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NORWEGIAN PETROLEUM DIRECTORATE

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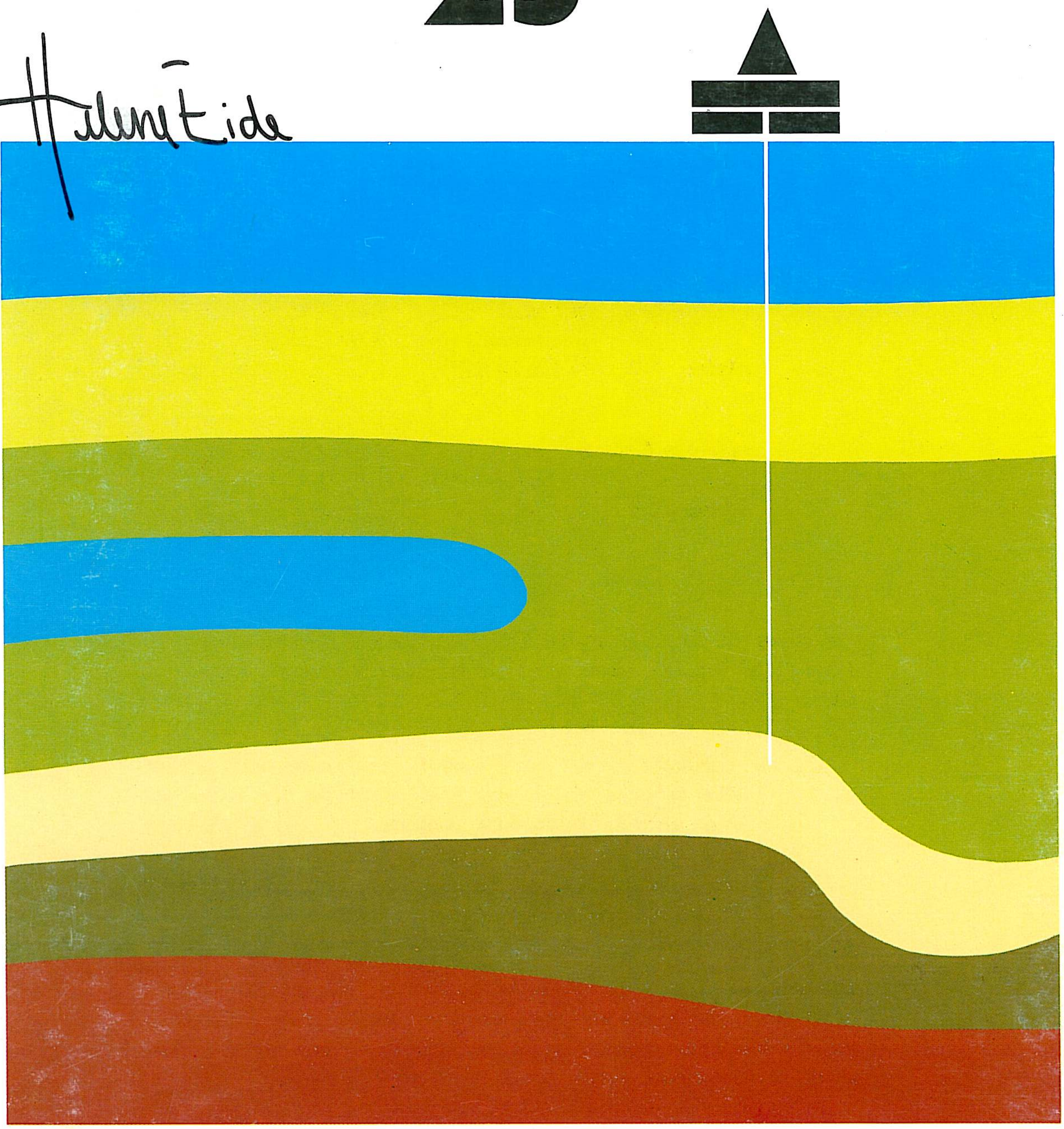
Helene Eide



Lithology. Wells Nos. 2/4-1 2/4-2 2/4-3 2/4-4 and 2/4-5

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Directions for the Norwegian Petroleum Directorate issued by the Ministry of Industry states that the Directorate among other duties shall:

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This is a part of the responsibility of the Resource Management Department in the Directorate and the present publication series is meant to partially fulfill this object. It is named NPD Papers and issued as consecutively numbered volumes.

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NPD Paper No. 25

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Preface

The Norwegian Petroleum Directorate has, among its duties, the responsibility for publication of releasable data connected to petroleum activities on The Norwegian Continental Shelf.

In this connection it has been decided to make a standardized description of drill bit cuttings as well as cores.

