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BIOSTRATIGRAPHY OF THE TERTIARY-
CRETACEOUS INTERVAL IN WELL 6407/9-1
(NORSKE SHELL)

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SHELL INTERNATIONALE PETROLEUM MAATSCHAPPIJ B.V., THE HAGUE
EXPLORATION AND PRODUCTION

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SUMMARY

This report presents the results of microfaunal, palynological and nannoplankton investigations of the Tertiary and Cretaceous interval penetrated by well 6407/9-1, Haltenbanken permit area, offshore Norway.

By interpreting all data gained by these studies the following stratigraphic subdivision is arrived at, formation and group tops being provided by Norske Shell:

<u>interval (m)</u>	<u>zone</u>	<u>age</u>	<u>group/format.</u>	<u>base boundary (bdf)</u>
410-770		Pliocene	} Nordland Hordaland	1340 m
At 790		Miocene		
835-1114		Miocene-Oligocene		
1135-1169.5		Oligocene		
1171-1378.5		Eocene	Balder	1377 m
1405-1533.5	NP4 or younger	Paleocene	Montrose	1533 m
1536-1539.5		prob.Maastrichtian	} Shetland	1562.5 m
At 1542.5	NK18	Early Campanian		
1545-1556.5		undiagnostic		
At 1558	NK18-14	Early Campanian-Santonian		
At 1562.5	NK18-9C	Early Campanian-Cenomanian		
At 1564		undiagnostic	} Cromer Knoll	1590 m
1565.5-1568.5	NK6-5	Barrem.-Hauterivian		
1572.1574.5		undiagnostic		
1576-1578.5	NK3A	Valanginian		
1582.5-1590	NK3-2	Valanginian-Berrias		

Key words

Norway, Haltenbanken, stratigraphy, micropalaeontology, palynology, calcareous nannoplankton, Pliocene, Miocene, Oligocene, Eocene, Paleocene, Late Cretaceous, Early Cretaceous.

I. INTRODUCTION

At the request of Norske Shell for the definition of age boundaries in the post-Jurassic section of their well 6407/9-1, SIPM-EP/12.1 performed biostratigraphic analyses of selected SWS and cuttings from the Tertiary/Cretaceous section. Micropalaeontological analyses is based on cuttings for the interval above the 13 ³/₈" casing. Below the casing selected SWS were investigated and additionally a few cutting samples.

The Cretaceous sequence, densely sidewall sampled, was dated and subdivided by means of calcareous nannoplankton.

As the section assumed to represent the uppermost part of the Cretaceous sequence, proved to be barren of nannoplankton, a few SWS available from the critical interval were analysed on their palynomorph content.

14 cutting samples covering the interval 410-860 m drd and 30 SWS over the interval 835-1537.5 m lgd were studied micropalaeontologically. 33 SWS were investigated for calcareous nannoplankton over the interval 917.5-1590 m lgd, and finally 4 SWS of the interval 1533.5-1539.5 m lgd were studied palynologically.

Because the interpretation of depositional environments relies generally on microfaunal investigations which for the present well were limited to the detection of age markers in a minimum number of samples from the Neogene-Latest Cretaceous interval, some remarks only on a tentative environmental interpretation have been added.

A micropalaeontological distribution chart (Encl.1) as well as a calcareous nannoplankton distribution chart (Encl.2) are enclosed.

Information gathered from the biostratigraphic reports on the adjacent wells 6507/11-1 and 6507/12-1 has been used.

II. STRATIGRAPHY

II.1 TERTIARY (410 m drd - 1533.5 m lgd)

II.1.1 Pliocene (410 m drd - 770 m drd)

Fauna: Based on the abundant presence of Cibicides lobatulus var. grossa the above mentioned age can be concluded. Usually this species is considered to top in the Late Pliocene in the North Sea, but it might range into the Early Pleistocene in more northerly areas.

The lower boundary of this interval is placed at the examined cutting above the one with definite older age indications.

