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ROBERTSON RESEARCH INTERNATIONAL LIMITED

OILFIELDS REPORT NO. 2245

REPORT ON A WELL-SITE BIOSTRATIGRAPHICAL INVESTIGATION OF THE INTERVAL 3400m - 3780m IN THE NORSK HYDRO OFFSHORE WELL 30/7-3

by

J. A. SEYMOUR

Project No. IIA/767/1286

Prepared for;

Robertson Research International Ltd.,
Ty'n-y-Coed,
Llanrhos,
Llandudno LL30 1SA.
Gwynedd, North Wales.

Norsk Hydro A/S,
Petroleum Division,
Bygdøy alle 2,
Oslo 2,
Norway.

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Enclosures

I

INTRODUCTION

This report summarises the results of a micropalaeontological/ stratigraphical study carried out during the drilling of the Norsk Hydro (Petroleum Division) Norwegian offshore Well 30/7-3. This well-site investigation involved the lower part of the Upper Cretaceous section. The work was carried out under our Project No. IIA/767/1286.

It was explained by the Client that the Well, now drilling deep in the Upper Cretaceous, had failed to pick up the 'M1' marker. This marker is of particular importance in that it controls the pre-target casing point. It was felt that a micropalaeontological study might help to locate the stratigraphical position of the bottom of the hole.

The initial request for this investigation was received on the 29th September. The work which forms the basis of this report was completed over the period 29th September - 5th October; Mr. Seymour arriving on the rig on the 30th September and departing on the 4th October. During this period the well remained at a drilled depth of 3785m, whilst Schlumberger logs, a sidewall core shoot, and casing were run.

A preliminary summary of these findings was submitted to the Norsk Hydro Oslo office on the 5th October. Notwithstanding any further work upon this well section, a finalised report, complete with micropalaeontological chart, was requested for the work done on this particular occasion.

The scope of this study was limited to the availability of samples at the well-site, where it was found that wet, unwashed samples were available

covering the interval 3485m - 3785m; this was supported by dried samples for the interval 3373m - 3787m. A single sidewall core (3780m) was also made available for this study.

A summary of the stratigraphy of this section is included in the following chapters. The terminology for the environmental conclusions discussed in the final chapter follows that of Hedgpeth (1957) from which Table 1 of this report is taken.

The picked slides and washed residue preparations are presently filed in the confidential records section of these laboratories, and are thus available to the client at any time.

We gratefully acknowledge the co-operation and assistance received from the various members of Norsk Hydro, both in fascilitating the well-site visit and in the performance of the investigations on the rig.

II

UPPER CRETACEOUS SUMMARY

From information supplied by the Client it is believed that a regular succession of Tertiary into Upper Cretaceous is present in this well. Arenaceous sediments around 2500m are regarded as probable Palaeocene age. A sequence of thin limestones at 2528m, underlain by a thin development of silty-sandstone which in turn passes down into shale beds, from 2540m - 2548m, is considered to represent a Lower Palaeocene (Danian aged) interval. This is succeeded down-hole by a significant development of limestones. These commence at 2548m and persist, with some non-carbonate intercalations in the lower part, down to 2620m. This unit is regarded as representing the top of the Upper Cretaceous section; and correlations (both lithological and geophysical) can be made to nearby wells which clearly support this prognosis.

Thereafter, this and nearby wells all enter an extensive and much less distinctive section composed of intermixed sequences of shales, claystones and marls carrying intermittent thin interdigitations of both limestones/dolomites and, more rarely sandstones.

Nevertheless a somewhat more pronounced limestone development circa 2775m in Well 30/7-3 is accompanied by clays which for the first time are conspicuously red-brown coloured. This level might possibly bear correlation to 2916m and below in Well 30/10-5, where interbedded marl and silty-limestone is succeeded by shales with occasional red-brown colour. 2916m in 30/10-5 is therefore picked as the Maastrichtian/Campanian boundary.

Below this, lithological and well-log control diminishes to a minimum, so that at 3500m and below any proposed correlations are conjectural. Lithological pointers involve the possible correlation to other wells of the following horizons in Well 30/7-3.

(i) A conspicuous limestone development at 3630m.

(ii) A less well-developed limestone break at 3738m.

