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BIOSTRATIGRAPHY OF TROLL WELL 31/6-2

CLIENT/ OPPDRAGSGIVER

STATOIL

RESPONSIBLE SCIENTIST/ PROSJEKTANSVARLIG

Haavard Selnes

AUTHORS/ FORFATTERE

Bell, Bessesen, Løfaldli, Selnes, Skarbø, Verdenius, Vigran

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SUMMARY/ SAMMENDRAG

The uppermost samples represented are of Early Pleistocene age. Then follows a Palaeogene section of about 400 m. Cretaceous beds are penetrated at 970 m with a thin layer of Maastrichtian age. The Cretaceous comprises about 375 m of the well, with a differentiated Early Cretaceous of about 185 m.

Black shales can be subdivided in Berriasian, Early Portlandian and Early Portlandian - Late Kimmeridgian. Top Jurassic (Early Portlandian) is set at 1345 m. Sandy deposits of Early Kimmeridgian to Late Callovian ages (about 85 m) and sands of Callovian, Callovian, Bathonian, Bajocian ages (about 325 m) occur between 1459 and 1902 m. These seem to have been deposited in shallow-marginal marine environments for the most part.

Aalenian to Late Toarcian coaly beds are penetrated at 1915.5 m and the well bottoms in Early Jurassic bedsof Toarcian age.

KEY WORDS/ STIKKORD

Norway	TROLL
31/6-2	Biostratigraphy

G2/haa/1/ems

CONTENTS AND SUMMARY STRATIGRAPHY 31/6-2

INTRODUCTION

STATOIL's well 31/6-2 is the fourth well to be drilled in evaluation of the hydrocarbon production potential of the TROLL-field after the 31/2 discovery. The exploration is by co-operation of Norsk Hydro a.s., Saga Petroleum a.s. and Statoil. The TROLL-field is situated in the northern North Sea, in the Hordaplatform area, in which IKU has gained considerable experience during biostratigraphical studies of several well on the blocks 31/2, 31/4 and 30/6.

The biostratigraphy of well 31/6-2 is based on analyses of ditch cuttings, sidewall cores and core chips.

Due to the fairly good coverage of sidewall cores and core chips from the Jurassic, the biostratigraphic zonation of this part of the well is to a large extent based on such samples. This has allowed a relatively good stratigraphic resolution, also in the Middle Jurassic taking into account the poor yield of fossils from some of these beds.

The sidewall coverage of the Paleocene and Cretaceous is relatively sparse, and division of these beds is therefore to a large degree based on fossil tops.

The ditch cuttings samples from the Cretaceous were for some intervals highly contaminated by content of resistant mud additives (lignosulfonate).

The well has been divided into intervals expressed in terms of standard stages/substages. These are to some extent interpretive and, particularly in the Middle/Upper Jurassic, we have laid more emphasis on describing and highlighting paleontological events/occurrences worthy of special note. We hope that these will be of value in local correlations and will continue this practice in the following well. The data resulting from this well enables refinement of the age designations of some of the "event-horizons". Revisions of datings of 31/6-1, 31/3-1 and 31/5-2 are given in the relevant parts of the text of this well.

Locations of palynomorphs representing important stratigraphic tops (primarily Cretaceous - Middle/Late Jurassic) have been fixed by England Finder references. We have also detailed specimens of "informal taxa" by this means. This will be presented in a special report.

Interval boundaries are based on paleontological evidence only, and are not adjusted to lithostratigraphic boundaries. A simplified kerogen differentiation has been carried out from Paleocene and down. Changes in kerogen composition are used for environmental interpretations.

Micropaleontological analyses were carried out by Løfaldli (Cretaceous, Jurassic), Skarbø (Quaternary, Tertiary) and Verdenius (Paleogene).

Palynological work was done by Bell (Upper and Middle Jurassic), Selnes (Tertiary, Cretaceous, Upper Jurassic and Vigran (Lower Jurassic).

The ditch cuttings lithology was described and logged by Bessesen. He also carried out descriptions of sidewall cores and core chips.

Final compilation of the report was carried out by Bell and Selnes.

From 1. January 1984, Bell, Selnes and Skarbø, have been under management of STRATLAB a.s., and were contracted by IKU after agreement with the operator, to carry out management of the project and biostratigraphic work on Tertiary micropaleontology and Tertiary, Cretaceous and Late/Middle Jurassic palynology.

The collaborators of the project wish to express their thanks to their contact persons in Statoil for their valuable co-operation during the work with this report.

STRATIGRAPHY

420 - 550 m EARLY PLEISTOCENE?

Lithology

The lithology down to 540 m is dominated by sand and gravel partly mixed with light olive grey clay. The sand and gravel consist mainly of quartz and rock fragments. The quartz appears mostly as light grey, fine to very coarse, subangular to rounded grains. Both crystalline and sedimentary rock fragments are common.

Minor amounts of shell fragments, foraminifera and pyrite are recorded. At approximately 540 m moderately brown siderite constitutes 50% of the lithology.

Micropaleontology

The interval is characterized by the distinct species Uvigerina sp. 1 together with Planulina ariminense and Sigmoilopsis schlumbergeri. The assemblages are poor to fairly rich and are mainly composed of calcareous benthic specimens with Elphidium excavatum and Bulimina marginata as the dominating species. Reworking of Cretaceous specimens are noted, particularly in the lower section. The lowermost sample also included reworked Early Tertiary microfossils.

The assemblages obtained from the ditch cuttings samples probably represent a mixing of faunas typical of cold and warm water environments. The cold water forms are represented by Cassidulina reniforme, Islandialla norcrossi/helenae, Stainforthia loeblichi, Nonion labradoricum, E. excavatum and B. marginata. The warm water forms are represented by Uvigerina sp. 1, P. ariminense, S. schlumbergeri, Trifarina angulosa, Bolivina sp. 1, Cibicides pseudoungerianus, Pyrgo bulloides and Textularia sagittula.

The presence of C. reniforme, Islandiella spp., N. labradoricum and S. loeblichi together with the absence of Cibicides grossa (a Late Pliocene marker) suggest a Pleistocene age for the interval. The Uvigerina specimens are distinct from the species usually representing the genus during Holocene/Pleistocene in the area (U. peregrina). The

sediment may thus be of an Early Pleistocene age, though evidence is weak.

Environment

Mainly cold water indicators tolerating some fresh water influx are recorded, reflecting glacial activity in adjacent areas. Varying content of normalmarine planktonic foraminifera and warm water benthic indicators probably reflects fluctuations of the sea level and different types of water masses during deposition.

560 m OLIGOCENE - EARLY MIOCENE

Lithology

The lithology consists of olive grey to brownish grey claystone together with the above described light olive grey clay/claystone and sand.

Micropaleontology

Ditch cuttings sample 560 m contained the first downhole Eocene assemblage interpreted to be in situ together with a significant component of caved Pleistocene specimens, and a number of reworked Cretaceous foraminifera. Additionally some very few fairly well preserved specimens, slightly light brownish stained, occurred. These were recognized as Stilostomella sp., Hoeglundina elegans and Sigmomophina regularis. The latter is restricted to Oligocene or Early Miocene. Presence of Stilostomella and the state of preservation is similar to the Oligocene faunas met in wells 31/31, 31/5-2 and 31/6-1. This favours an Oligocene age. However, S. regularis was not recognized in these wells and all the typical forms are missing in the present well. Thus we should not exclude the possibility of an Early Miocene age.

The interval containing these fossils is probably a thin horizon situated somewhat between 550 and 560 m.

Environment

The number of in situ specimens is too low to draw any wide conclusions. However, the fact that formainifera are present is evidence of a more or less marine environment. The poor assemblage probably excludes a normal marine salinity, thus an inner neritic to littoral environment is tentatively suggested.

560 - 640 m EARLY - MIDDLE EOCENE

Lithology

Light olive grey, olive grey and brownish grey claystone/siltstone are the main lithology in this interval. Minor amounts of light greenish grey claystone are present below approximately 580 m. Limestone is also present below 580 m and makes up 50% of the lithology from 610 to 620 m. The limestone is off-white to light grey, grainy, partly argillaceous and partly micromicaceous. This limestone is not recorded below 640 m. Very fine to very coarse sand is present in the uppermost part of this interval, but the amount gradually decreases downwards.

Micropaleontology

The three samples of this interval yielded a poor arenaceous foraminiferal assemblage with common accessories such as Inoceramus prisms, fish teeth, radiolarians, ostracods and fecal pallets. Several of these accessories are probably caved. Because of the presence of Ammolofene clavata an Eocene age is most probable; Cyclammina amplectens and common Caenosphaera sp. are in favour of Early Eocene age, possibly extending inn Middle Eocene. The presence of Dorothia principiensis and Kerreriella conversa can be correlated to similar occurrences in basal Eocene sediments of wells from the same area.

Comment

The ditch cuttings samples available in the upper section of the well are at 10 m intervals and detailed examination is not therefore possible. The uppermost sample (560 m) contained both Eocene and Middle

Tertiary fossils together with reworked Cretaceous immediately below sediments of presumed Quaternary age. There are several possible interpretations of these observations. The Middle Tertiary fossils may be derived from one or more thin horizons of Oligocene and/or Miocene age which occur in the "seeming" 40 m.y. non-sequence between 550 and 560 m. We cannot however exclude the possibility that the middle Tertiary and Cretaceous elements are both reworked into the Quaternary.

Environment

The assemblage is evidence of a marine deep neritic to bathyal environment.

670 - 965 m PALEOCENE

Lithology

Dark olive brown partly tuffaceous claystone/siltstone and tuff are the main lithologies from 640 m to 770 m. Medium grey to light grey and medium dark grey claystones make up the lithology from 770 to 880 m where olive grey to light olive grey claystone becomes dominant. The claystone is become slightly darker downwards and below 930 m the colour is olive grey.

Micropaleontology

A Paleocene age is assigned to the interval from the highest occurrence of Coscinodiscus sp. 1 downward. In this well, only one single specimen of Coscinodiscus sp. 1 was met at 670 m, consequently the level of confidence of the stratigraphic breakdown in not high. Down to 850 m the samples are very poor or nearly barren. At 820 m Bolivina is met that has some affinity to B. corkei. This specimen is probably caved. From 880 m to 940 m a slightly richer arenaceous foraminiferal assemblage is met. This has been observed in comparable intervals of preveiously analysed wells. The relative enrichment has no strict biostratigraphic meaning however.

Palynology

Palynological work commenced at 900 m where an ordinary Paleocene flora of relative low diversity were met with e.g. Glaphocysta ordinata plexus (which may include Areoligera medusetteformis and A. senonensis, Apectodinium augustum/hyperxanthum, Alisocysta rugolirata/circumtabulata, Ceratiopsis striata and Thalassiphora delicata.

Apectodinium augustum/hyperacanthum belong to Late Paleocene, but since it is only recorded in the cuttings samples 900 and 928 and not in the between lying SWC sample it may be caved.

Some reworking has obviously taken place during deposition of this interval, evidenced by occurence of Early Cretaceous and Jurassic species as Muderergia simplex and Nannoceratopsis pellucida.

At 950 m Ceratiopsis diebelii appears, a species which ranges from the earliest Paleocene (Danian) to Maastrichtian.

Environment

The faunal evidence is in favour of a marine, probably neritic to bathyal environment in the upper and middle parts of the section.

A consistant high yield of amorphous organic material characterizes the lower part of the interval. This point to oxygen deficiency near the bottom.

The common occurences of dinoflagellate cysts indicate open marine surface conditions with well aerated waters. Bisaccates, woody particles and coaly fragments are also common in the palynologically investigated parts of the interval, indicating some proximity to the coast. Representatives of the chloraphycean algae Botryococcus and Ulva are encountered from a few samples towards the base of the interval. Their appearance may be due to fresh water influence.

970 - 975 m MAASTRICHTIAN

Lithology

White and light brown limestone is the main lithology in the one sample from this interval. Medium grey to medium dark grey and olive grey claystones may comprise 20% of the sample.

Micropaleontology

A rich fauna of arenaceous and calcareous foraminifera is met in this unit. The arenaceous group includes species of Bathysiphon, Haplophragmoides, Ammodiscus, Pelosina, Glomospira and Dorothia. The calcareous benthonic element is mainly made up of nodosariids, polymorphiniids and species of Gavelinella, Osangularia, Bolivina, Reussella and Gyroidinoides. The planktonic foraminifera consist of Rugoglobigerina, Globigerinelloides and Heterohelix. The presence of Stensioeina pommerana, Bolivina incrassata, Reussella szajnochae, Heterohelix globulosa and Rugoglobigerina rugosa suggests that Maastrichtian sediments are penetrated. Inoceramus prisms are very common.

