abundant below 3920m. Terrestrial palynomorphs are abundant in the uppermost part probably due to caving and reduced to rare to common in the lower part. Marine palynomorphs also decrease from common to rare or absent down through the interval. This development is also interpreted as a decrease in caving downwards.

Wood fragments are dominating down to 3880m, and from 3900m where they are rare they increase again downwards, becoming dominating at 4000m and 4020m. Inertinite is common in the upper part and common to abundant from 3920m. It is again reduced to common and rare at 4000m and 4020m.

Degraded debris is rare to common through the interval. Its presence may be due to caving from the late Jurassic sequence.

A single SWC from 3982m was examined. The kerogen assemblage contain common finely dispersed debris, rare terrestrial palynomorphs and common marine palynomorphs. Wood fragments are common and inertinite abundant. Abundant membraneous material was recorded from this assemblage.

General lithology

The top of this interval is characterized by incoming of abundant sandstone and quartz at 3820m. Grey siltstone and silty shale appear at 3890m and 3900m and dominate the lower part of the interval. Occasional sandstones are also present below 4000m..

The SWC at 3982m consists of dark grey silty shale.

Depositional environment

A marginal marine environment with high terrestrial input was established. A transgressive development is indicated in the lower part of the interval and a regressive development towards the top of the interval with increasing energy.

Interval 4035 - 4140m

Age: Late Pliensbachian -
early Toarcian

Palynology

The palynomorph productivity across this interval is again poor. However, the presence of Chasmatosporites major and Cerebropollenites cf thiergartii in SWCs at 4035m and 4067m is characteristic near the Pliensbachian - Toarcian boundary. Nannoceratopsis gracilis has been recorded at 4035m (SWC). It is regarded as "in situ" at this depth. This species does not range into sediments older than the late Pliensbachian.

Kerogen analysis

Three SWCs from 4035m, 4067m and 4115m were examined. Finely dispersed debris is common in the uppermost sample and rare in the two lower samples. Terrestrial palynomorphs are common in the two uppermost samples and rare at 4115m, while marine palynomorphs are common in the uppermost sample at 4035m and absent from the two lower samples.

Wood fragments are common at 4035m and 4115m and abundant at 4067m. Inertinite shows an increase downwards from rare at

4035m to dominating at 4115m. Membraneous material is common and abundant at 4035m and 4067m respectively and absent from the assemblage at 4115m.

Kerogen assemblages from DCSs show common finely dispersed debris throughout the interval. Palynomorph productivity was poor, only rare terrestrial palynomorphs were recorded during the quantitative study at 4080m and 4102.5m.

Wood fragments are abundant at 4040m probably partly due to caving from the interval above. They are rare at 4060m and 4080m and show marked increase towards the base of the interval where wood fragments are dominating. The amount of wood and inertinite was, however, difficult to estimate due to added lignite in the samples.

A distinct appearance of greyish aggregates is observed at 4040m, reaching a maximum at 4060m. This is probably due to calcareous or sideritic cementation.

General lithology

This interval is dominated by dark partly silty shale. Subordinate v.f.sandstone is also present across this interval. Added lignite is abundant in the lower part of the interval.

The SWC at 4035m consist of laminated dark grey shale/light grey siltstone. At 4067m light grey v.f. quartz sandstone with silty shale laminae is found. The SWC at 4115m consists of poorly sorted v.f.sandstone with dark patches.

Sedimentary environment

A restricted marginal marine environment was established during deposition of this interval. Terrestrial input was low in the lower part of the interval but increased considerably upwards.

Interval 4140 - ca 4180m

Age: Late Pliensbachian

Palynology

The appearance of Nannoceratopsis senex and Quadraeculina anellaeformis (large var.) at 4140m (DCS) and 4155.5m (SWC) respectively marks the top of this interval. Palynomorph productivity is extremely poor, but the two species are regarded as diagnostic of the late Pliensbachian.

Kerogen analysis

The SWC at 4155.5m produced a kerogen assemblage with abundant finely dispersed debris and terrestrial palynomorphs. Marine palynomorphs are common, mainly represented by small acritarchs. Wood fragments are abundant and inertinite rare. Membraneous material is again abundant at this horizon.

The assemblages from the DCSs at 4140m and 4160m differ from that seen in the SWC. This is probably due to caved material. The decrease in inertinite seems to be significant as well as the appearance of greyish finely dispersed debris. The greyish aggregates appearing in the interval above show a second maximum within this interval.