Depositional environment: Marine, inner neritic based on associations of Cibicides, Elphidium, Quinqueloculina, Nonion and the microfossil debris of pelecypods, echinoids, and bryozoans.

Remarks: Samples in this interval contained some foraminifera of Oligocene and Miocene age which are considered to be reworked, a feature also known from other northern North Sea wells.

II.1.2 Miocene (790 m drd)

Fauna: In ctg 790 m drd Globocassidulina subglobosa is present, having its top in Miocene strata. Furthermore a few Oligocene planktonic foraminifera were observed which are supposed to be reworked, together with the usual fauna observed in the Pliocene interval above, which is considered to be caved.

Remarks: Cuttings 790 m drd - 840 m drd were very rich in glauconite, usually present in Late Miocene-Early Pliocene strata in this area.

II.1.3 Miocene-Oligocene (835 m lgd - 1114 m lgd)

Fauna: The upper part of this interval (SWS 835 m lgd - ctg 860 m drd) yielded rich, undiagnostic assemblages consisting of pyritized worm tubes, sponge remains (spicules and Geodia sp.).

In deeper samples some Radiolaria, pyritized diatoms and a few planktonics are present as well.

From 1010.5 m lgd downwards some undiagnostic arenaceous foraminifera occur additionally. A firm age determination was not possible on these assemblages. In wells 6507/11-1 and 6507/11-2 a comparable assemblage together with Bolboforma spp. was encountered. Therefore on regional evidence an Oligocene-Miocene age was given to this interval. Diatom sp.3 King 1983 (Int. Geol. Sciences Rep. 82/7), an Oligocene marker has not been encountered in this well in contrast to the adjacent wells.

Eocene markers found in samples 1070.5 m lgd (Triceratium sp.) and in 1114 m lgd (broken specimen of Spiroplectamina spectabilis) are considered reworked since they occur above definite Oligocene.

Nannoplankton: Four SWS (viz. 917.5 m lgd, 985.5 m lgd, 1070.5 m lgd, 1094.5 m lgd) proved to be barren of nannoplankton.

Depositional environment: Marine, outer neritic to upper bathyal, restricted bottom circulation resulting in low pH and oxygen deficiency based on assemblages of sponge remains, radiolaria, pyritized worm tubes and diatoms.

II.1.4 Oligocene (1135 m lgd - 1169.5 m lgd)

Fauna: The top of definite Oligocene is marked by the highest occurrence of Turrilina alsatica, known not to occur in strata younger than Oligocene. The association of Rotaliatina bulimoides, Turrilina alsatica and Flabellina budensis in SWS 1169.5 m lgd points to a Middle Oligocene age. Bulimina subtruncana, an Eocene form occurring in 1135 m lgd is considered to be reworked.

Depositional environment: Marine, outer neritic to upper bathyal, minor restriction of bottom water circulation resulting in a lowered pH and some oxygen deficiency based on associations of rich radiolaria and common agglutinants (SWS 1167.5 m lgd) or associations dominated by pyritized diatoms and sponge remains with, in addition, few agglutinants and calcareous benthonics.

II.1.5 Eocene (1171 m lgd - 1378.5 m lgd)

Fauna: The top of the Eocene is marked by the presence of the diatom Triceratium sp. which is usually encountered in Early Eocene strata. In SWS 1338 m lgd the Eocene markers Spiroplectammina spectabilis and Ammomarginulina sp.A are present. Turrilina brevispira and Globigerina linaperta/triloculinoidea gr. in SWS 1340 m lgd indicate Early Eocene. Base Eocene is taken at the level (SWS 1378.5 m lgd) where Coscinodiscus sp.1 is still present.

Depositional environment: Marine, outer neritic to upper bathyal, varying restriction of bottom water circulation resulting in low pH and severe oxygen deficiency for SWS 1171-1281 m lgd based on associations of pyritized diatoms, radiolaria and minor number of agglutinants.

SWS 1338 m lgd solely contains abundant agglutinants pointing to minor restriction only.