Palynology

Palynomorph yield did not contribute to the stratigraphic interpretation of this interval. The only SWC sample available was practically barren with respect to palynomorphs, and the ditch cuttings sample from 970 m yielded forms which equally well could be of Paleocene age, either as caved or by their indifferent Paleocene/Maastrichtian ranges.

Environment

An assemblage consisting of arenaceous and calcareous foraminifera together with large amounts of Inoceramus prisms suggests an open marine, neretic environment.

980 - 995 m CONIACIAN - TURONIAN

Lithology

The samples from this interval are contaminated by both abundant casing cement as well as mica and nut shell additives. However, the lithology consists probably of white glauconitic limestone and moderately brown marl. Grey to medium dark grey claystone may constitute 5% of the cuttings.

Micropaleontology

The uppermost sample of this unit yielded quite rich assemblages. The main part of the microfossils in this sample is thought to be caved from the Maastrichtian strata above. A few individuals of Marginotruncana marginata occur in this sample, and the presence of this species points to a deposition a Coniacian - Turonian age. Some of the samples from this sequence are quite rich in radiolaria and Inoceramus prisms.

Palynology

The upper limit of this interval is fixed by micropaleontological evidences. The record of Senoniasphaera cf. protrusa in the 985 ditch cuttings sample contributes only to a general Campanian - Turonian age, as this form is not thought to penetrate the Cenomanian. This species is the only palynological Cretaceous evidence of this sample, the other palynomorphs are suspected to be caved.

At 995 m (SWC) a rich and diverse dinoflagellate cyst flora are met with, dominated by Senoniasphaera protrusa, Odontochitina operculata, Xenascus ceratioides and Exochosphaeridium phragmites. Other important species are Cyclonephelium distinctum, C. hughessi, Palaeohystrichophora infusoroides, Surculosphaeridium longifurcaturm, Dinopterygium cladoides and Florentinia deanei.

C. hughesii and C. membraniphorum are thought to have tops in Turonian, and Florentinia deanei is not reported above the Coniacian. Surculosphaeridium longifurcatum does not extend above Santonian, but

regular occurences of this species are generally associated with Turonian and Cenomanian strata. The lower limit of this interval is tentatively set at the deepest SWC occurence of Senoniasphaera cf. protrusa at 995 m, combined with the top occurence of Florentinia mantelli in the sample below. The 995 m SWC sample may, however, on basis of the observations of Cyclonephelium hughesii and C. membraniphorum belong to the Turonian interval below.

Environment

The faunal content of the upper parts of the interval and the high yield of dinoflagellate cysts in the lower parts, point to deposition in an open marine environment.

Input of Micrhystridium/Veryhacium/acritarchs and microforaminifera together with amorphous organic material, indicate some stagnancy in the sea floor environment.

1005 - 1050 m TURONIAN

Lithology

The samples down to 1030 m are strongly contaminated by mud additives (mica and nut shells). However, the dominant lithology throughout the interval is recorded as medium grey to medium light grey calcareous claystone, partly grading to marl. The claystone is slightly micromicaceous and partly silty.

Micropaleontology

The poor microfauna consists of some calcareous and arenaceous foraminifera together with radiolaria and Inoceramus prisms. No comments as to the age and environment can be given.

Palynology

Florentinia mantelli appears at 1005 m and is regularly encountered downwards. This species has a known top of range in Turonian.

Between 1025 and 1050 m a characteristic assemblage is concerned with, which include Cribroperidinium "fimbriatum", Isabelidinium acuminatum, Senoniasphaera rotundata, Florentinia ferox, Adnatosphaeridium chonetum and dinoflagellate Incertae sedis forma A (Norvick & Burger 1975). To our experience this assemblage is indicative of a Late Cenomanian or Turonian age. We tentatively assign it a Turonian age, on the basis of the common occurrence of Isabelidinium acuminatum. This may be a correlative horizon and is in accordance with Turonian datings given in 31/6-1 and 31/3-1 (see 31/3-1 report p. 16) and Coniacian - Turonian dating in 31/5-2. One observation of Muderognia staurota may be due to reworking of Early Cretaceous beds.

Environment

A very high yield of dinoflagellate cysts point to deposition in an open marine environment. The oxygen supply to the sea floor seem to have been reasonably high, evidenced by abundant occurences of coaly fragments.

1060 - 1120 m CENOMANIAN

Lithology

As in the above interval medium grey to medium light grey very calcareous claystone is recorded as the main lithology. The claystone is slightly micromicaceous and partly silty. From 1080 to 1100 m abundant mica is noted (?additives).

Micropaleontology

A few individual of the planktonic genus Rugoglobigerina are met. Radiolaria and Inoceramus prisms also occur. The boundaries of this unit are wholly based on palynology.

Palynology

This section is characterized by a very high yield of dinoflagellate cysts represented by numerous taxa.

Cassiculosphaeridia reticulata appear at 1060 m. This species has a top in ?Campanian, but regular occurences seems to be consistant with a Cenomanian or older Cretaceous age. The appearance of this species is accompanied by a marked increase of Surculosphaeridium longifurcatum, Palaeohystrichophora infusoroides and Odontochitina operculata, which support a Cenomanian or Early Cenomanian/Late Albian age assignment.Cleistosphaeridium huguoniotii becomes common in this interval and grades into the similar species Chlamydophorella nyei from the abovelying strata. This shift in domination between these species is thought to happen in the Cenomanian.

There is one isolated observation of Litosphaeridium siphoniphonum at 1090 m. This species is not common above the Cenomanian.

Cyclonephelium hughesii is common throughout the interval, but is sparsely registered in a few ditch cuttings samples below. The SWC at 1127,5 m did not yield this species. Common and regular occurence of C. hughesii is typical of Turonian (where it probably tops) and Cenomanian. Early Cenomanian/Late Albian registrations are rather rare. A similar extention of this species is experienced in 31/6-1. In 31/3-1 C. hughesii was recorded from one sample in the Early Cenomanian/Late Albian section, but here in abundance.

Environment

The extremely rich dinoflagellate cyst flora represents deposition in an open marine environment with good living conditions for phytoplankton.

Amorphous organic material is consistently recovered from the interval and indicates some reduction in oxygen supply near the bottom.

1127,5 - 1175 m EARLY CENOMANIAN/LATE ALBIAN

Lithology

At 1122.5 m a light grey silty marl appears and becomes the main lithology below 1130 m. The medium grey to medium light grey calcareous claystone described above are not recorded below 1145 m. From 1170-77 light brown marl is the main lithology.

Micropaleontology

A very rich microfossil fauna mainly made up of calcareous and arenaceous foraminifera together with large amounts of Inoceramus prisms is present in this unit. The foraminiferal assemblages are dominated by species of planktonic individuals, in this case species of Hedbergella. The calcareous benthonic element includes species of Gavelinella, Gyroidinoides together with polymorphinids and nodosariids. The arenaceous group is dominated by species of Ammodiscus, Bathysiphon, Haplophragmoides, Ammobaculites, and Glomospirella. The richness in species of Hedbergella together with Whiteinella brittonensis, Gavelinella baltica, Eggerellina marinae, and Lingulogavelinella globosa suggests a Cenomanian-Late Albian age.

Palynology

A marked decrease in palynomorph yield takes place between 1120 and 1127,5 m. Litosphaeridium siphoniphonum is commonly in the 1127,5 m sample and is regularly encountered below. Regular and common occurrences of this species point to an Early Cenomanian/Late Albian age. This age assignment is supported by regular records of Hexagonifera chlamydata from 1127,5 m and downwards.

Also of note are the regular and/or common occurrences of Stephodinium coronatum, Palaeohystrichophora infusoroides and (lower in the interval) Disphaeria munda and Aptea eisenacki. Most of these species are typically Early Cenomanian/Late Albian.

Environment

The richness in planktonic foraminifera points to a deposition in an open marine, neritic environment.

1185 - 1225 m ALBIAN

Lithology

Medium grey to medium light grey claystones/marls dominates the lithologies in this interval, together with increasing amounts of light olive grey claystone. Dark reddish brown to moderate brown claystone is present below 1200 m.

Micropaleontology

The fauna in this unit resembles the assemblages found in the unit above. However, new elements come in at 1185. The presence of the species Haplophragmoides chapmani, Reophax minuta and Uvigeranimunina sp. 1 suggests that Haplophragmoides concavus and Plectorecurvoides together with rich occurrences of Glomospira and Ammodiscus is further evidence of a general Albian-Aptian age. Radiolaria, ostracoda and Inoceramus prisms occur. Inoceramus prisms are particularly common in the lower part of the sequence.

Palynology

The record of Apteodinium grande (common) and Deflandrea gallia at 1190 m indicates the penetration of Albian deposits. These species are thought to be confined to the Late Albian. Lithodina stoveri, which occurs in the same (ditch cuttings) sample generally tops below A. grande in the lowermost Late or Middle Albian. L. stoveri is present fairly regularly throughout the interval. These records suggest a Late or Middle Albian age for the greater part of this interval.

The record of Ovoidinium verrucosum lower in the well (presumed caved at 1230 m) does, however, suggest the presence of latest Albian at some

level in the well. The most noteable feature of the interval is the regular and abundant/common occurrence of Oligosphaeridium dictyophorum.

Environment

Richness in arenaceous foraminifera of the genera Glomospira and Ammodiscus together with quite high content of planktonic foraminifera and Inoceramus prisms suggests a deposition in a neritic environment. This is supported by the fairly high content of dinoflagellate cysts.

1230 - 1270 m BARREMIAN - HAUTERIVIAN

Lithology

The marls and claystones described above, are the main lithology throughout this interval. Dark reddish brown to moderate brown, light olive grey and medium grey to medium light grey are the dominant colours. From 1240 to 1280 m abundant mud additive (mica) strongly contaminates the samples.

Micropaleontology

A rich fauna of benthonic foraminifera is present in this sequence. Planktonic foraminifera are also very common in the uppermost part. The arenaceous element of the fauna includes species of Bathysiphon Haplophragmoides, Ammodiscus, Glomospirella, Ammobaculites, Trochammina and Glomospira. There is an increase of nodosariids from the unit above. The occurrence of the species Gavelinella barremiana, Globorotalites bartensteini, Lenticulina wisselmanni, Valvulineria gracillima and Marginulinopsis gracilissima indicates a Barremian - Hauterivian age. Inoceramus prisms are common especially in the upper portion. Radiolaria ostracodes and fish teeth occur.

Palynology

A Barremian or older Cretaceous age is suggested at 1230 m by the record of Sirmiodinium grossi and Pseudoceratium pelliferum at

1257 m. The section is otherwise poor with respect to dinoflagellate cysts. The only SWC available is unreliable as it yielded an Upper Jurassic dinoflagellate cyst assemblage with Glossodinium dimorphum, Chlamydophorella membranoidea and Gonyaulacysta "portlandiense".

Environment

A considerable increase in amorphous organic material takes place at 1230 m. This indicates restricted bottom conditions. However, the representation of this kerogen type must also be seen on the background of the possible reworking of Upper Jurassic black shales into this section.

The faunal yield is indicative of deposition in an open marine neritic environment.

1275 - 1294 m VALANGINIAN

Lithology

Light olive grey claystone is the dominant lithology in this interval. Medium grey to medium light grey and dark reddish brown to moderate brown claystones/marls are also common. Minor amounts of light brown marl appear below 1280 m. The samples are slightly contaminated by mica (additive).

Micropaleontology

A quite rich assemblage of calcareous and arenaceous foraminifera together with radiolaria, echinoid stems and Inoceramus prisms is present in this unit. The fauna consists much of the same species as found in the unit above. The increase of the calcareous genus Lenticulina from 1275 m is usually associated with Valanginian deposits.

Palynology

A rich and diverse dinoflagellate cyst flora is obtained from this section. Among the observed forms can be mentioned:

Pseudoceratium pelliferum, Sirmiodinium grossi, Dingodinium cerviculum, Heslertonia heslertonensis, Phoberocysta neocomica, Systematophora schindewolfii, Batioladinium radiculatum, Tubotuberella apatela, Scriniodinium pharo, Occisucysta sp. A (Davey 1982) and Gochteodinia villosa.