The sample descriptions are based on the "Standard Legend — Exploration and Production Department of the Royal Dutch/Shell group of companies". The Directorate much appreciates the Royal Dutch/Shell companies and A/S Norske Shell Exploration and Production's permission to use their legend.

The samples and the wire line logs from the herein described well are released to scientific institutions, companies and other interested organizations for further studies. The material pertinent to the well can be examined in the Directorate. For practical reasons an application must be made in each case.

The application should state what material is to be examined, what kind of examination will be made, and the purpose of the studies. It should be addressed to:

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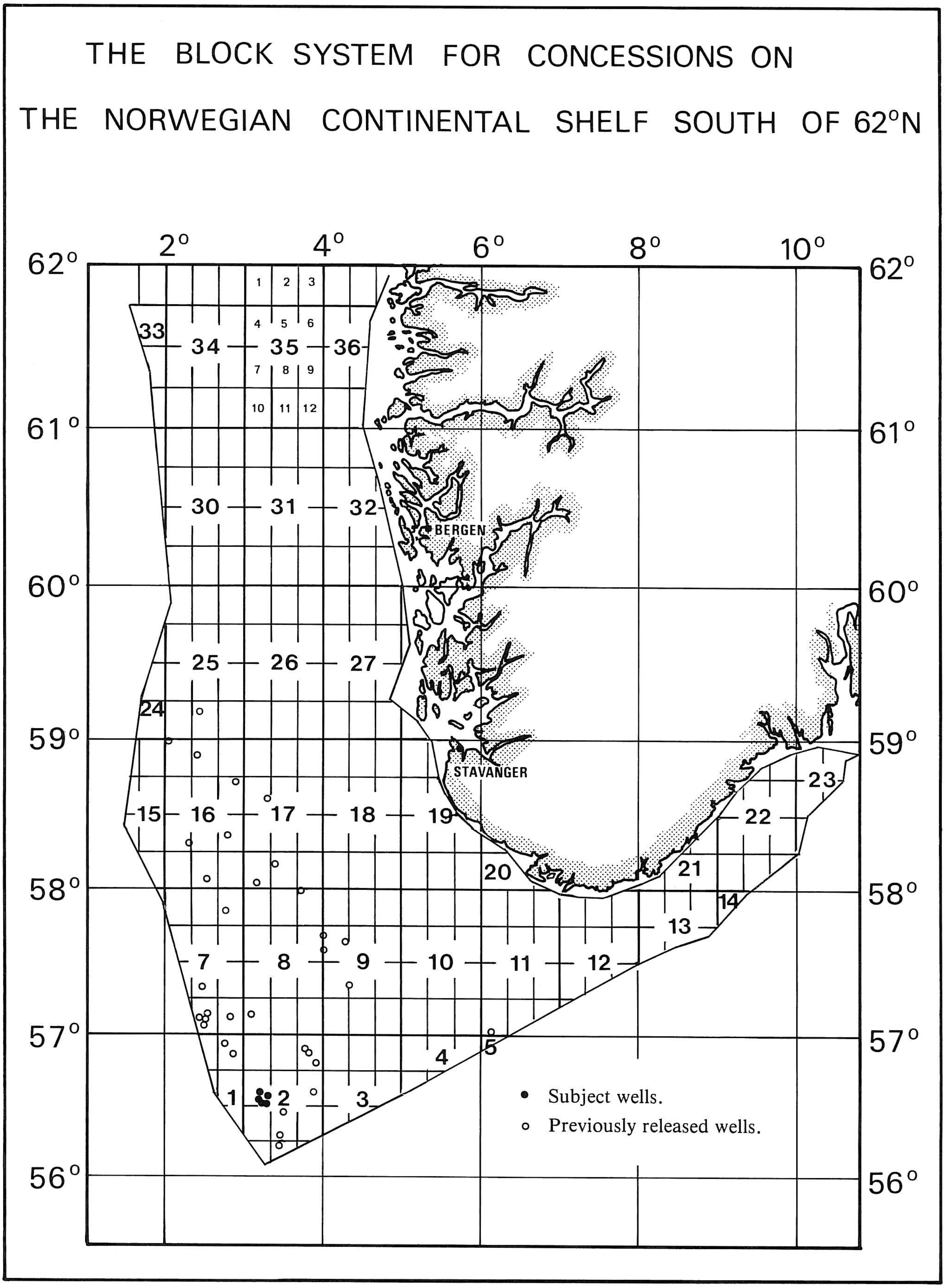
THE BLOCK SYSTEM FOR CONCESSIONS ON
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Previously released wells.