SWS 1340 m lgd exhibits an assemblage of calcareous benthonics, planktonics and rare agglutinants indicating an open marine, outer neritic to upper bathyal setting with oxygenated bottom waters.

SWS 1376 m lgd and 1378.5 m lgd contain few pyritized diatoms and rare agglutinants pointing to restricted bottom water circulation in an outer neritic to upper bathyal environment.

II.1.6 Paleocene (1405 m lgd - 1533.5 m lgd)

Fauna: SWS 1405 m lgd was barren of foraminifera. In line with earlier investigations of Paleocene sections in North Sea wells, a Late Paleocene age is attributed to the sterile beds underlying deposits with Coscinodiscus sp.1. The following SWS viz. 1425.5 m, 1449 m, 1469.5 m, 1532 m, 1533.5 m, 1536 m, 1537.5 m lgd, yielded arenaceous assemblages indicating an Eocene-Paleocene age. Paleocene markers were not encountered. However, such a re-occurrence of Eocene-Paleocene arenaceous fauna below a barren interval of extrapolated Late Paleocene age is observed rather ubiquitously in the subsurface of the North Sea.

Palynomorphs: SWS 1533.5 m lgd is barren.

Nannoplankton: SWS 1449, 1469.5, 1510, and 1533.5 m lgd are barren.
SWS 1528.5 and 1523 m lgd: Zone NP4 or younger.

Age-diagnostic criteria are the presence of Cruciplacolithus tenuis s.str., Neochiastozygus perfectus, Prinsius martinii and Toweius spp.

Only two specimens have been observed in SWS 1532 m lgd. In SWS 1528.5 m lgd nannoliths occur regularly of which a high percentage is derived from Late Cretaceous. Therefore it may be possible that at least part of the Paleocene markers are also reworked.

Depositional environment: Marine, outer neritic to probably upper bathyal, bottom water circulation limited leading to low pH and reduced oxygen supply based on the occurrence of diversified rich associations of agglutinants.

II.2 LATE CRETACEOUS (1536 m lgd - 1562.5 m lgd)

II.2.1 probably Maastrichtian (1536 m lgd - 1539.5 m lgd)

Fauna: Except for one specimen of Globigerinella sp. in SWS 1537.5 m lgd no indications of Late Cretaceous were observed. The remaining fauna is dominated by agglutinants.

SWS 1536 m lgd contained mainly pyritized diatoms.

Palynomorphs: SWS 1536, 1537.5 and 1539.5 m lgd yielded more or less identical microplankton floras, indicating a Coniacian-Maastrichtian age (probably Maastrichtian only). This is based on the occurrences of:

Isabelidium cooksoniae Coniacian-Maastrichtian

I. cooksoniae/korojonense

Odontochitina costata

Dinogymnium sp.

Microdinium sp.1 (E-1403), Maastrichtian-Paleocene, one specimen only at 1536 m lgd.

Nannoplankton: SWS 1536, 1537.5 and 1539.5 m lgd are barren.

Depositional environment: Marine, outer neritic to upper bathyal, limited bottom water circulation, resulting in low pH and oxygen deficiency based on assemblages of pyritised diatoms and rare sponge remains (SWS 1536 m lgd). Decrease of restriction at the level of SWS 1537.5 m lgd is shown by an association of common agglutinants and only minor number of pyritized diatoms.

II.2.2 Early Campanian (1542.5 m lgd)

Nannoplankton: Early Campanian, Zone NK18.

Age-diagnostic is the presence of Aspidolithus sp.132 and A.sp.135.

II.2.3 Undiagnostic (1545 m lgd - 1556.5 m lgd)

Nannoplankton: SWS 1545, 1549.5, 1552.5 and 1556.5 m lgd are barren.

II.2.4 Early Campanian-Santonian (1558 m lgd)

Nannoplankton: Maastrichtian-Santonian, zones NK 26-14.