Although the possibility of reworking should be taken into consideration, we consider the record of Gochteodinia villosa at 1280 m (top in Late Ryazanian - ?Early Valanginian), Tubotuberella apatela at 1294 m and Ctenidodinium elegantulum at 1294 m (base in Valanginian) as evidence of a Valanginian age. Also of note are the occurrence of Scriniodinium pharo and Occisucysta sp. A Davey 1982 (? = O. cf. evittii of other authors) at 1294 m.

Enviroment

A deposition in a neritic environment is most probable on basis of faunal content.

Amorphous organic material is common in the entire section. This is generally associated with slightly anoxic bottom conditions. However, we suspect reworking of the black shales, and some of this material could be derived.

1302,5 - 1315 m VALANGINIAN - BERRIASIAN

Lithology

The lithology of this interval does not differ significantly from the above interval. However, minor amounts of siderite are recorded below 1310 m and contaminants are not noted.

Micropaleontology

No new elements were noted in micropaleontological preparations from this interval.

Palynology

This is palynologically an interstitial zone delimited downwards by the top of obvious Berriasian taxa and upwards by the bottoming out of species which are not usually encountered from Berriasian (see comments in the foregoing section).

The interval is poorly represented by palynomorphs, and the only SWC available did not contribute to the stratigraphical interpretation.

1325 - 1344,5 m BERRIASIAN

Lithology

A dark grey fissile, laminated and carbonaceous claystone appears at approximately 1330 m (in SWC at 1326.5 m) and becomes the main lithology below 1347.5 m. The claystone is slightly micromicaceous and partly silty. The claystones and marls described in the above interval are common (?cavings).

Micropaleontology

A relatively rich microfossil fauna is registered in this unit. These microfossils consist of calcareous and arenaceous foraminifera together with radiolaria, ostracodes and Inoceramus prisms. The calcareous genus Lenticulina is common in the uppermost sample. A part of the fauna is thought to be caved. The presence of Haplophragmoides cf. canui, Haplophragmoides cf. infracalloviensis and cone-shaped radiolaria suggests a Berriasian or Late Jurassic age for this unit.

Palynology

A relatively rich and diverse dinoflagellate cyst flora is met with in this interval. Important species are: Batioladinium pomum (common to abundant), B. radiculatum, Dingodinium spinosum and Egmontodinium expiratum.

The lower limit of the interval is set at the SWC base of Batioladinium pomum and B. radiculatum which have a base in the Berriasian. These species are reported to have a top in the Berriasian (Davey 1982) though this is not well established.

Dingodinium spinosum, which has a top occurence in this well at 1326 m, seems to have a relatively well established top in the Berriasian.

Egmontodinium expiratum at 1344,5 m is not reported above Berriasian. Pseudoceratium pelliferum is noted at 1335 m (cuttings), If in-situ, this would imply a probable Late Berriasian age.

Environment

The very high content of amorphous organic material points to oxygen deficiency near the bottom during deposition, while the surface waters have provided good living conditions for dinoflagellates.

The recovery of woody tissue, bisaccates, nonsaccate pollen and spores is remarkable high in this interval, indicating proximity to the shore.

A deposition in a marginal marine to inner neritic environment is therefore concluded.

1345 - 1411 m EARLY PORTLANDIAN (=UPPER MIDDLE VOLGIAN, BOREAL USEAGE)

Lithology

Dark grey fissile, laminated and carbonaceous claystone are the main lithology of this interval. The claystone is slightly micromicaceous and partly silty. The above claystone and marls are present down to 1400 m where abundant casing cement are recorded.

Micropaleontology

The microfossil content consists of two elements, one is the caved individuals from the strata above, the other is the original fauna. The last-mentioned group includes species of Haplophragmoides and various

types of radiolaria. Haplophragmoides cf. excavatus is a common species. The presence of cone-shaped radiolaria together with Haplophragmoides cf. canui, H. cf. infracalloviensis and H. cf. excavatus indicate a Berriasian or Late Jurassic age. However, the occurrence of common H. cf. excavatus has in previous "Troll" wells been associated with Jurassic, Early Portlandian deposits. We therefore set the upper limite at 1345 m.

Palynology

The upper limit of interval is fixed by micropaleontology. A relatively rich and varied microflora is met with in the 1360 m SWC sample. The greater part of the palynomorphs are longranging Early Cretaceous/Upper Jurassic forms.

Evidence of an Early Portlandian age is provided at 1360 m by Egmontodinium polyplachophorum, which has its first downhole occurrence in this sample. This species is known to range from the latest Early Portlandian into Kimmeridgian. The lowermost SWC occurence of Gochteodinia villosa, in the 1411 m sample, is used to define the base of the interval. The species Dingodinium spinosum and Egmontodinium expiratum have bottom of range in the latest part of Early Portlandian. The two latter are in this well restricted to the 1360 m sample. Wallodinium krutzchii is regular throughout the interval, and is not observed below 1411 m.

The first downhole common occurrence of the chlorophycean algae Pterospermella is at 1360 m. This species is often associated with latest Jurassic deposits, but is probably facies related.

Other improtant constituents of the flora are: Sirmiodinium grossi, Chlamydophorella membranoidea, Hystrichodinium pulchum, Cyclonephelium distinctum, Scriniocassis dictyotus, Senoniasphaera jurassica, Glossodinium dimorphum and Caddosphaera halosa.

The interval can be divided in two biozones on basis of marked changes in floral composition.

I) 1360 - 1390 m

This zone is characterized by common occurrences of Pterospermella and regular observations of Tasmanites and large sphaeromorphs. These plant fossils may, however, be of restricted regional correlative value, since they are thought to be environmentally controlled.

The diversity of dinocysts are moderate. Characteristic features are common and regular occurences of Hystrichodinium pulchrum and Chlamydophorella membranoidea, together with a cyst combination of latest Early Portlandian age (Gochteodinia villosa/Egmontodinium polyplacophorum/E. expiratum/Dingodinium spinosum).

II) 1399 - 1411 m

Typical for this zone is the common to abundant yield of a highly diverse dinoflagellate cyst flora.

Tasmanitides have scattered occurrences in this zone.

In the 1399 m SWC sample Senoniasphaera jurassica and Glossodinium dimorphum add to the species listed in zone I. Ctenidodinium panneum appears at 1410 m, but is only registered from ditch cuttings samples in this well. These species have top of range in Early Portlandian.

Caddosphaera halosa becomes regular from 1399 m and downwards, though does not seem to occur in the abundance with which it is recorded in other wells. The common and only occurrence of Scriniodinium sp. A (Ioannides et al.) and the abundance of G. longicornis in the 1399 m sample should be noted.

The lowest registration of Gochteodinia villosa overlaps with the top of G. mutabilis in the 1411 m sample (these species probably intergrade). Since G. mutabilis in the previous TROLL-reports is used for delimiting the next interval upwards, we here maintain this convention. Hence the 1411 m sample represents both top and bottom of these neighbouring intervals.

Environment

The presence of planktonic radiolaria and common dinoflagellate cysts indicate a marine environment with well circulated surface water. The high content of amorphous organic material indicate oxygen deficiency at least near the bottom.

Micrhystridium/Veryhacium occurs sporadically and in low numbers. Bisaccates, spores/nonsaccates, cuticular material and woody tissue vary from common to present. This may point to deposition in a shallow near shore low energy environment.

1411 - 1453 m EARLY PORTLANDIAN - LATE KIMMERIDGIAN (=MIDDLE TO EARLY VOLGIAN, BOREAL USEAGE)

Lithology

Down to 1435 m the dark grey carbonaceous claystone described above is recorded as the main lithology. The interval below 1455 m is cored. The claystone becomes more silty and contains very fine sand. Below about 1450 m glauconite is recorded (see core descriptions).

Micropaleontology

The microfossil content resembles the assemblages found in the unit above. Some of the fauna may be caved. The supposed in-situ fauna includes species of Haplophragmoides and cone-shaped radiolaria. (Lithostrobus, Dictyomitra). These radiolaria are common in all samples investigated. The richness in these forms may point to an Early Portlandian - Kimmeridgian age.

Palynology

The upper limit of this interval is defined on the first downhole observation of Gochteodinia mutabilis at 1411 m. This species is essentially a Kimmeridgian/earliest Portlandian species. As mentioned above it co-occur with G.villosa in this sample. The bottom of range of

G. villosa is relatively well established in the upper part of the Early Portlandian and is replaced by G. mutabilis in the lower part of the Early Portlandian.

A characteristic feature is the income of dinocyst which we have referred to Rhombodella ?sp. at 1411 m. This form is similar to Atopodinium prostcatum (Drugg 1978), and ?Maduradinium sp. A Davey 1978.

Acanthaulax sp. A (Ioannides et al.) and Egmontodinium ovatum appear at 1426 m. The latter is known from the earliest part of Early Portlandian and the Late Kimmeridgian. E. ovatum is also noted at 1448.45 m.

Oligosphaeridium pulcherimum (sensu Raynaud/Ioannides et al.) is met at the 1435 m level and downwards. This species and Acanthaulax sp. A are essentially Late Kimmeridgian.

A noticeable change in kerogen yield takes place between 1426 m and 1435 m. The kerogen composition above 1426 m is similar to that of the interval above, with abundant amorphous material, common dinoflagellate cysts, bisaccates, spores and microforaminifera.

Below 1426 m a marked decrease in amorphous material, microforaminifera, dinoflagellates and bisaccates take place, giving way to a corresponding increase in woody particles and coaly fragments. A corresponding change was also noted in wells 31/6-1 and 31/5-2. We are, however, uncertain if this is correllatable, time equvalent event.

A number of species bottom out in the 1426 m sample; e.g. Hystrichodinium pulchrum and Chlamydophorella membranoidea.

The lower part of the interval yielded much poorer floras. The lower limit is set at 1453 m at which level Gonyaulacysta cf. perforans is recorded. This is the same species as recorded in the equivalent interval in well 31/5-2 (see encl. 4 of 31/5-2). The 1453 m sample also yielded Gonyaulacysta jurassica, indicating a level well down in the Late Kimmeridgian for this sample.

Environment

The samples from 1411 m to 1426 m can hardly be separated from the interval above with respect to kerogen composition. They might represent a shallow nearshore marine environment with anaerobic conditions near the bottom, but with well circulated surface waters which have ensured good living conditions for dinoflagellate cysts.

The kerogen composition below 1426 m, with low yield of amorphous, point to deposition under some oxygen support near the bottom. Increase in coaly particles is connected with environments where the organic sediments have been available for microbial and chemical decomposition. This is consistant with a relative high energy during deposition.

1459.45 - 1482.7 m EARLY KIMMERIDGIAN (= KIMMERIDGIAN, BOREAL USEAGE)

Lithology

The 1457.65-.70 core chips consist of a greenish black glauconite sandstone, and marks a change in the lithology from the shale above to sandstone. A high content of galuconite is present in the samples down to 1460 m. This decreases downwards and glauconite is not recorded in core chips below 1470 m (see core descriptions).

Micropaleontology

With the exception of some few cone-shaped radiolaria, Haplophragmoides spp. and H. cf. excavatus this interval is barren of microfossils. If insitu these would suggest a Portlandian or Kimmeridgian age.

Palynology

Penetration of deposits of Early Kimmeridgian or older age is indicated at 1459.45 m (core) by the record of Stephanelytron scarburghense and Sentusidinium "minimum". These are thought to top in the Early Kimmeridgian though do extend down into older strata. The absence of species characterising Oxfordian or older deposits does however, imply

a Kimmeridgian age. Moreover, Systematophora areolata was recorded from the same sample and this species is not thought to occur commonly in the Oxfordian.

Hystrichogonyaulax cladophora (Early Kimmeridgian and older) occurs sporadically (often fragmentary specimens) from 1460.35 m and a possible record is made at 1457.65 m. The 1457.65 m sample is rather similar with respect to palynofacies and lithology (glauconitic sand) and should probably be included within this interval. However, as definite fossil evidence is lacking we set the top of the interval at 1459.45 m.

The interval is extended down to the 1482.7 m core at which level an unidentified cyst termed Paralecaniella? sp. occurs abundantly. This occurrence is probably controlled by facies though may be useful as a local correllation parameter. This species also occurs in well 31/5-2 (see note on p. 29 of 31/5-2 report) and in well 31/6-3 (report in prep.). We tentatively suggest that these horizons may be correllatable.

The horizon is dated as Early Kimmeridgian to preserve unity with well 31/5-2 though the evidence is not conclusive:

- the record of Systematophora of areolata in the same sample weighs in favour of a Kimmeridgian age.