In general, the greatest overall similarity appears to be incorporated in the Upper Cretaceous section of Well 30/10-5. In that Well there occurs:

(i) A break into a section of shale with thin limestone stringers at 3450m. This occurs within the 'Lower Senonian' interval.

(ii) A thick, very well defined limestone at 3630m which is taken to represent the topmost beds of a 'Turonian - Upper Cenomanian' interval.

(iii) A third interval comprising shaly marls interbedded with thin limestones - commencing around 3804m and representing the uppermost beds of a 'Cenomanian - Albian' interval.

This last horizon is accepted as the M1 marker horizon in Well 30/10-5. This same level is considered to correlate with 12116' in Well 30/5-1 (which is where the M1 was picked). Originally, 12116' in 30/5-1 was suggested as the possible top of the Lower Cretaceous being at the top of an 'Albian' interval. Subsequent revision suggests that this is more equivalent to the top of the 'Cenomanian - Albian' interval of 30/10-5, with the top of Lower Cretaceous in 30/5-1 actually being some 600' lower.

III

MICROPALAEONTOLOGY AND STRATIGRAPHIC INTERPRETATION

General Comments

A total of eighteen samples were prepared and analysed out at the rig-site. These samples covered the interval 3400m - 3780m, with primary emphasis directed towards the sub-intervals 3600m - 3660m and 3760m - 3780m. This coverage comprised seventeen ditch cuttings samples and a single sidewall core sample. The main intention was to attempt to discover the age of the beds above and across the first major limestone break; and to age the beds at the present bottom of the hole (i.e. immediately underlying the limestone break at c. 3740m). As time permitted, further samples were examined (within the limits of the run of samples available) aimed at (a) filling the intervening section between 3660m and 3760m and (b) obtaining indications of age higher in the section.

All the samples examined yielded poor to fair foraminiferal assemblages, often restricted in variety and often composed of dwarfed, impoverished specimens. However, all the samples contained some microfauna.

There is a noticeable dearth of calcareous benthonics throughout the interval examined. At three points, small agglutinated foraminifera abound and form the dominant faction of the assemblage. In the majority of samples examined, however, small, often rather poorly preserved, planktonic specimens are the dominant feature.

Notwithstanding the following results, it must be stressed that the difficulties and problems of interpretation are heavily compounded when considering a poorly fossiliferous section of limited thickness taken out of context from its well section.

Stratigraphic Succession

From an analysis of these samples alone, a clear-cut definition of stratigraphic stages is not possible, but by a certain amount of deduction and interpretation by inference a reasonable age determination is possible.

The following table sets out the stratigraphical succession inferred from this analysis:

3400m - 3550m	Lower Senonian
3550m - 3600m	?basal Coniacian - Turonian
3600m - 3700m	Turonian
3720m - 3740m	Turonian - Cenomanian
3760m - 3780m	Cenomanian (?older Cenomanian)

Lower Senonian

The three samples examined at 3400m, 3500m and 3550m contain little of diagnostic value. Haplophragmoides spp. appear regularly in all three samples, as do occasional, small, planktonic specimens referred to Rugoglobigerina rugosa rugosa. The sample at 3550m yielded a more varied assemblage in which Bathysiphon spp. occurred more abundantly, and which also contained rare Clavulinoides disjuncta, Reussella sp. A. and small

Globotruncana spp. Having regard to the position of these three samples overlying the microfaunal assemblage recorded between 3600m - 3700m, a Lower Senonian age is adduced.

Turonian

A faunal break must occur below 3550m and from 3600m - 3700m the nine samples yielded more prolific residues representing a faunule in which generally small and not too well preserved planktonic foraminifera were the dominant factor. The appearance of an association of Globotruncana spp. accompanied by specimens comparable to Praeglobotruncana spp., suggests a Turonian age for this group of samples. At the top of the sub-interval, the sample at 3600m includes abundant specimens of Globotruncana marginata. A single specimen of G. linneiana linneiana is also present together with a number of planktonic specimens referred to the genus Hedbergella spp. and others which have affinities with Praeglobotruncana stephani or Praeglobotruncana inornata. This assemblage is repeated in the residue at 3610m and 3620m with the inclusion of a specimen of Globotruncana linneiana tricarinata, an additional G. linneiana linneiana, and more definitive Praeglobotruncana cf. stephani. Fairly frequent Haplophragmoides spp. and nodosarian fragments accompanied by rare ostracoda and radiolaria form the bulk of the microfaunal assemblage in the remainder of these samples. A Turonian age is assigned to the whole of the sub-interval, but the unexamined overlying sediments (3550m - 3600m) could extend upwards from topmost Turonian into basal Coniacian levels.