General lithology

Sample quality is extremely poor over this interval due to dominance of added lignite. Grey siltstone appears to be the dominant "in situ" lithology with some v.f. sandstone.

The SWC at 4155.5m consists of dark grey siltstone.

Depositional environment

A restricted marginal marine environment also prevailed during the deposition of this interval.

Interval ca 4180 - 4220m Age: ?Pliensbachian

Palynology

This interval is recognized only on the basis of lithological criteria (see below). Rare palynomorphs present are regarded as caved.

Kerogen analysis

The SWC at 4194m contains common finely dispersed debris, terrestrial and marine palynomorphs. The marine palynomorphs are mainly small acritarchs. Wood material is abundant, while inertinite and membranous material are common.

Finely dispersed debris and aggregates show a delayed decrease in the DCSs. Terrestrial palynomorphs are common at 4220m while marine palynomorphs are not recorded. Wood and inertinite are common.

General lithology

Porly sorted, partly reddish f. to v.c. quartz sandstone dominates over this interval.

The SWC at 4194m consists of v.f. to f. sandstone with dark sandy shale laminae. This lithology is very similar to that observed at 4155.5m..

Depositional environment

A restricted marine to marginal marine high energy environment is suggested for this interval.

Comments

This sandstone interval is possibly representing a transgressive episode at the base of the Pliensbachian - Toarcian sedimentary cycle. An erosional boundary towards the underlying Hettangian - ?early Sinemurian sequence is inferred. The exact position of this boundary is, however, difficult to locate due to poor palynomorph productivity in the upper sandy part of the interval below. It is, however, placed at the first appearance of palynomorphs which become characteristic elements of the spore and pollen floras below.

Interval ca 4220 - 4380m Age: Hettangian - ?early Sinemurian

Palynology

This interval is poorly defined palynologically by a gradual incoming of spores and pollen typical for the Hettangian - early Sinemurian assemblages. The low palynomorph productivity is due to increased sand deposition towards the top of the unit.

Lycopodiumsporites semimuris and Eucommiidites troedsoni reappear at 4220m. Further downwards Stereisporites perforatus, Uvaesporites argentaeformis, Eucommiidites granulosus and Monosulcites punctatus appear between 4220m and 4320m.

The presence of Contignisporites cooksonii at 4220m and 4320m, and Cerebropollenites mesozoicus at 4320m if "in situ", indicates an age not older than the early Sinemurian.

Kerogen analysis

Two SWCs were examined from 4225m and 4295m. The upper assemblage is dominated by inertinite and wood fragments. Finely dispersed debris and terrestrial palynomorphs are rare. The assemblage at 4295m is again dominated by wood and inertinite. Finely dispersed debris and terrestrial palynomorphs are common while membraneous and degraded debris are rare in this assemblage. Finely dispersed debris is mainly of wood origin.

The kerogen assemblages from DCSs over this interval show increase in finely dispersed debris from rare in the upper

part to common and abundant in the lower. Terrestrially derived palynomorphs are abundant in the upper part but reduced to common further down. Marine palynomorphs, present down to 4320m, are probably caved from the interval above. This is supported by information from SWCs. Wood fragments are common to abundant in the upper part and abundant to dominating in the lower, while inertinite is common in the upper part and slightly increases downwards to abundant. Membraneous material is abundant in the upper part but shows a gradual decrease downwards. Below 4340m it is rare. Aggregates probably caved from the interval above, continue down to 4300m and then disappear.

General lithology

Appearance of abundant grey siltstone at 4240m represents a change of lithology from the interval above. Sandstone, partly caved from the overlying interval still dominates down to 4320m.

True coal appears in DCS at 4260m and together with small amounts of bituminous shale represent a characteristic new element. From 4340m, coal, bituminous shale and grey siltstone become dominating lithologies, sandstone content being considerably reduced. Two SWCs were examined from this interval. At 4225m a fine, slightly micaceous sandstone is observed, and at 4295m a black, bituminous silty shale is observed.

Depositional environment

This interval was deposited in a non-marine environment. The different types of sediments present suggest rapid changes in energy reflecting a mosaic of subenvironments probably within delta top/coastal plain environment. Abundant membranaceous material and terrestrial palynomorphs indicate that local vegetation contributed to the plant material present.

The parallel increase in finely dispersed debris and wood material downwards is evidence of accumulation of locally produced wood material in a relatively low energy environment.

Interval 4380 - 4490m

Age: Hettangian

Palynology

The top of this interval is defined by the appearance of Pinuspollenites minimus and Marattisporites scabratus at 4380m and Trachysporites fuscus and T. asper at 4420m.