- Meiourogonyaulax "membranipilaris" also occurs at 1482.7 m. The total range of this species is unknown, though in 31/5-2 it occurs immediately below the Paralecaniella? sp. horizon together with species suggesting a Middle to Late Oxfordian age (Scriniodinium galleritum + Acanthaulax venustra).

Despite the uncertainty over the exact stratigraphic age the bloom of this species combined with the presence of M. "membranipilaris" at about the same stratigraphic level in the two wells suggests time equivalence of the horizon.

Environment

The uppermost sample from this interval contains common dinoflagellate cysts and the main kerogen component consists of coaly fragments. The lithology consists of glauconitic sandstone with some traces of bioturbation. These factors suggest shallow marine conditions. An abundance of glauconite is sometimes associated with areas characterised by little or no detrital sedimentation and this could therefore represent a condensed sequence or a minor non-sequence.

Lower in the interval, marine dinoflagellate cysts are rare and often fragmentary, gluconite is not recorded and the sands become more micaceous. The main kerogen component is woody tissue which consists mostly of cortex-like material. This suggests shallow, inshore conditions. The 1482.7 m is dominated by a single species which we have termed Paralecaniella? sp. The environmental significance of this is uncertain though Elsik (1977, Palynology) considers that Paralecaniella sensu stricto from the Paleocene is indicative of marginal marine conditions. This would seem consistent with the kerogen and lithological characteristics of the lower part of the interval.

1484.25 - 1523.13 m ?EARLY KIMMERIDGIAN (= ?KIMMERIDGIAN, BOREAL USEAGE)

Lithology

This interval is cored and consists of fine-medium grained olive grey sandstone. The sandstone is very micromicaceous and contains black claystone laminae and argillaceous partings.

Micropaleontology

Microfossils were not recorded from this interval and hence no comment can be made.

Palynology

There is practically no evidence for the dating of this interval. The record of Stephanelytron scarburghense at 1504.14 m implies only an Early Kimmeridgian or older age and is inconclusive. The general character of the palynofacies and paucity of microplankton is otherwise similar to that of the lower part of the above interval and differs from the richer floras recorded in the samples below. A tentative ?Early Kimmeridgian age is therefore proposed.

Environment

Marine dinoflagellates are almost entirely lacking though there are some few rare occurrences together with occassional Micrhystridium/Veryhachium acritarch. This suggests at least some connection to the sea. The main kerogen elements consist of cuticle, coaly fragments and woody tissue of which cortex-like material is dominant in the upper part of the interval, down to 1504.14 m. Inshore, probably marginal marine conditions seem likely. There is a minor facies change between 1504.14 and 1523.13 m and cortex-like material is not recorded in significant quantities from the 1523.13 m sample which otherwise resembles material from the interval below.

1529.95 - 1544.8 m OXFORDIAN

Lithology

This interval is cored and consists of a very fine-medium grained, light olive grey sandstone. The sandstone is interlaminated with black carbonaceous and micaceous laminae. Shell fragments are recorded in the 1529.95 core chip (see core description).

Micropaleontology

Microfossils were not recorded from this interval and again, no comment can be made.

Palynology

Penetration of Oxfordian deposits is indicated at 1529.95 m by the record of Scriniodinium galleritum and Rigaudella aemula. These species are not thought to extend up into the Kimmeridgian. Nannoceratopsis pellucida (top in the basal Kimmeridgian) is also recorded from the 1529.95 m sample. The two samples represented by this interval are otherwise poor in microplankton and the assemblages recorded do not allow dating to sub-stage (i.e. Late/Early) level.

Comment

Deposits from around the Oxfordian - Kimmeridgian boundary seem to be of marginal marine character and contain very few useful stratigraphic fossils. We note that the ?Early Kimmeridgian dating of the interval above is tentative and to some extent arbitary in order to maintain consistancy with earlier reports. The occurrence of marine fossils which we have used to define "top Oxfordian" could therefore merely be a reflection of the onset of more marine conditions. That is: the lack of common marine fossils prevents certain identification of the Oxfordian - Kimmeridgian boundary. We have here adhered to our earlier practice and used the first downhole occurrence of S. galleritum and/or R. aemula as defining "top Oxfordian" and hope that this will avoid confusion.

Environment

Conditions were probably similar to the lower part of the above interval: marginal marine though marine elements are more common and cuticular material and woody tissue less common, possibly suggesting somewhat higher energy conditions.

1544.8 - 1576.65 m EARLY OXFORDIAN - LATE CALLOVIAN

Lithology

The coring continues throughout this interval, and the core chips consist of sandstones. The sandstones vary from light olive grey to dark olive grey, and are micromicaceous and partly very argillaceous. Lamination, flaser- and lenticular bedding are recorded. At approximately 1550 and 1560 m there is recorded a very dense, very calcareous sandstone, containing abundant shells and shell fragments (see core descriptions).

Micropaleontology

Apart from some coneshaped and spherical radiolaria (?caved) the only microfossils recorded were Bathysiphon spp., Lagena sp. and some few Polymorphinids. These may be caved and do not enable any stratigraphic conclusions.

Palynology

Assemblages are much richer in dinoflagellate cysts than in the intervals immediately above and below and the uniformity of the assemblage makes this quite a distinctive unit. The main elements are Hystrichogonyaulax cladophora, Gonyaulacysta jurassica, Scriniodinium galleritum, S. crystallinum, Rigaudella aemula and Escharisphaeridia pocockii. Most of these species are present consistently and are common at several horizons. The assemblage as a whole is typical of the Early Oxfordian - Late Callovian though most of the above elements are not restricted to these sub-intervals.

The top of the unit is set at the uppermost occurrence of these distinctive assemblages. More age restricted species include:

- Gonyaulacysta jurassica longicornis at 1547.48 m

- Gonyaulacysta scarburghense/areolata (= Acanthaulax senta) at 1561.8 and 1567.45 m. This species is restricted to the Early Oxfordian and the upper part of the Late Callovian.

Less well known species but which are nevertheless important in view of their occurrence in this interval in the other "Troll" wells include:

- Sentusidinium "minimum". This also occurs regularly in the equivalent interval in 31/6-1 and fairly regularly in 31/5-2.

- Meiourogonyaulax cf. callomonii at 1545.81 and 1554.65 m. This is the same M. cf. callomonii as in 31/6-1 (see enclosure 4 of 31/6-1) and the two occurrences may be approximately time equivalent.

- Meiourogonyaulax "reticulate periphragm" at 1545.81 and 1554.65 m. This species also occurs in well 31/5-2 though there is less certainty regarding the time equivalence.

Other occurrences of note which may be of value in local correllations are:

- Escharisphaeridia pocockii at 1544.8-1552.45 m. This species occurs in 31/6-1 (see enclosure 4 of 31/6-1).

- The common occurrence of Rigaudella aemula at 1544.48-1552.45 m and 1571.6-1576.65 m. Achmes of this species are noted in the previous wells (31/6-1, 31/3-1, 31/5-2).

- The occurrence of Gonyaulacysta jurassica longicornis.

It should be noted that these are only suggested possible correllation parameters and more detailed study is required to confirm of deny these.

The base of the interval is drawn at the lower limit of the distinctive assemblages and coincides with the (local) bases of R. aemula, S. crystallinum and (apart from one possibly anomalous record) of Scriniodinium galleritum.

Environment

The lithology of this unit consists mostly of fine to medium micaceous sands showing traces of crossbedding and common shelly macrofossil debris at some horizons. Dinoflagellate cysts are common throughout the interval. The main kerogen components are woody tissue and coaly fragments though cuticular material is common at the base and top of the interval and cortex-like material is common in the 1564.45 and 1571.60 m cores. There are several minor facies changes down through the interval. These factors suggest an essentially shallow marine deltaic type of environment probably with changing conditions and not too far from shore. There is a major facies change at the base of this interval.

1579.35 - 1720 m CALLOVIAN (MOSTLY MIDDLE, N.B., SEE COMMENTS!)

Lithology

The interval is cored down to 1619 m. The core chips show medium dark grey-dark grey sandstones. The sandstone is partly very calcite cemented and contains occasionally abundant shell fragments. It is also partly very argillaceous and very micaceous (see core descriptions). The cutting samples from 1619 to 1720 m consist of sandstone and 20-50% medium dark grey - dark grey claystone. The claystone, however, is very fine-medium grained light olive grey sandstone. The sandstone is slightly micaceous partly calcareous and very friable.

Micropaleontology

The poor fauna recovered from this interval is probably caved, though Haplophragmoides spp., which occur fairly regularly could be in situ. Some crinoid stems were also noted at 1690 m. This does not allow any stratigraphic conclusion to be drawn.

Palynology

Assemblages recorded from this interval are poor throughout and there is no sound basis for dating other than the juxtaposition of better

dated intervals above and below and comparison with other wells. In general the poor assemblages, punctuated by sporadic (in this well rare) occurrences of Sentusidinium spp., Meiourogonyaulax spp. and Ctenidodinium spp. are characteristic of the equivalent intervals in 31/6-1, 31/3-1 and 31/5-2.

Of particular note with regards to correlation is the occurrence at 1579.35 m (the uppermost sample) of Sentusidinium "membranigranulosum". This species occurs in a seemingly identical stratigraphic position in well 31/5-2 (see enclosure 5, well 31/5-2) and this occurrence is probably of significance: the two occurrences may be time equivalent.

Also of note is the occurrence of Pareodinia prolongata at 1686 m.

Comments

This interval is dated as Callovian (mostly Middle) due to the occurrence of species denoting an age around the Middle/Early Callovian boundary in the sample immediately below its base. This implies that the age of the present (1479.35-1720 m) interval is probably of mostly Middle Callovian age, at least in this well. In wells 31/6-1, 31/3-1 and 31/5-2 the equivalent interval is designated as: Callovian (mostly Middle to Early). The present evidence suggests that this should be revised to Callovian (mostly Middle).

Environment

Marine dinoflagellate cysts are rare throughout this interval though sporadic occurrences in most samples do indicate open connection with the sea. The main kerogen component is woody tissue of which cortex-like material is an important element in most samples. Cuticular material is also common at most levels. An inshore marginal marine deltaic depositional site with open connection to the sea is suggested. The poor microfaunas and occassional macrofossils debris (crinoids) also support a marginal marine or inner neritic environment.

1726 m MIDDLE - EARLY CALLOVIAN (N.B. SEE COMMENTS!)

Lithology

One sidewall core: Sandstone, light olive grey-olive grey, very fine to medium grained, partly argillaceous, friable, slightly micaceous, non calcareous.

Micropaleontology

This interval is represented by a single sidewall core sample which was insufficient for micropaleontological analysis after preparation for palynology.

Palynology

A rich assemblage was recorded from the single sample representing this interval and this contrasts markedly with the intervals above and below.

The most noteable features are the common occurrence of Chytroeisphaeridia hyalina, C. cerastes and the (rare) occurrence of Stephanelytron cf. sp. A Stover et al. and Stephanelytron sp. According to Riley and Fenton 1982 and Raynaud 1979 C. hyalina and C. cerastes have an achme in the upper part of the Early Callovian. Similarly, according to Stover et al. 1977 and Raynaud 1979 the genus Stephanelytron has a base in the Middle Callovian or possibly (Raynaud) the upper part of the Early Callovian. This is a distincitve genus and its base is considered relatively well established.

This implies that the age of this sample is probably close to the Middle/Early Callovian boundary and is accordingly dated as Middle/Early Callovian.

Other occurrences of note are the record of common Sentusidinium "spongiosum" and the lowermost record of Gonyaulacysta jurassica and Sirmiodinium grossi (SWC) the latter two species have a base in the upper part of the Bathonian.

Comment

The evidence for the dating of this sample is outlined above. The assemblage recorded is distinctive, probably represents a local facies development and may well be time equivalent on a local basis. This facies, containing similar elements has been noted in the previous "Troll" wells:

31/6-1: The inverval designated "Early Callovian" contains very common C. hyalina and S. "spongiosum" and the assemblage is otherwise similar to that of the present interval in 31/6-2.

31/5-2: The interval designated as "E. Callovian? - Bathonian" contains a rich assemblage including common C. hyalina, C. cerastes and S. "spongiosum".

31/3-1: The interval designated as "E. Callovian? - Bathonian" contains a rich assemblage including common S. "spongiosum" (this was logged on Enclosure 5 as Sentusidinium? "microgranulate/spongy" wall and in part as Meiourogonyaulax deflandrei before our designation of S. "spongiousum" as an informal species.

The 31/6-1 and 31/5-2 horizons bear a strong resemblance to the 1726 m sample in 31/6-2 and we suggest that they may be equivalent. The datings should therefore be revised. The 31/3-1 horizon is also similar though the resemblance is less striking and we are less certain as to the equivalence. The paleontological evidence does though provide "back up evidence" if there are other correllation parameters available.