From 3630m to 3680m agglutinated forms are more conspicuous; with Haplophragmoides spp., nodosarian fragments and polymorphinids representing

a large part of each sample. The planktonic complement of these samples shows little variation except that Globotruncana spp. appears less frequently, whilst various forms of Hedbergella spp. and Praeglobotruncana spp. appear as above.

A marked influx of siderite was noted in the sample at 3650m and this may have significance in future correlations. Succeeding samples (3660m, 3680m, 3700m) also contain a little siderite, which may well be caving from the rich horizon above 3650m.

Turonian - Cenomanian

The next change that is apparent is in the two samples 3720m and 3740m. The predominant agglutinated assemblage represented in these samples renders them largely indeterminate as to age, but their position between two faunal units of more determinate age lends to an assumption of Turonian - Cenomanian age at these depths. Haplophragmoides spp., Bathysiphon spp. and Pelosina complanata all appear fairly frequently in these samples. A single Tritaxia cf. dubia, occasional Reussella sp. A and R. szajnochae praecursor and rare ostracoda are recorded from these samples.

Cenomanian

Finally, a distinctly different assemblage is encountered over the lowermost interval (3760m - 3780m) of the section studied. Planktonic foraminifera again appear more significantly and are represented in this instance by a suite of Hedbergella spp. which includes H. cf. brittonensis, H. delrioensis and

H. cf. planispira. Although not present at 3760m, Glomospira gordialis appears frequently at 3770m and is fairly abundant at 3780m. This is possibly of stratigraphical significance since an abundance of G. glomospira usually indicates the topmost Lower Cretaceous (Albian). Small rotalids reminiscent of Valvulineria aff. gracillima occur commonly within this group of samples alongside small agglutinated specimens referred to Arenobulimina cf. macfadyeni, which also increase in abundance towards 3780m. Many of the specimens in the ditch cuttings sample at 3780m were conspicuously green-stained. The impression occasioned by this microfaunal association is of basal Upper Cretaceous or youngest Lower Cretaceous age. Certainly the sediments at 3780m cannot be older than early Albian and it is doubtful if a true Lower Cretaceous (Albian) faunal assemblage is represented here; clearly, however, they are older than the Turonian sediments at 3600m - 3700m. In the absence of the more varied fauna normally associated with Albian beds, it is suggested that these 'basal' beds comprise Cenomanian aged sediments, with emphasis on the possibility that they represent older (if not earliest) Cenomanian age.

IV

STRATIGRAPHICAL CORRELATION

Because of the poorly developed microfaunas encountered, it is not possible to arrive at an absolute stratigraphic age designation for this section. A generalised succession of ages is indicated, however, from which we can interpret a sequence from Lower Senonian sediments at 3400m passing down through Turonian beds, and a Turonian - Cenomanian unit, to older Cenomanian at 3780m. Evidence provided from this section thus suggests that the top of the Cenomanian stage should occur in Well 30/7-3 between 3700m and 3750m.

Since it is understood that the M1 marker has been identified (on well-log information?) in Well 30/10-5 at 3804m, then it would appear that this represents the first significant limestone horizon in an interval of 80m recognisable as shales and marls with rare limestone stringers. Furthermore this horizon is suggested as marking the top of a 'Cenomanian - Albian' interval.

From this, it therefore seems that the limestone occurring in Well 30/7-3 at circa 3738m is a correlatable horizon, since this also approximates to the top of the Cenomanian interval; and furthermore the distinctive limestone is followed by marlstone and shales in which the stringers of limestone are also noted over a thickness of at least 35m.

Having established the identity of the M1 horizon it then becomes apparent that the distinctive lithological horizon in 30/10-5, beginning at circa 3630m, and consisting of some 40m mainly of limestone, is correlatable to Well 30/7-3. In the subject well these beds occur at an identical horizon (i.e. 3630m) with the occurrence of a well-developed, grey to white, hard,

microcrystalline limestone.