Age-diagnostic is the presence of Micula decussata. However, since SWS 1542.5 m lgd is Early Campanian (NK18) the dating of SWS 1558 m lgd can be given as Early Campanian-Santonian.

It is remarkable that M. decussata is the only nannofossil species occurring in this sample. This may point to an environment deviating from normal open marine conditions. Because of the lack of other nannoplankton species a more precise dating cannot be obtained.

II.2.5 Early Campanian-Cenomanian (1526.5 m lgd)

Nannoplankton: Maastrichtian-Cenomanian, Zones NK26-9C.

Age-diagnostic is the presence of Cribrosphaera venata. However, since SWS 1542.5 m lgd is dated Early Campanian (NK18) an Early Campanian-Cenomanian age can be interpreted.

II.2.6 Undiagnostic (1564 m lgd)

Nannoplankton: No age-diagnostic species is present. The only species observed is the long ranging Watznaueria barnesae.

II.3 EARLY CRETACEOUS (1565.5 m lgd - 1590 m lgd)

II.3.1 Barremian-Hauterivian (1565.5 m lgd - 1568.5 m lgd)

Nannoplankton: SWS 1565 m lgd, Barremian-Late Hauterivian, Zones NK6-5.

Age-diagnostic is the presence of Micrantholithus hoschulzii and Nannoconus borealis.

SWS 1568.5 m lgd, Barremian-Middle Hauterivian, Zones NK6-4.

Age-diagnostic is the presence of Micrantholithus obtusus with deeply incised segments.

II.3.2 Undiagnostic (1572 m lgd - 1574.5 m lgd)

Nannoplankton: Age-diagnostic species are not present.

II.3.3 Valanginian (1576 m lgd - 1578.5 m lgd)

Nannoplankton: Middle-Early Valanginian, Zone NK3A.

Age-diagnostic is the presence of Micrantholithus speetonensis.

II.3.4 Valangian-Berriasian (1582.5 m lgd - 1590 m lgd)

Nannoplankton: SWS 1582.5 and 1585 m lgd, Valanginian-Berriasian, Zones NK3-2.

Age-diagnostic is the presence of M. speetonensis in the overlying interval and Cretarhabdus crenulatus s.l. in the underlying interval. Other criteria are absent.

SWS 1586, 1587.5, 1588.5 and 1590 m lgd, ?Early Valanginian-Berriasian, ?Zone NK2. Age-diagnostic is the presence of one doubtful specimen of Nannoconus dolomiticus at 1586 m lgd and one specimen of Cretarhabdus crenulatus s.l. at 1590 m lgd.

III. CORRELATION

Based on the information from the biostratigraphic reports on the adjacent wells 6507/11-1 and 6507/12-1 a number of additional correlative horizons within the Tertiary are apparent, viz:

	6407/9-1	6507/11-1	6407/12-1
1. base S with crs rock fragm./top abundant Glc = approx.PL/MI bound.	762 m lgd	1430 m drd	1342 m lgd
2. ?hiatus, log marker, lith.change, top of abundant aggl. forams and radiolaria = approx. top EO	1169.5 m lgd	1820 m drd	1670 m drd
3. top <u>G. linaperta/triloc.</u> = approx. early part early EO	1340 m lgd	1980 m drd	1800 m drd

IV. CONCLUSIONS AND RECOMMENDATIONS

Because well 6407/9-1 is the first one which Norske Shell drilled in the Haltenbanken area and relatively little biostratigraphic information was available prior to drilling of this well, the post-Jurassic sequences have been densely sidewall sampled: viz. the Tertiary interval (below 13³/₈" casing, 827-1533 m) was covered with 47 SWS, whilst 23 SWS were shot in the Cretaceous section (1533-1590 m). However, as the present study aimed primarily at a fast delineation of time-boundaries, not all samples were analysed by means of the one biostratigraphic tool considered most appropriate for the respective time-intervals, e.g. microfauna for the Tertiary and nannoplankton for the Cretaceous.