Environment

Similar to the above intervals, shallow - marginal marine. The abundance of dinoflagellate cysts suggests a minor marine incursion at this level.

1735 - 1775 m EARLY BATHONIAN

Lithology

The interval consist of light olive grey sandstone and very fine to very coarse grain is recorded. 5-10% medium dark grey to dark grey claystones are recorded throughout (?caved) together with minor amounts of limestone.

Micropaleontology

Microfossils recovered from this sequence are presumed to be caved.

Palynology

The record of Meiourogonyaulax valensii (sensu Fenton 1981) in the 1735 m ditch cuttings and 1745 m sidewall suggest penetration of Early Bathonian or older strata. Also of note is the occurrence of Aldorfia aldorfensis at 1735 and 1755 m. These species also extend down into the Late Bajocian though the absence of Bajocian species (see below) suggest an Early Bathonian age. M. valensii also occurs in well 31/3-1 and there is a suspected occurrence in 31/5-2. In both of these wells the occurrence seem to be at an equivalent stratigraphic level.

There are few other noteworthy records and some of the cuttings samples are hevaily contaminated by uphole material.

Environment

Organic recovery is somewhat lower in this interval than in the above intervals. Cuticular material is less common though the main kerogen component is woody tissue of which cortex-like material is a significant component. Marine dinoflagellates are present sporadically. A shallow - marginal marine environment is suggested. A non-sequence of some magnitude is implied between the present interval and the interval above.

1783 - 1902 m BAJOCIAN (LATE?)

Lithology

Sandstone varying from offwhite to olive grey dominates this interval. The sidewall cores indicate a grainsize varying from very fine to coarse. However, in the cutting samples, very fine to very coarse sand is present throughout the interval. Dark grey argillaceous lenses are recorded and limestone may occasionally constitute 20-30% of a cutting sample.

Micropaleontology

A poor fauna consisting of Haplophragmoides spp. Trochammina sp., Lagena sp., Haplophragmoides cf. excavatus and some few radiolaria were recovered. Most of these could be caved.

Palynology

A Bajocian age is suggested at 1783 m by the abundant occurrence of Meiouogonyaulax superornata. To date this species has only been recorded in Late Bajocian deposits and we conclude that a Late Bajocian age is most likely at least at this level. Valensiella vermiculata and V. ampula, recorded between 1783-1820 m and in the 1895 m cuttings sample are also thought to be Late Bajocian and younger. In the lower part of the interval Ctenidodinium gochtii is quite common and occurs regularly between 1831 and 1895 m. This is also thought to be Late Bajocian and younger though as there is limited sidewall control we do not know if these are caved or not.

Comment

Most of the forms recorded point to a Late Bajocian age for this interval. If this is so a minor non-sequence is implied between the base of this interval and the top of the interval below. However, Early Bajocian palynological assemblages are very poorly known. Hence although the species noted above have not been recorded from the Early Bajocian we cannot with any degree of certainty state that they do not extend into the Early Bajocian and cannot therefore exclude the possibility of an Early Bajocian age.

N.B. Early Bajocian as used here is NOT EQUIVALENT to the Aalenian but to the (now outmoded) English Middle Bajocian. Thus:

Terminology used in "Troll" reports	Alternative terminology (not used here)
Late Bajocian	Late Bajocian
Early Bajocian	Middle Bajocian
Aalenian	Early Bajocian

Environment

Marine dinoflagellate cysts are generally more common than in the above interval and there are traces of amorphous matter in the kerogen preparations. However, this is probably derived from limestones and probably does not imply any restriction in the circulation. The main kerogen components are again woody tissue and coaly fragments though organic recovery is generally fairly low and cortex-like material is no longer a dominant aspect of the woody tissue. This could imply a slightly more distal depositional site though spores are relatively common at some horizons. Tasmanitid alga are present between 1805-1831 m. These are marine organisms though often occur in slightly abnormal salinities. Coarse sandstones and gravel sized material are present at several levels, particularly towards the base suggesting relatively high energy probably oxidising environment.

1915.5 - 1950 m AALENIAN TO LATE TOARCIAN

Lithology

Down to 1930 m the lithology consists of sandstone similar to the above interval together with some coal fragments. From 1930 to 1940 m 50-60% coal is recorded in the cuttings. Below the coal interval the lithology is dominated by an olive grey - brownish grey - grey waxy underclay.

Micropaleontology

A few radiolaria, gastropods, bivalves and arenaceous foraminifera are observed. These may be caved. Some few gastropods were noted at 1950 m. No comments as to the age and environment is possible.

Palynology

The top of this interval is marked by the income of Nannoceratopsis gracilis, Chasmatosporites major and Parvocysta bullula in the 1915.5 m sidewall.

The base of the interval was fixed by the lowest appearance of Callialasporites spp. These forms are common in the 1937 m SWC and in 1950 m ditch cuttings. Callialasporites is believed to have a base in the Late Toarcian. Their common appearance at 1937 m (and 1950 m cuttings sample) may suggest that we are dealing with the latest part of this interval.

Environment

Marine dinoflagellate cysts are recorded in low numbers only in the uppermost (1915.5 m SWC) and lowermost (1950 m cuttings) samples. These indicate some limited marine influence, at least at these levels. In the upper part of the interval (1915.5 - 1925/30 m) coarse to fine sands and occassional oolites are recorded. A shallow, marginal marine, high energy, probably near shore environment is suggested for this part. Lower in the interval (1930-1940 m) coals and seat earths are recorded suggesting marginal to non-marine environments. Marine elements (rare) are again noted in the lower part of the interval (1950 m).

1960 - 1980 m TOARCIAN (?EARLY)

Lithology

A grey to medium light grey claystone/siltstone is present below 1950 m and becomes together with very fine to very coarse sand the main lithology below 1960 m.

Micropaleontology

A few radiolaria and some Haplophragmoides spp. were recorded. These may be caved and no conclusions as to the age and environment can be drawn.

Palynology

The interval was distinguished from that above by the abundance of Nannoceratopsis gracilis and Chasmatosporites major and the top occurrence of Cerebropollenites thiergartii at 1960 m. Further Callialasporites spp. was apparently absent. This taxon is generally believed to have a base in the Late Toarcian. Clear Early Toarcian markers were absent.

Environment

The marine dinoflagellate Nannoceratopsis gracilis is abundant in this interval and this in normally taken as indicative of marginal marine conditions.

1988.5 - 2020 m EARLY TOARCIAN

Lithology

The amount and the grainsize of the sand present in the cutting samples decreases downwards and below 2010 m grey to medium light grey. Claystone/siltstone is the dominant lithology.

Micropaleontology

As above, a few radiolaria and some individuals of Haplophragmoides is met. These may be caved. No comments as to the age and environment is possible.

Palynology

The assemblages are essentially similar to those of the above interval though the income of small spherical bodies at 1988.5 m and below is generally associated with the Early Toarcian.

Environment

Dinoflagellate cysts are again common, together with terrestrially derived elements. A shallow - marginal marine environment is proposed. In the lowermost sample the fresh water alga Botryococcus was recorded. This indicates fresh water input and the possibility of slightly brackish conditions.

DESCRIPTION OF SIDEWALL CORES

AND

CORECHIPS

31/6-2

SIDEWALL CORES
(wet samples)

908 m Claystone, medium dark grey, very silty, slightly sandy (very fine), mod. hard-hard, friable, micromicaceous, containing scattered organic fragments, non calcareous.

940 m Claystone, dusky yellowish brown - olive black, soft - mod. hard, brittle, blocky, waxy, micromicaceous, non calcareous.

965 m Claystone, dusky yellowish brown - olive black, mod.hard, blocky, waxy, slightly micromicaceous, non calcareous.

975 m Marl/limestone, light brown - offwhite, dark grey, silty, grainy, mod.hard, friable, slightly micromicaceous, glauconitic, containing scattered organic fragments.

995 m Marl/claystone, grey - dark grey, friable, blocky, weakly laminated, micromicaceous.

1050 m Claystone, dark grey, silty, mod.hard, blocky, brittle, micromicaceous, very calcareous.

1127,5 m Claystone, dark grey - greyish black, slightly silty, mod.hard - hard, blocky - subfissile, very micromicaceous, non calcareous.

1170 m Marl, moderate brown, silty, hard, blocky, brittle, micromicaceous.

1202 m Claystone, dark grey - olive grey, brittle, hard, subfissile - platy, waxy, micromicaceous, calcareous.

1250 m Marl, dark reddish brown, mod.hard, brittle, blocky, earthy, slightly micromicaceous.

1294 m Marl medium grey - olive grey, mod.hard, blocky, slightly micromicaceous.

1311 m Claystone, brownish grey (olive grey, greenish grey), mod.hard, subfissile, brittle, earthy, very micropyritic, slightly micromicaceous, partly calcareous.

1326,5 m Claystone, black-brownish black, soft-mod.hard, brittle, fissile, micropyritic, slightly micromicaceous, non calcareous, very carbonaceous.

1344,5 m Claystone, black-brownish black, mod.hard, brittle, fissile, micropyritic, slightly micromicaceous, carbonaceous.

1360 m Claystone, black - brownish black, mod.hard, fissile, micropyritic, slightly micromicaceous, non calcareous, carbonaceous.

1380 m Claystone, black, mod.hard - hard, fissile, slightly micropyritic, slightly micromicaceous, non calcareous, carbonaceous.

1399 m Claystone, black, mod.hard, fissile, slightly micropyritic, slightly micromicaceous, non calcareous, carbonaceous.

1411 m Claystone, greyish black - olive black, subfissile - platy, moderately hard, brittle, slightly micromicaceous, slightly micropyritic, non calcareous.

1426 m Claystone, greyish black, silty, fissile, moderately hard, brittle, micromicaceous, slightly micropyritic, non calcareous.

1630 m Sandstone, dark olive grey, very fine - fine, very argillaceous, friable, micromicaceous, slightly calcareous, carbonaceous.

1660 m Sandstone, olive grey, very fine - fine, argillaceous, friable, micromicaceous, slightly calcareous.

1686 m Sandstone, olive grey, very fine - fine, argillaceous very friable, micromicaceous, slightly calcareous.

1710 m Sandstone, light olive grey, very fine - fine, slightly argillaceous, very friable, slightly micaceous.

1726 m Sandstone, light olive grey, olive grey, very fine - medium, partly argillaceous, friable, slightly micaceous, non calcareous.

1745 m Sandstone, light olive grey - olive grey, very fine - medium, partly argillaceous, very friable, slightly micaceous, slightly calcareous.

1783 m Sandstone, light olive grey - olive grey, very fine - medium (coarse), partly argillaceous, friable, micaceous, non calcareous.

1800 m Sandstone, olive grey, very fine - fine, argillaceous, friable - moderately hard, micaceous, non calcareous.

1831 m Sandstone, olive grey, very fine - medium, argillaceous, moderately hard, slightly micromicaceous, non calcareous.

1855 m Sandstone, off white - olive grey, very fine - coarse, argillaceous, partly very argillaceous moderately hard - hard, slightly micaceous, disintegrates in 10% HCl.

1902 m Sandstone, off-white, with dark grey argillaceous parts and lenses very fine - coarse, moderately hard, micromicaceous, disintegrates in 10% HCl.

1915,5 m Sandstone, off-white, with abundant argillaceous, very fine - fine, moderately hard, micromicaceous, calcareous.

1927 m Sandstone, off-white - olive grey, very fine, very argillaceous, moderately hard - hard, micromicaceous. Interlaminated with Claystone greyish black, silty, fissile, micromicaceous slightly micropyritic.

1937 m Claystone, medium grey - dark grey, moderately hard, brittle, micromicaceous, slightly micropyritic, non calcareous.

1988,5 m Sandstone, white - olive grey, very fine - fine, partly argillaceous, friable, very calcareous, with laminae and lenses of Claystone brownish black, silty, disintegrates in 10% HCl.

31/6-2 CORE CHIPS

1435,00-1435,05 m Claystone, dark grey - greyish black, very silty, sandy (very fine), moderately hard - hard, brittle, very fissile, very micromicaceous, micropyritic, carbonaceous, non calcareous.

1439,50-1439,55 m Claystone, dark grey - greyish black, very silty, sandy (very fine), moderately hard - hard, brittle, very fissile, very micromicaceous, slightly micropyritic, carbonaceous, non calcareous.