Having thus established a correlation over the lower part of the section, correlation at higher levels is weakly suggested by the inclusion on the well-log of zones in which the primary clay/claystone/marl sediments carry a conspicuous content of thin limestone bands. The most prominent of these is perhaps between 3350m and 3410m. Visual analogy suggests that these levels may correlate with the interval 3450m - 3480m in Well 30/10-5.

V

CONCLUSIONS

1. The association of a lithological sequence of shales (often finely micaceous) and limited interbedded thin developments of limestones, dolomites and dolomitic shales generally suggests deposition in deeper shelf areas. This is evidenced by the presence of fine, argillaceous sediments and a distinct absence of coarser sediments; the limited intervals of carbonate development; and the presence of mica - although finely subdivided and in relatively limited amounts. Microfaunal analysis supports this picture with very reduced numbers of calcareous benthonic foraminifera; a greater preponderance of small, finely agglutinated forms; and an abundance of small planktonic specimens - indicating outer sublittoral (perhaps outer marginal outer sublittoral) environments. This environment is considered to have usually maintained reasonably open connections to the open sea and oceans, but other environmental factors (possibly unusually turbulent conditions resulting in heavily silted waters) have reduced this environment to one only marginally favourable to the support of planktonic microfauna.

2. Further drilling, as per the forward programme of the well will test the validity of the correlations put forward in the previous chapters and based on this micropalaeontological analysis. Unless an alternative M1 horizon is more confidently identified closely underlying the present casing shoe, then this marker has already been encountered - but was unaccompanied by any gas kick.

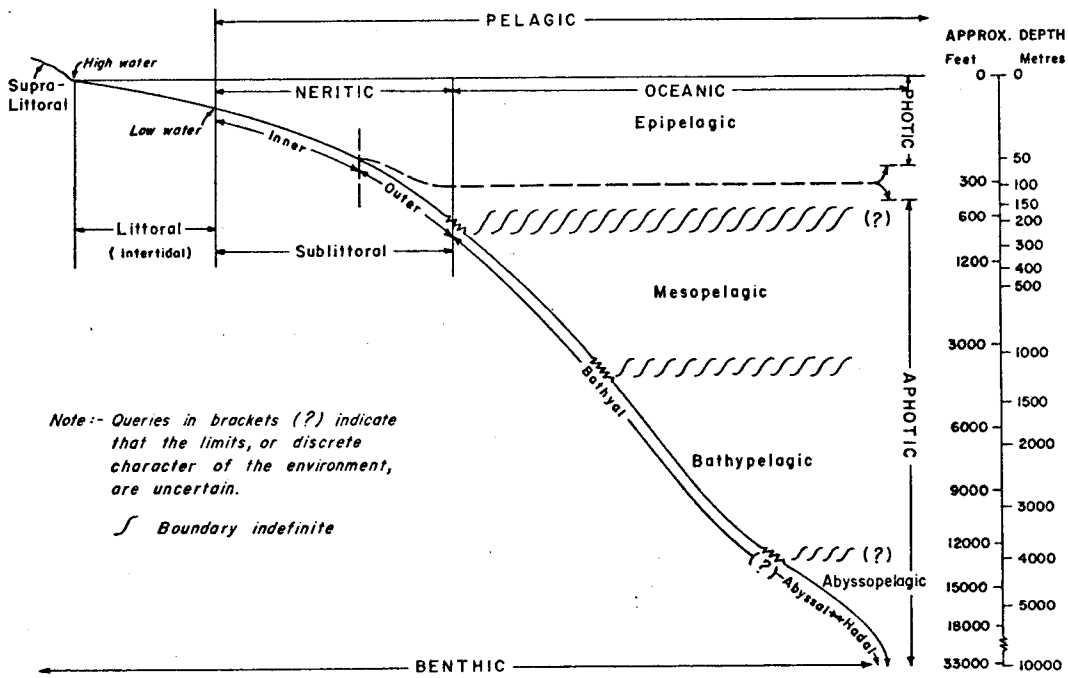
3. It is clear from the foregoing biostratigraphical interpretation that a moderately condensed sequence is present at the 30/7-3 location - compared with the equivalent section seen in Well 30/10-5.

4. It would seem possible that the marker horizon referred to as M1 in fact corresponds fairly closely to the better known 'Plenus Marl' horizon. This is readily recognised in more southerly areas and can now be identified as a log marker in more northerly locations, where it corresponds with the horizon marking the top of the Cenomanian interval.