The interval is further characterized by common Eucommiidites granulatus/troedsoni.

This assemblage belonging to the Trachysporites/Pinuspollenites zone defines a Hettangian age.

Kerogen analysis

Three SWCs were examined from this interval. Finely dispersed debris is rare at 4380m. Terrestrial palynomorphs are rare and marine palynomorphs absent. Wood fragments dominate the assemblage while inertinite is abundant. Membraneous material is rare. The assemblage examined at 4420m shows abundant finely dispersed debris and terrestrial palynomorphs. Marine palynomorphs are again absent. Wood and inertinite are abundant. The sample at 4452m produced an assemblage completely dominated by mud contamination and is not representative for the "in situ" lithology.

Kerogen assemblages from DCSs show high stability over this interval. Finely dispersed debris is abundant to dominating while terrestrial palynomorphs are common. Marine palynomorphs were not recorded. Both wood and inertinite fragments are abundant throughout this interval. Membraneous material is rare to common.

General lithology

The interval is dominated by bituminous shale and coal and grey to light grey laminated silt and v.f. sandstone.

The SWC at 4380m consists of grey silt with plant debris.
The SWC at 4420m consists of black bituminous shale. A brownish mud is observed in the SWC at 4452m.

Depositional environment

A non-marine environment continued down through this interval. Local vegetation produced the kerogen assemblages present.

Interval 4490 - 4547m

Age: Hettangian, early

Palynology

This interval is defined by the appearance of Aratrisporites minimus and the continued presence of P.minimus, I.fuscus and I. asper. Rich spore and pollen assemblages have been recorded from the DCSs within the interval containing species like Retusotriletes mesozoicus, Acanthotriletes varius, Lycopodium-sporites austroclavatidites and Clavatipollenites hughesii. A number of species recorded from the interval above are also present.

Two SWCs were processed from this interval. Both produced rich but poorly preserved spore and pollen assemblages. Diagnostic species were not recorded.

Kerogen analysis

The two SWCs from this interval produced kerogen assemblages with common to abundant finely dispersed debris. Terrestrial palynomorphs are rare at 4510m and abundant at 4534m. Marine palynomorphs are absent. The assemblage at 4510m is totally dominated by poorly preserved wood fragments. Inertinite is common and membraneous material extremely rare. Wood material also dominates at 4534m and inertinite is abundant. Membraneous material is common at this level.

Kerogen assemblages from the DCSs show high stability also over this interval. Finely dispersed debris is common to abundant, terrestrial palynomorphs are common. Wood material

is abundant in most assemblages but increases to dominating in the middle part of the interval. Inertinite is common in this part of the interval, in all other samples abundant. Membraneous material is mostly rare. Appearance of degraded material increasing to common at 4530m and 4535m probably results from degradation of wood material as indicated by abundant poorly preserved wood material in the SWC at 4510m.

General lithology

DCSs present several different lithologies of poorly sorted fine to medium sand, bituminous silt/silty shales and coal. The SWCs at 4510m and 4534m are made up of dark brownish to black bituminous shale.

Coal and bituminous shale dominate in the middle part of the interval.

The observed lithologies suggest that repeated sedimentary cycles of sand, silt, shale and coal are present within this interval.

Depositional environment

A non-marine environment, probably a coastal plain with mainly overbank sediments were developed within this interval. Local vegetation resulting in coal swamp formation was established.

The presence of degraded and poorly preserved wood material suggests periods of fluvial influence.

Interval 4547 - 4560 TD

Age: Rhaetian Late Triassic

Palynology

Appearance of the species Limbosporites lundbladii, Ovalipollis ovalis and Ricciisporites tuberculatus var. in the SWC at 4547m defines the top of this interval. Incoming of these species are diagnostic of the late Rhaetian. L.lundbladii was also recorded from the SWC at 4554m and the DCS at 4550m and 4560m. O.ovalis is present in the DCS at 4560m. The DCS at 4550m and 4560m are dominated by caved material from the intervals above.

Kerogen analysis

The kerogen assemblages from DCS 4550m and 4560m are completely dominated by caved material and are not representative for this interval. The assemblage from the SWC at 4547m is dominated by terrestrial palynomorphs and wood fragments, while that from 4554m are dominated by wood and inertinite, terrestrial palynomorphs being rare. Marine indicators have not been recorded.

General lithology

The lithologies observed in DCSs are probably not representative for their interval. The SWCs at 4547m and 4554m consist of silty brownish mud and unconsolidated sand in a white matrix respectively.