1443,05-1448,5 m Siltstone, dark grey, slightly brownish, clayey, sandy (very fine), moderately hard, brittle, very fissile, very micromicaceous, trace micropyrite, glauconitic, carbonaceous, non calcareous.

1453,70-1453,75 m Siltstone, dark grey, clayey, sandy (very fine), moderately hard, brittle, fissile, micromicaceous, trace micropyrite, glaconitic, carbonaceous, non calcareous.

1457,65-1457,70 m Glauconite sandstone, dark grey - greenish black, fine - medium, argillaceous, friable, containing scattered quartz grains, micromicaceous, carbonaceous, non calcareous, weakly laminated. One burrow, probably Diplocraterion yoyo, is recorded.

1460,35-1460,40 m Sandstone, light grey - dark grey, fine-medium, subangular-subrounded, argillaceous, friable, micromicaceous slightly calcareous. Abundant glauconite appear as greenish black grains.

1469,45-1469,80 m Sandstone, light olive grey, with occasionally dark grey laminae, fine-medium, subangular-subrounded, friable, micromicaceous, slightly calcareous. Glauconite occur as rounded greyish black grains.

1477,25-1477,30 m Sandstone, olive grey, fine to medium, subangular to subrounded, very friable, micromicaceous, non calcareous.

1482,70-1482,75 m Sandstone, light olive grey, fine-medium, subangular-subrounded, very friable, micromicaceous, non calcareous.

1484,25-1484,30 m Sandstone, light olive grey - white, argillaceous, very fine to coarse, argillaceous, subangular to angular, mainly clear grains, friable, micaceous, partly carbonaceous, non calcareous.

1495,15-1495,18 m Sandstone, medium dark grey, with brownish black laminae, very fine-medium, argillaceous, subangular, friable, very micaceous, slightly calcareous, partly carbonaceous.

1504,14-1504,18 m Sandstone, light olive grey with distinct black argillaceous and micaceous laminae, very fine-medium, subangular, argillaceous, friable, very micaceous, slightly calcareous, containing scattered organic fragments.

1522,13-1522,18 m Sandstone, dark grey - brownish black, laminated, very fine-medium, subangular-subrounded, argillaceous, very friable, very micaceous, slightly calcareous.

1529,95-1595,98 m Sandstone, grey-medium dark grey, very fine-medium, subangular, argillaceous, friable, very micaceous, slightly calcareous, containing shell fragments.

1535,69-1535,72 m Sandstone, light olive grey, interlaminated with a black carbonaceous shale, very fine-medium, subangular, slightly argillaceous, friable, slightly micaceous, containing scattered organic fragments.

1544,80-1544,85 m Sandstone, olive grey, with black argillaceous and very micaceous laminae, very fine-medium, subangular-subrounded, friable, slightly micaceous, slightly calcareous.

1545,81-1545,84 m Sandstone, light olive grey, with brownish black, argillaceous and very micaceous laminae (flaser bedding) very fine-medium, subangular, slightly micaceous, partly calcareous, partly carbonaceous, containing fossile fragments.

1547,48-1547,50 m Sandstone, olive grey-olive black, with lenticular/flaser bedding, very fine to medium, subangular argillaceous, partly very argillaceous, moderately hard, very micaceous, slightly calcareous, partly carbonaceous.

1549,60-1549,65 m Sandstone, grey-medium dark grey, very fine-fine, argillaceous, very dense, micaceous, very calcite cemented, containing abundant shells and shell fragments.

1552,45-1552,50 m Sandstone, olive grey-dark olive grey, very fine-fine, argillaceous, medium hard - hard, micaceous, calcareous, containing scattered shell fragments.

1554,65-1554,67 m Sandstone, olive grey-dark olive grey, very fine-medium, subangular, very argillaceous, friable, micaceous, slightly calcareous, containing fossile fragments.

1561,80-1561,85 m Sandstone, medium grey, slightly brownish, very fine-fine, very dense, slightly micaceous, glauconitic, very calcite cemented. Containing abundant shells and shell fragments.

1564,68-1564,72 m Sandstone, dark grey, very fine-fine, very argillaceous, moderately hard, very micaceous, non calcareous, carbonaceous. With very thin laminae and lenses of less argillaceous sand.

1567,45-1567,50 m Sandstone, dark grey, very fine-fine, argillaceous, friable-moderately hard, micaceous, slightly calcareous. With thin laminae and lenses of less argillaceous, sand.

1571,60-1571,63 m Sandstone, olive grey, very fine - medium, subangular, argillaceous, friable - moderately hard, micaceous, micropyritic, calcareous.

1576,65-1576,68 m Sandstone, olive grey, very fine-very coarse, subangular-rounded, conglomeratic, argillaceous, friable, slightly micaceous, very calcareous, containing coarse shell fragments.

1579,35-1579,40 m Sandstone, light grey, fine-medium subangular, very dense, micaceous, very calcite cemented, containing shell fragments.

1587,50-1587,55 m Sandstone, dark olive grey, very fine-medium subangular, very argillaceous, moderately hard, micaceous, slightly calcareous.

1594,17-1594,25 m Sandstone, medium dark grey, very fine, subangular, very argillaceous, hard-moderately hard, very micaceous, calcareous, containing abundant shell fragments.

1595,45-1595,50 m Sandstone, medium dark grey-dark grey, very fine-fine, subangular, very argillaceous, very micaceous, very calcareous, containing abundant shell fragments.

1602,48-1602,52 m Sandstone, dark olive grey - brownish grey, very fine-coarse, subangular, slightly argillaceous, friable, micaceous, very calcareous, containing abundant shells and shell fragments.

1617,80-1617,85 m Sandstone, medium dark grey-dark grey, very fine-fine, subangular, very argillaceous, moderately hard, micaceous, slightly calcareous.

WELL NO.: 31/6-2

CLIENT: STATOIL

Enclosure: 1
IKU Ref.: 04.0175.05
Analyst(s): Skarbø/Verdenius
Date: March 1984

Taxalist: *Micropaleontology 1 of 2*
Interval: 420 – 940 m
Scale: 1 : 2000

CORE/SWC: • present ○ common ◒ abundant ● dominant
CUTTINGS: | present □ common ◪ abundant ■ dominant
CORED INTERVAL: ▮
?/cf./aff.: uncertain record or affinity
R : *reworked*

Comments:

SYSTEM	STAGE/ SUBSTAGE	ZONE	SCALE DEPTH (m)	SAMPLE DEPTH (m)
QUATERNARY	? EARLY PLEISTOCENE		420	420
			450	450
			480	480
			500	510
			540	540
	OLIG.–E.MIO.		550	550
	EARLY – MIDDLE EOCENE		600	560
				570
				610
			640	
			650	
TERTIARY	PALEOCENE			670
			700	700
			750	730
				760
			800	790
				820
			850	850
				880
			900	910
				940
			950	

CRETACEOUS REWORKING
ELPHIDIUM EXCAVATUM
CASSIDULINA LAEVIGATA
BULIMINA MARGINATA
MELONIS BARLEEANUM
CIBICIDES PSEUDOUNGERIANUS
NEOGLOBOQUADRINA PACHYDERMA SIN.
PYRGO BULLOIDES
BOLIVINA SP.1
UVIGERINA SP.1
SIGMOILOPSIS SCHLUMBERGERI
PLANULINA ARIMINENSE
TRIFARINA ANGULOSA
TEXTULARIA SAGITTULA
ISLANDIELLA NORCROSSI/HELENAE
STAINFORTHIA LOEBLICHI
CASSIDULINA RENIFORME
QUINQUELOCULINA SEMINULA
NONION LABRADORICUM
ELPHIDIUM ALBIUMBILICATUM
PROTELPHIDIUM ORBICULARE
CASSIDULINA OBTUSA
STILOSTOMELLA SP.
HOEGLUNDIA ELEGANS
SIGMOMORPHINA REGULARIS
TEXTULARIA PLUMMERAE
CYCLAMMINA AMPLECTENS
CAENOSPHAERA SP. (RADIOL.)
BATHYSIPHON EOCENICA
AMMOLAGENA CLAVATA
DOROTHIA PRINCIPIENSIS
SACCAMMINA PLACENTA
GYROIDINOIDES SOLDANII
BATHYSIPHON SP.
KARRERIELLA CONVERSA
TROCHAMMINA GLOBIGERINIFORMIS
DIATOM SP.
COSCINODISCUS SP.1
COSCINODISCUS SP.
AMMODISCUS CRETACEUS
KALAMOPSIS GRZYBOWSKII
HYPERAMMINA SP.
CYCLAMMINA SP.
RECURVOIDES DEFLEXIFORMIS
HAPLOPHRAGMOIDES SP.
GLOMOSPIRA CHAROIDES
HAPLOPHRAGMOIDES KIRKI
DIATOMS
BRYOZOANS
SPONGE SPICULE
FECAL PELLETS
OSTRACODS
RADIOLARIANS
FISH TEETH
INOCERAMUS PRISMS

WELL NO.: **31/6-2**

CLIENT: **STATOIL**

Enclosure: 2
IKU Ref.: 04.0175.05
Analyst(s): M.LØFALDLI
Date: March 1984

Taxalist: Micropaleontology 2 of 2
Interval. 970 – 2020 m
Scale: 1 : 1000

CORE/SWC	CUTTINGS	CORED INTERVAL
• present	¦ present	▮
○ common	□ common	
◒ abundant	◩ abundant	
● dominant	■ dominant	

?/cf./aff.: uncertain record or affinity

Comments:

WELL NO.: 31/6-2 (18) **31/6-2**

CLIENT: **STATOIL**

Enclosure: 3
IKU Ref.: 04.0175.05
Analyst(s): H.Selnes
Date: March 1984

Taxalist: Palynology 1 of 3
Interval: 900 – 1344.5 m
Scale: 1 : 1000

CORE/SWC: • present ○ common ◒ abundant ● dominant
CUTTINGS: | present □ common ◪ abundant ■ dominant
CORED INTERVAL

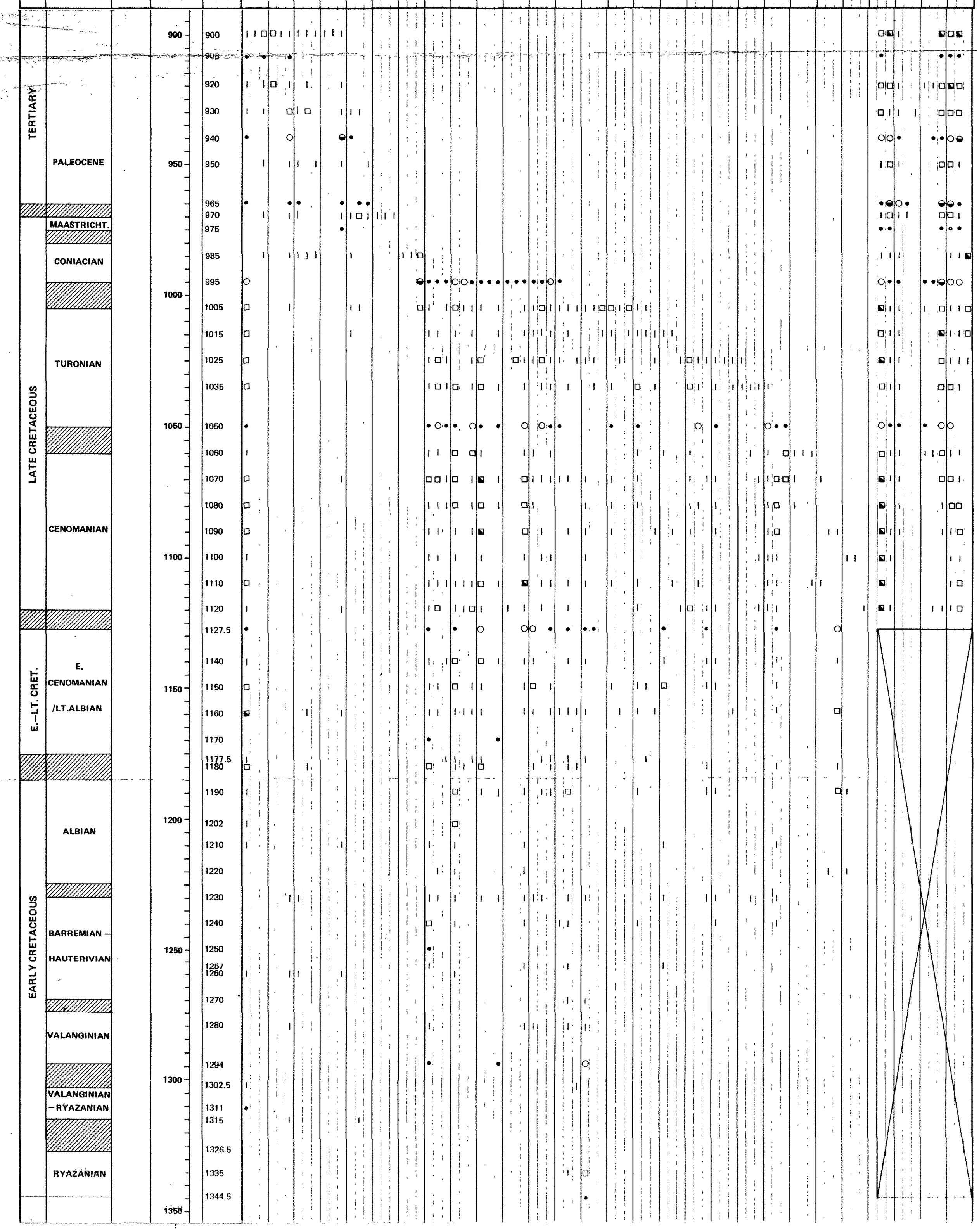
?/cf./aff.: uncertain record or affinity