5. In more northerly latitudes the Cenomanian Stage usually appears to be fairly thin, commonly being represented by intervals of considerably less than 100'. This being the case, the section here reviewed is not anomalous to this suggested breakdown. If the M1 horizon represents the top of a relatively thin Cenomanian Stage, and is identified in Well 30/7-3 with the limestone at 3738m, then the sediments at 3770m - 3780m would well equate to basal Cenomanian or topmost Albian.

TABLE 1

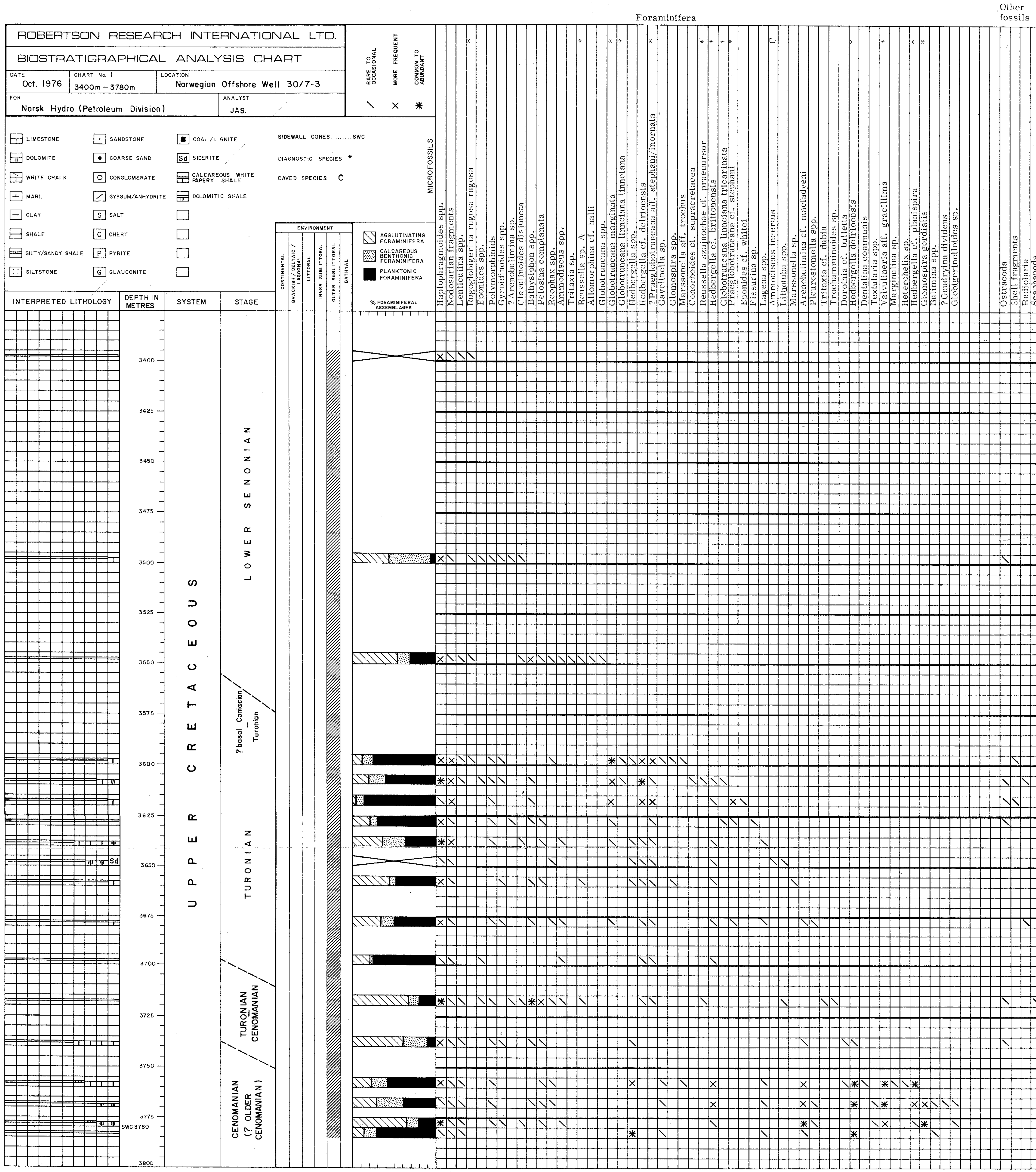
CLASSIFICATION OF MARINE ENVIRONMENTS



The classification of marine environments used in this report is presented in diagrammatic form above. Pelagic (water) and Benthic (bottom) environments are recognised.