Depositional environment

Deposition of this interval took place in a non-marine medium to high energy strongly oxydizing environment.

Depositional history

Based on information and interpretations presented in this report the depositional history in Well 6407/1-2 may be outlined as follows:

During Rhaetian times a top delta or coastal plain environment was established in the area. After a short period of non-deposition or slight erosion around the Triassic - Jurassic boundary (4547m) sedimentation continued in the Hettangian - ?early Sinemurian (4547 - ca 4220m) with deposition of bituminous shales, coals, silt- and sandstones in a top delta or coastal plain environment. Sedimentation kept pace with subsidence and the area shows high stability during this period. Increased sandstone deposition towards the top of the interval shows that fluvial processes were more extensive during the later part of this sedimentary cycle. Sedimentation terminated in the ?early Sinemurian and a period of erosion or non-deposition occurred in the late Sinemurian and possibly into the early Pliensbachian.

The area was transgressed in the Pliensbachian with deposition of a marginal marine sandstone (?4220m - 4180m) and a restricted shallow marine basin was established. Silty shales, silt and sandstones were deposited during the late Pliensbachian to late Toarcian. Periods of low sediment input occurred probably due to low relief in the area.

This sedimentary cycle terminated with deposition of sandstones (3820-3890m) in a regressive development.

A restricted marine or brackish low energy environment was established and shales were deposited above the sandstone horizon during the Aalenian (?Bajocian) (3805-3820m).

An unconformity separates this unit from the silty shales of earliest Bathonian age above (3760-3805m) and again sandstones were deposited in a regressive development marking the termination of the Bathonian sedimentary cycle (3661-3760m).

The area was transgressed in the early Oxfordian, and silty shales were deposited (3580-3661m). The upper part of the incomplete Oxfordian sequence was deposited in a marine environment with restricted circulation. High input of terrestrial plant debris under partly stagnant conditions formed a typical 'hot shale' facies (3538-3560m).

Kimmeridgian and Portlandian sediments are not recorded from this well, but evidence of a Ryazanian transgression is seen at 3528.5m. Marine shales of this age also present a 'hot shale' facies.

A long period of non-deposition separates the Ryazanian from the overlying Aptian - Cenomanian sedimentary cycle (2650-3526m). Red and dark claystones were deposited during the Aptian and open normal marine conditions were established. A thick sequence of marine sediments were deposited during the Albian-Cenomanian and significant subsidence occurred the area resulting in an increased rate of sedimentation.

An unconformity is suggested around 2650m separating the late Cretaceous and the Cenomanian. During the ?Santonian - early Campanian marine sediments again were laid down (2347.5-2650m).

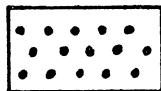
Red and dark grey marine claystones were deposited during the Maastrichtian. Unconformities are probably present both below and above this unit.

Sedimentation commenced in the early Paleocene and marine conditions prevailed until the middle Oligocene. A sequence of greenish and red clays, mudstones and minor silt- and sandstone were deposited (2320-1800m). Distinct changes in sedimentary environment within the framework of an open marine shelf environment are seen through the sequence. These changes probably reflect variations in sediment input rather than drastic variations in subsidence.

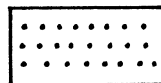
A period of uplift and non-deposition or erosion occurred in the late Oligocene - early Miocene. An unconformity separates the early-middle Oligocene from the late Miocene at 1730-1800m.

An open marine shelf environment was established in the late Miocene - early Pliocene with deposition of mudstones (1430-1730m). During the Pliocene the basin subsided considerably and a thick sequence of sandy and silty mud was deposited (590-1430m). An open marine shelf environment prevailed throughout the interval.

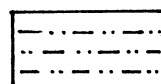
Sedimentation continued into the early Pleistocene with deposition of sandy and silty clay in a marine shelf environment (410-590m).

LEGEND TO ENCLOSURESLITHOLOGY

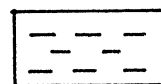
SAND/SANDSTONE
MEDIUM - COARSE



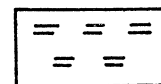
SAND/SANDSTONE
FINE - MEDIUM



SILT/SILTSTONE



CLAY/SHALE



MUD

SAMPLES

Ditch cuttings sample (DCS)



Sidewall core (SWC)



Conventional core (CC)

FOSSIL OCCURENCE

Rare - persistent (DCS)



Common - abundant (DCS)



Rare - persistent (SWC)



Common - abundant (SWC)



Rare - persistent (CC)



Common - abundant (CC)