Comments:

SYSTEM | STAGE/SUBSTAGE | ZONE | SCALE DEPTH (m) | SAMPLE DEPTH (m)

TERTIARY
PALEOCENE
MAASTRICHT.
CONIACIAN
TURONIAN
CENOMANIAN
LATE CRETACEOUS
E.–LT. CRET.
E. CENOMANIAN /LT. ALBIAN
ALBIAN
BARREMIAN – HAUTERIVIAN
VALANGINIAN
VALANGINIAN – RYAZANIAN
RYAZANIAN
EARLY CRETACEOUS

SPINIFERITES SPP.
S. RAMOSUS
GLAPHROCYSTA ORDINATA PLEXUS
APECTODINIUM AUGUSTUM/HYPERACANTHUM
DEFLANDREA OEBISFELDENSIS
CERATIOPSIS STRIATA
CORDOSPHAERIDIUM SPP.
ALISOCYSTA RUGOLIRATA/CIRCUMTABULATA
THALASSIPHORA DELICATA
NANNOCERATOPSIS PELLUCIDA
MUDERONGIA SIMPLEX
PALAEOPERIDINIUM PYROPHORUM
P. BASILIUM
PALAEOCYSTODINIUM HYPERXANTHUM
CERATIOPSIS DIEBELII
LEJEUNIA SP.
HYSTRICHOSPHAERIDIUM STELLATUM
CHATANGIELLA CF. TRIPARTITA
ACHOMOSPHAERA RAMULIFERA
PALAEOCYSTODINIUM AUSTRALINUM
SENONIASPHAERA CF. PROTROSA
CYCLONEPHELIUM DISTINCTUM
C. HUGHESII
C. MEMBRANIPHORUM
ODONTOCHITINA OPERCULATA
XENASCUS CERATIOIDES
CHLAMYDOPHORELLA NYEI
PALAEOHYSTRICHOPHORA INFUSOROIDES
CANNINGIA SP.
APTEODINIUM SPP.
OLIGOSPHAERIDIUM ANTHOPHORUM
CHATANGIELLA SP.
SURCULOSPHAERIDIUM LONGIFURCATUM
SPINIFERITES POROSUS
DINOPTERYGIUM CLADOIDES
EXOCHOSPHAERIDIUM PHRAGMITES
FLORENTINIA DEANEI
OLIGOSPHAERIDIUM COMPLEX
TRICHODINIUM CASTANEUM
HYSTRICHODINIUM PULCHRUM
TRITHYRODINIUM SPP.
SPHAEROMORPH A
GONYAULACYSTA ORTHOCERAS
CHATANGIELLA DITISSIMA
MICRODINIUM CRINITUM
FLORENTINIA MANTELLI
ACHOMOSPHAERA SAGENA
CORONIFERA OCEANICA
STEPHODINIUM CORONATUM
FLORENTINIA FEROX
F. RADICULATA
BROWN SPHERES
CRIBROPERIDINIUM "FIMBRIATUM"
ODONTOCHITINA COSTATA
PALAEOPERIDINIUM CRETACEUM
MUDERONGIA STAUROTA
TANYOSPHAERIDIUM VARIECALAMUM
ADNATOSPHAERIDIUM CHONETUM
SENONIASPHAERA ROTUNDATA
DINOFL. INC. SEDIS (NORVICK & BURGER)
ISABELIDINIUM ACUMINATUM
CLEISTOSPHAERIDIUM HUGUONIOTII
C. POLYPES
CASSICULOSPHAERIDIA RETICULATA
HYSTRICHOSPHAERIDIUM DIFFICILE
MICRODINIUM IRREGULARE
FROMEA FRAGILIS
EXOCHOSPHAERIDIUM ARNACE
LITOSPHAERIDIUM SIPHONIPHORUM
CYCLONEPHELIUM COMPACTUM
KLEITHRIASPHAERIDIUM LOFFRENSIS
CALLAIOSPHAERIDIUM ASYMMETRICUM
DINOFLAGELLATES
BISACCATES
SPORES/NON SACCATES
ULVA SP.
BOTRYOCOCCUS
MICRHYSTRIDIUM/VERYHACHIUM
MICROFORAMS (SMALL)
COALY FRAGMENTS
WOODY TISSUE
AMORPHOUS
LIGNOSULFONATE



WELL NO.: 31/6-2 (18) **31/6-2**

CLIENT: **STATOIL**

Enclosure: 4
IKU Ref.: 04.0175.05
Analyst(s): H.Selnes
Date: March 1984

Taxalist: Palynology 1B of 3
Interval: 1127.5 – 1344.5 m
Scale: 1 : 1000

CORE/SWC	CUTTINGS
• present	| present
○ common	□ common
◒ abundant	◪ abundant
● dominant	■ dominant

CORED INTERVAL

?/cf./aff.: uncertain record or affinity

Comments:

x: B.radiculatum/longicornutum

SYSTEM	STAGE/ SUBSTAGE	ZONE	SCALE DEPTH (m)	SAMPLE DEPTH (m)
EARLY CRETACEOUS	E. – LT. CRET.			1127.5
				1140
	E. CENOMANIAN/ LT. ALBIAN		1150	1150
				1160
				1170
				1177.5
	ALBIAN			1180
				1190
			1200	1202
				1210
				1220
				1230
	BARREMIAN/ HAUTERIVIAN			1240
			1250	1250
				1257
				1260
				1270
				1280
	VALANGINIAN			
				1294
			1300	1302.5
	VALANGINIAN – RYAZANIAN			1311
				1315
				1326.5
	RYAZANIAN			1335
				1344.5
			1350	

GONYAULACYSTA ORTHOCERAS, SPONGIOSA
HEXAGONIFERA CHLAMYDATA
SUBTILISPHAERA PERLUCIDA
DOROCYSTA LITOTES
COMASPHAERIDIUM CHOMETES
SCRINIODINIUM CAMPANULUM
PSEUDOCERATIUM DETTMANIAE
CANNINGIA TORULOSA
CALIGODINIUM ACERAS
HAFNIASPHAERA HYALOSPINOSA
KLEITHRIASPHAERIDIUM SP.
GARDODINIUM TRABECULOSUM
XIPHOPHORIDIUM ALATUM
CF. HESLERTONIA HESLERTONENSIS
DISPHAERIA MUNDA
APTEA EISENACKII
BOURKIDINIUM SP.
CAUCA PARVA
AFF. PARALECANIELLA
APTEODINIUM GRANDE
DEFLANDREA GALLIA
CRIBROPERIDINIUM MUDERONGENSE
LITHODINIA STOVERI
OLIGOSPHAERIDIUM DICHTYOPHORUM
CANNINGIA SP.
OVOIDINIUM SCABROSUM
LITOSPHAERIDIUM CONISPINUM
PROLIXOSPHAERIDIUM CONISPINUM
APTEODINIUM SPONGIOSUM
PSEUDOCERATIUM TURNERI
BROWN ENDOCYSTS
OVOIDINIUM VERRUCOSUM
FROMEA AMPHORA
SIRMIODINIUM GROSSII
PSEUDOCERATIUM REGIUM
GLOSSODINIUM DIMORPHUM
CHLAMYDOPHORELLA MEMBRANOIDEA
PAREODINIA SPP.
GONYAULACYSTA "PORTLANDIENSE"
CANNINGIA COMPTA
PSEUDOCERATIUM PELLIFERUM
AVELLODINIUM FALSIFICUM
GOCHTEODINIA VILLOSA
DINGODINIUM CERVICULUM
CANNINGIA SPUMOSA
BATIOLADINIUM RADICULATUM
HESLERTONIA HESLERTONENSIS
GONYAULACYSTA SPP.
PHOBEROCYSTA NEOCOMICA
SYSTEMATOPHORA SCHINDEWOLFII
CTENIDODINIUM ELEGANTULUM
TUBOTUBERELLA APATELA
GONYAULACYSTA DIUTINA
G. FASTIGIATA
G. HYALODERMOPSIS
KLEITHRIASPHAERIDIUM EONIDES
PROLIXOSPHAERIDIUM DEIRENSE
GONYAULACYSTA FIMBRIATA
SPINIFERITES DENTATUS
SCRINIODINIUM PHARO
OCCISUCYSTA SP. A DAVEY 1979
OLIGOSPHAERIDIUM SP.1 DAVEY 1982
ADNATOSPHAERIDIUM SP.
BATIOLADINIUM POMUM
DINGODINIUM SPINOSUM
APTEODINIUM GRANULOSUM
MADURADINIUM SP. A DAVEY 1982
EGMONTODINIUM EXPIRATUM
CASSICULOSPHAERIDIA MAGNA
GONYAULACYSTA NUCIFORMIS
SYSTEMATOPHORA AREOLATA
DINOFLAGELLATES
BISACCATES
SPORES/NON SACCATES
ULVA SP.
PTEROSPERMOPSIS
TASMANITES
MICRHYSTRIDIUM/VERYHACHIUM
MICROFORAMS (LARGE)
MICROFORAMS (SMALL)
COALIFIED PARTICLES
WOODY TISSUE
AMORPHOUS
LIGNOSULFONATE

WELL NO.: 31/6-2 (18) **31/6-2**

CLIENT: **STATOIL**

Enclosure: 5
IKU Ref.: 04.0175.05
Analyst(s): Bell/Selnes
Date: April 1984

Taxalist: Palynology 2 of 3
Interval: 1350 – 2020 m
Scale: 1 : 1000

CORE/SWC: • present ○ common ◒ abundant ● dominant
CUTTINGS: | present □ common ◪ abundant ■ dominant
CORED INTERVAL
?/cf./aff.: uncertain record or affinity

Comments:

1. H.cf.cladophora 1457: perforate cingular phlange
2. V.ovula 1630: fine reticular network
3. Assumes Paralecaniella? is a dinoflagellate
4. Estimates mudeon oxidised material from 1710 – 1902 m, except 1800 m SWC

C: S.galleritum, very coarse reticulum
E: E.cinctum, elonate var.
F: Fragmentary specimens and therefore uncertain identification

SEE ALSO ENCL. 5, 6

SYSTEM	STAGE/ SUBSTAGE	ZONE	SCALE DEPTH (m)	SAMPLE DEPTH (m)
	BERRIASIAN		1350	1350
				1360
	EARLY			1370
	PORTLANDIAN			1380
				1390
			1400	1399
				1410
	EARLY			1411
	PORTLANDIAN			1420
	TO LATE			1426
	KIMMERIDGIAN			1435.00-05
				1439.50-55
				1443.05-10
			1450	1448.45-50
				1448.90-95
				1453.00-05
				1457.65
	?EARLY			1459.45
	KIMMERIDGIAN			1460.35
				1469.75
				1477.25
				1482.7
				1484.25
	?EARLY			1495.1
	KIMMERIDGIAN		1500	1504.14
				1522.13
				1529.95
	OXFORDIAN			1535.69
				1544.8
	EARLY			1545.81
	OXFORDIAN		1550	1547.48
	TO LATE			1552.45
	CALLOVIAN			1554.86
				1561.80
				1564.68
				1567.45
				1571.60
				1576.65
				1579.35
				1587.5
				1594.17
			1600	1600 D
				1602.48
				1610 D
				1617.8
				1620 D
	CALLOVIAN			1630 S
	(MOSTLY			1640 D
	MIDDLE)		1650	1650 D
				1660 S
				1670 D
				1686 S
			1700	1700 D
		M.–E.CALLOVIAN		1710 S
				1720 D
				1726 S
				1735 D
	EARLY			1745 S
	BATHONIAN		1750	1755 D
				1765 D
				1775 D
				1783 S
				1790 D
			1800	1800 S
				1810 D
	BAJOCIAN			1820 D
	(?LATE)			1831 S
				1845 D
			1850	1855 S
				1865 D
				1875 D
				1885 D
				1895 D
			1900	1902 S
				1915.55
	AALENIAN			1927 S
	TO LATE			1937 S
	TOARCIAN			
			1950	1950 D
				1960 D
	?EARLY			1970 D
	TOARCIAN			1980 D
				1988.5
	EARLY		2000	2000 D
	TOARCIAN			2010 D
				2020 D