PELAGIC	BENTHIC
Neritic	Supralittoral
Oceanic	Littoral (Intertidal)
Epipelagic	Sublittoral
Mesopelagic	Inner
Bathypelagic	Outer
Abyssopelagic	Bathyal
	Abyssal
	Hadal

The classification is after Hedgpeth (1957) and results from several years discussion by a Committee of the Division of Earth Sciences, National Research Council, National Academy of Sciences, Washington D. C.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BIOSTRATIGRAPHICAL ANALYSIS CHART
DATE Oct. 1976
CHART No. 1 3400m – 3780m
LOCATION Norwegian Offshore Well 30/7-3
FOR Norsk Hydro (Petroleum Division)
ANALYST JAS.
RARE TO OCCASIONAL
MORE FREQUENT
COMMON TO ABUNDANT
LIMESTONE
DOLOMITE
WHITE CHALK
MARL
CLAY
SHALE
SILTY/SANDY SHALE
SILTSTONE
SANDSTONE
COARSE SAND
CONGLOMERATE
GYPSUM/ANHYDRITE
SALT
CHERT
PYRITE
GLAUCONITE
COAL / LIGNITE
SIDERITE
CALCAREOUS WHITE PAPERY SHALE
DOLOMITIC SHALE
SIDEWALL CORES.........SWC
DIAGNOSTIC SPECIES *
CAVED SPECIES C
MICROFOSSILS
ENVIRONMENT
CONTINENTAL
BRACKISH / DELTAIC / LAGOONAL
LITTORAL
INNER SUBLITTORAL
OUTER SUBLITTORAL
BATHYAL
AGGLUTINATING FORAMINIFERA
CALCAREOUS BENTHONIC FORAMINIFERA
PLANKTONIC FORAMINIFERA
% FORAMINIFERAL ASSEMBLAGES
INTERPRETED LITHOLOGY
DEPTH IN METRES
SYSTEM
STAGE
Foraminifera
Other fossils
Haplophragmoides spp.
Nodosarian fragments
Lenticulina spp.
Rugoglobigerina rugosa rugosa
Eponides spp.
Polymorphinids
Gyroidinoides spp.
? Arenobulimina sp.
Clavulinoides disjuncta
Bathysiphon spp.
Pelosina complanata
Reophax spp.
Ammodiscus spp.
Tritaxia sp.
Reussella sp. A
Allomorphina cf. halli
Globotruncana spp.
Globotruncana marginata
Globotruncana linneiana linneiana
Hedbergella spp.
Hedbergella cf. delrioensis
? Praeglobotruncana aff. stephani/inornata
Gavelinella sp.
Glomospira spp.
Marssonella aff. trochus
Conorboides cf. supracretacea
Reussella szajnochae cf. praecursor
Hedbergella cf. brittonensis
Globotruncana linneiana tricarinata
Praeglobotruncana cf. stephani
Eponides cf. whitei
Fissurina sp.
Lagena spp.
Ammodiscus incertus
Lituotuba sp.
Marssonella sp.
Arenobulimina cf. macfadyeni
Pleurostomella spp.
Tritaxia cf. dubia
Trochamminoides sp.
Dorothia cf. bulletta
Hedbergella delrioensis
Dentalina communis
Textularia spp.
Valvulineria aff. gracillima
Marginulina sp.
Heterohelix sp.
Hedbergella cf. planispira
Glomospira gordialis
Bulimina spp.
? Gaudryina dividens
Globigerinelloides sp.
Ostracoda
Shell fragments
Radiolaria
Scaphapoda
3400
3425
3450
3475
3500
3525
3550
3575
3600
3625
3650
3675
3700
3725
3750
3775
3800
SWC 3780
Sd
UPPER CRETACEOUS
LOWER SENONIAN
? basal Coniacian – Turonian
TURONIAN
TURONIAN – CENOMANIAN
CENOMANIAN (? OLDER CENOMANIAN)