Depending on future requirements of Norske Shell it is suggested that the entire set of SWS and additional cuttings be analysed comprehensively on microfauna, nannoplankton and palynomorphs, as the dense SWS coverage promises a wealth of biostratigraphic information to be gained which in turn would make this well a Tertiary-Cretaceous key section for this area.

NORWAY			SIDE WALL SAMPLE CORE	SPECIES LIST																				ABUNDANCE	PRESERVATION												
AGE	NANNO-PLANKTON ZONE	DEPTH IN m		CRUCIPLACOLITHUS TENUIS S.S.	NEOCHIASTOZYGIUS PERFECTUS	PRINSIUS MARTINII	TOWEIIUS SPP	WATZNAUERIA BARNESAE	MICULA DECUSSATA	ASPIDOLITHUS SP.132	ASPIDOLITHUS SP.135	REINHARDTITES A	REINHARDTITES B	REINHARDTITES B/C	PHANULITHUS OVALIS	PHANULITHUS OBSCURUS	EIFFELLITHUS EXIMIUS	LUCIANORHABDUS MALEFORMIS	CRIBROSPHAERA VENATA	NANNOCONUS BOREALIS	MICRANTHOLITHUS HOSCHULZII	RHAGODISCUS ASPER	MICRANTHOLITHUS OBTUSUS			HELENIA CHIASTIA	SPEETONIA COLLIGATA	MICRANTHOLITHUS SPEETONENSIS	PALAEOPONTOSPHAERA SALEBROSA	SOLLASITES HORTICUS	NANNOCONUS DOLOMITICUS	CYCLAGELOSPHAERA MARGERELI	CRETARHABDUS CRENULATUS	ZEUGRHABDOTUS EMBERGERI	WATZNAUERIA FOSSACINCTA		
		1449																																			
		1469.5																																			
		1510																																			
PC	NP 4-?	1528.5	●	○	○	○																													+	+	
PC	NP 4-?	1532		●	○				●																										+	+	
		1533.5							●																											+	+
		1536																																		+	+
		1537.5																																		+	+
		1539.5																																		+	+
CA.L	NK 18	1542.5					○	●	●	●	○	●	●	●	●	●	●	●	●	●	●														+	+	
		1545																																		+	+
		1549.5																																		+	+
		1552.5																																		+	+
		1556.5																																		+	+
SA-MA		1558							○																										+	+	
CE-MA		1562.5					○	○																												+	+
KK		1564					○	○																												+	+
HT.U-BR	NK 5-6	1565.5					■	■												○	○	○													+	+	
HT-BR	NK 4-6	1568.5					■	■												○	○	○													+	+	
KL		1572					■	■												●	●	●	●	○											+	+	
KL		1574.5					■	■												●	●	●	●	○											+	+	
VA	NK 3A	1576					■	■												●	●	●	●	○											+	+	
VA	NK 3A	1578.5					■	■												●	●	●	●	○											+	+	
BE-VA	NK 2-3	1582.5					○	○												○	○	○													+	+	
BE-VA	NK 2-3	1585					○	○																												+	+
BE-VA.L	NK 2	1586					○	○												○	○	○													+	+	
		1587.5					○	○												○	○	○													+	+	
		1588.5					○	○																												+	+
BE-VA.L	NK 2	1590					■	■															●												+	+	

LEGEND

ABUNDANCE		PRESERVATION
per species	all species	
● RARE	- ABSENT	-- VERY POOR
○ FEW	± RARE/FEW	- POOR
● COMMON	+ COMMON	± AVERAGE
■ ABUNDANT	++ ABUNDANT	+ GOOD

SHELL INTERNATIONALE PETROLEUM MAATSCHAPPIJ B.V.
THE HAGUE EXPLORATION & PRODUCTION

NORWAY OFFSHORE

NANNOPLANKTON DISTRIBUTION CHART
WELL 6407/9-1
INTERVAL 1449 - 1590 m
NOT TO SCALE

Author: B. Prins	Encl.: 2	Date: November 1984
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