SYSTEMATOPHORA SPP.
SIRMIODINIUM GROSSII
PARALECANIELLA MEMBRANOIDEA
BOURKIDINIUM SP.
TUBOTUBERELLA APATELA
CRUSPIDINIUM CRUSPIDUM DAVEY 82
HISTRICHOSPHAERA PITCHARUM
AVELLODINIUM FALSICRISTUM
CRUSPIDINIUM CF. CRUSPIDUM
G. "PORTLANDIENSE"
OLIGOSPHAERIDIUM SP.1 DAVEY 1982
OLIGOSPHAERIDIUM CF. COMPLEX
E. POLYPLACOPHORUM
ECHINIDINIUM EXPIRATUM
OCHETODINIA VILLOSA
SPHAEROMORPHS (LARGE)
BALLODINIUM OBLONGUM
DINOGYMNIUM ACUMINATUM
DINOGYMNIUM CERVICULUM
PROLIXOSPHAERIDIUM GRANULOSUM
PROLIXOSPHAERIDIUM PARVISPINOSUM
OLIGOSPHAERIDIUM CF. DILUCULUM
WALLODINIUM KRUTZSCHII
SYSTEMATOPHORA AREOLATA
VALENSIELLA OVULA
APTEODINIUM SPP.
GONYAULACYSTA JURASSICA
GONYAULACYSTA PERFORANS
OLIGOSPHAERIDIUM "RECURVED DISTAL SPINES"
GONYAULACYSTA PSEUDOCRISTATA
GONYAULACYSTA NUCIFORMIS
EGMONTODINIUM TORYNUM
CANNINGIA SP. A (SARJEANT 1984)
CADOSPHAERA RALOSA (= SPHERICAL CYST W. KALYPTRA)
SCRINIODINIUM SP. A (LOANNIDES ET AL.
SCRINIODINIUM PANNOSUM
GLOSSODINIUM DIMORPHUM
KLEITHRIASPHAERIDIUM SP.
ECHINIDINIUM SP.1 DAVEY 1982
CTENIDODINIUM PANNEUM
MESOSPHAERIDIUM SP. A DAVEY 82
OCHETODINIA MUTABILIS
SCRINIODINIUM PILATA
GONYAULACYSTA SP. A (= "ANTENNULA")
ACANTHAULAX SP. A (LOANNIDES ET AL.
MENDICODINIUM SP.
CRUSPIDINIUM CF. PULCHERIMUM SENSU RAYNAUD (LOANNIDES
SYSTEMATOPHORA "ANASTOMOSING SPINES"
EGMONTODINIUM DIVATUM
EGMONTODINIUM TRUNCATUM
LEPTODINIUM SUBTILE
GONYAULACYSTA CF. PERFORANS (AS 31/6–2)
GONYAULACYSTA JURASSICA
HISTRICHOGONYAULAX CLADOPHORA
SCRINIODINIUM LURIDUM
ESCHARISPHAERIDIUM MAULA"
STEPHANELYTRON SCARBURGHENSE
EPILOSPHAERA AREOLATA
ETRATOSPHAERIDIUM ARBIFERA
ETRATOSPHAERIDIUM SP.
PARALECANIELLA? SP.
PARALECANIELLA MEMBRANIPILARIS
MANNOCERATOPSIS PELICIDA
SCRINIODINIUM GALLERITUM
ROSAIDOSPHAERIDIA
ECHINIDINIUM APOCOCKII
CAVING CONTAMINATION
DINOFLAGELLATES
ACRITARCHS
SPORES
CLEISTOSPHAERIDIUM SP.
MICROHYSTRIDIUM/VERYHACHIUM
TASMANITIDS
PRASINOPHYCEAE
MICROFORAMS (SMALL)
PTEROSPERMELLA
ALGAL FRAGMENTS
COALLY FRAGMENTS
WOODY TISSUE/STRUCTURED
ARBORIPHOUS
BOTRYOCOCCUS
OTHER POLLEN

WELL NO.: 31/6-2 (18) **31/6-2**

CLIENT: **STATOIL**

Enclosure: 6
IKU Ref.: 04.0175.05
Analyst(s): Bell/Vigran
Date: April 1984

Taxalist: Palynology 3 of 3
Interval: 1544 – 2020 m
Scale: 1 : 1000

CORE/SWC: • present ○ common ◒ abundant ● dominant
CUTTINGS: | present □ common ◪ abundant ■ dominant
CORED INTERVAL
?/cf./aff.: uncertain record or affinity

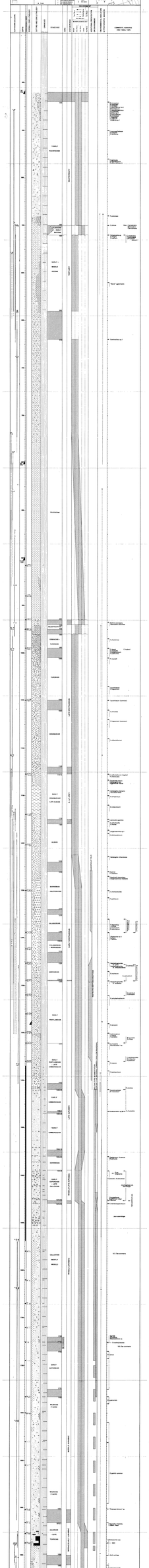
Comments:

K: Pareodinia ceratophora with Kalyptra

SEE ALSO ENCLOSURE 5

SYSTEM	STAGE/ SUBSTAGE	ZONE	SCALE DEPTH (m)	SAMPLE DEPTH (m)
MIDDLE JURASSIC	CALLOVIAN MOSTLY MIDDLE	M.–E.CALLOVIAN	1550	1544.8
				1545.81
				1547.48
				1552.45
				1554.65
				1561.80
				1564.68
				1567.45
				1571.60
				1576.65
				1579.35
				1587.5
				1594.17
			1600	1600 D
				1602.48
				1610 D
				1617.8
				1620 D
				1630 S
				1640 D
			1650	1650 D
				1660 S
				1670 D
				1686 S
			1700	1700 D
				1710 S
				1720 D
				1726 S
				1735 D
				1745 S
	EARLY		1750	1755 D
	BATHONIAN			1765 D
				1775 D
				1783 S
				1790 D
			1800	1800 S
				1810 D
				1820 D
	BAJOCIAN			1831 S
	(?LATE)			
			1850	1845 D
				1855 S
				1865 D
				1875 D
				1885 D
				1895 D
			1900	1902 S
E.–M.JURASSIC	AALENIAN – LATE TOARCIAN			1915.55
				1927 S
				1937 S
			1950	1950 D
				1960 D
	TOARCIAN ?EARLY			1970 D
				1980 D
E.JURASSIC	EARLY TOARCIAN			1988.5
			2000	2000 D
				2010 D
				2020 D

AMBONOSPHAERA CALLOVIENSE
TUBOTUBERELLA EISENACKII
CTENIDODINIUM ORNATUM
SCRINIODINIUM CRYSTALLINUM
MEIOUROGONYAULAX CF. CALLOMONII (AS 31/6–1)
ELLIPSOIDICTYUM CINCTUM
TUBOTUBERELLA EGEMENII
MEIOUROGONYAULAX "RETICULATE PERIPHRAGM." AS 31/6–2
CHYTROEISPHAERIDIA CHYTROEIDES
GONYAULACYSTA JURASSICA LONGICORNIS
MEIOUROGONYAULAX "HIGH LISTS, TRANSPARENT"
DRUGGIDINIUM? SP.
GONYAULACYSTA SCARBURGHENSE/AREOLATA
SURCULOSPHAERIDIUM CRIBROTUBIFERUM
PROLIXOSPHAERIDIUM PARVISPINUM
DIACANTHUM? SP.
TUBOTUBERELLA DANGEARDII
SENTUSIDINIUM CF. PELLONIENSE
CTENIDODINIUM CONTINUUM
SENTUSIDINIUM ETHYROCOMUM
S. CREBERBARBATUM
S. SPARSIBARBATUM
CLEISTOSPHAERIDIUM "STUBBY SPINES"
MEIOUROGONYAULAX DEFLANDREI
SENTUSIDINIUM RIOULTII
SENTUSIDINIUM SPP. (SMALL)
SURCULISPHAERIDIUM VESTITUM
"SENTUSIDINIUM MEMBRANIGRANULATUM"
MENDICODINIUM GROENLANDICUM
CTENIDODINIUM ROTUNDUM
PAREODINIA CERATOPHORA
GEN. ET SP. INDET. 1 GOCHT 1970 fig. 14
POLYSTEPHANOPHORUS PARACALATUS
PAREODINIA PROLONGATA
"SENTUSIDINIUM SPONGIOSUM FORMA 1"
CYCLOPSIELLA SP.
CHYTROEISPHAERIDIA HYALINA
HYSTRICHOGONYAULAX SP. "RESEMBLES CF. CONTINUUM"
MEIOUROGONYAULAX "OBTUSA"
CHYTROEISPHAERIDIA CERASTES
MEIOUROGONYAULAX SP. "LACE LIKE, SPINY LISTS"
STEPHANELYTRON CF. SP. A STOVER ET AL
VALENSIELLA AMPULA
STEPHANELYTRON SP.
ALDORFIA ALDORFENSIS
MEIOUROGONYAULAX VALENSII SENSU FENTON 81
SENTUSIDINIUM ASYMMETRICA
MEIOUROGONYAULAX SUPERORNATA
CTENIDODINIUM SELLWOODII
GONGYLODINIUM ERMINOTEICHOS
POLYSTEPHANOPHORUS? "BREVISPINOSUM"
VALENSIELLA VERMICULATA
CTENIDODINIUM GOCHTII
HYSTRICHOGONYAULAX PECTINIGERA
NANNOCERATOPSIS GRACILIS
FROMEA? SP. VERRUCATE
PALAEOPERIDINIUM? SP.
PARVOCYSTA BULLULA
CHASMATOSPORITES MAJOR
CRYBELOSPORITES VECTENSIS
LYCOPODIUMSPORITES AUSTRALOCLAVATIDITES
CYATHIDITES MINOR
CALLIALASPORITES SPP.
"PROTOCERATOPSIS" SP. ?=GEN. ET SP. NOV. MORGENROTH
CEREBROPOLLENITES MACROVERRUCOSUS
CONCENTRISPORITES HALLEI
PERINOPOLLENITES HALLEI
TODISPORITES MINOR
ARAUCARIACITES AUSTRALIS
SMOOTH TRILETES
CORRUGATISPORITES SPP.
BACULATISPORITES SPP.
CLASSOPOLLIS CLASSOIDES
NEORAISTRICKIA GRISTHORPENSIS
QUADRAECULINA ANELLAEFORMIS
CYATHIDITES AUSTRALIS
SPHERIPOLLENITES
ALISPORITES/VESICASPORA
CHASMATISPORITES SP. A
CEREBROPOLLENITES THIERGARTII
CHASMATOSPORITES APERTUS
ISCHYOSPORITES VARIEGATUS
SMALL SPHERICAL BODIES
LIMBOSPORITES LUNDBLADII



Institutt for kontinentalsokkelundersøkelser
CONTINENTAL SHELF INSTITUTE
Geology department

IKU REF.: 04.0175.05

CLIENT: **STATOIL**

WELL NO.: **31/6-2**

STRATIGRAPHIC LOG

SCALE: 1 500

ENCLOSURE: 7

BY: Bell, Bessesen, Løfaldli, Selnes, Skarbø, Verdenius, Vigran

Depth 420 – 2020 m
Water depth 326 m
Lat 60° 34' 58,2" N
Long 03° 54' 55,8" E

Casing shoe:
30" — 412 m
20" — 801 m
13 3/8" — 902 m
9 5/8" — 1391 m