Fig. 1

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Introduction

The Phillips Group was in 1965 assigned licence No. 18 which covered the blocks 1/5, 2/4, 2/7 and 7/11 on the Norwegian Continental Shelf. The Group consists of Phillips Petroleum Company Norway, Norske Fina A/S, Norske Agip A/S and Elf Aquitaine Norge A/S. Phillips was operator for the wells 2/4-1, 2/4-2, 2/4-3, 2/4-4 and 2/4-5 with drilling permits Nos. 33, 34, 35, 37 and 40 respectively.. These wells are called 2/4-1X, 2/4-1AX, 2/4-2X, 2/4-3X and 2/4-4AX by Phillips.

The main objectives of the wells were to test the Tertiary and the top of the Mesozoic sediments. The spudding and completion dates, and the locations of the wells are listed below:

Wells No.	Spudded	Completed	Location	
			N	E
2/4-1	21 08 69	05 09 69	56°32'38"	03°11'58"
2/4-2	18 09 69	24 12 69	56°32'08.7"	03°11'54.6"
2/4-3	27 01 70	31 05 70	56°32'42.1"	03°14'55.5"
2/4-4	02 06 70	01 08 70	56°30'48.9"	03°12'39.5"
2/4-5	21 06 70	27 08 70	56°34'28.4"	03°12'08.2"

The subject wells are the five first wells drilled on the Ekofisk structure. The drilling proved that this structure is a large oil and gas field.

When well 2/4-1 reached 1662 m it flowed oil and gas from Lower Miocene limestone, and the well was plugged and abandoned. Neither sonic nor gamma logs were run, and no cores were taken. Because of this no lithologic description has been carried out on this well.

The four other wells revealed oil and gas in limestone of Danian and Maastrichtian age.

Drilling operations

Well 2/4-1 was drilled to 1662 m (5452'), where they had a kick. Because of this the well was plugged and abandoned to control the kicking. The other wells were drilled without any technical problems. The wells 2/4-2 and 2/4-3 were drilled without returns to a depth of 619 m (2030'), and the wells 2/4-4 and 2/4-5 were drilled without returns to 622 m (2041') and 585 m (1920') respectively. In the intervals drilled without returns, seawater was used as drilling fluid, adding high viscosity mud when needed. Pertinent mud data is given in Tables 2a-e. Information about casings and cores taken are given in Tables 1 and 7. Other data are summarized below:

Well No.	Rig	Water depth		KB		Total depth	
		m	feet	m	feet	m	feet
2/4-1	Ocean Viking	71	233	27	89	1662	5452
2/4-2	Ocean Viking	70	231	27	89	3305	10843
2/4-3	Ocean Viking	71	232	27	89	3432	11257
2/4-4	Ocean Viking	71	233	27	89	3425	11234
2/4-5	Neptune VII	92	300	24	78	3320	10894

TESTING

One successful drill stem test was carried out in well 2/4-2 at the base of the Ekofisk Formation.

In well 2/4-3, 10 drill stem tests were carried out. Five of them were taken in the Ekofisk Formation, four in the Tor Formation and one in a limestone section in the Sele Formation.

In well 2/4-4, eight drill stem tests were carried out, one in the Tor Formation, the rest in the Ekofisk Formation.

In well 2/4-5, five drill stem tests were carried out, one was taken at the top of the Tor Formation, four were carried out in the Ekofisk Formation and one test failed. The results of the tests are given in Table 3.

Available material

Wire line logs, drill bit cuttings and wet samples are stored at the Norwegian Petroleum Directorate (NPD).

Sidewall cores were collected from the wells 2/4-3 and 2/4-5. They are in the possession of the operator. In well 2/4-3, 90 sidewall cores were taken, of which 75 were recovered. The sidewall cores were collected in the interval from 1668 m to 3005 m. In well 2/4-5 14 sidewall cores were taken in the interval from 3162 m to 3315 m.

Eight conventional cores were taken in well 2/4-2, 18 in well 2/4-3, three in well 2/4-4 and 12 conventional cores were taken in well 2/4-5. The cored intervals and recoveries are listed in Table 7.

The log runs and their depth intervals are given in Table 4.

Drill bit cuttings were collected from all five wells. The number of cuttings samples and their average weights are listed below:

Well No.	Number of cuttings samples	Average weight, g
2/4-1	112	13
2/4-2	390	14
2/4-3	304	15
2/4-4	312	18
2/4-5	304	22

The intervals of the cuttings samples are given in Tables 5a-e. The wet samples were divided in two at the NPD. One half was dried and the other half was washed through a 74 micron sieve and dried. The amount of material retained after washing and drying is listed together with the sample intervals in Tables 6a-e.

Geology

GENERAL

Comments on environment of deposition and lithostratigraphy are based on lithological descriptions and wire line log interpretations made in the NPD.

The lithostratigraphic nomenclature used in the text and on the appended log is based on the joint work of the UK-Norwegian lithostratigraphic committees (Deegan & Scull 1977).

Description and classification of lithology are based on Shell's Standard Legend 1976 (Shell Internationale Petroleum Maatschappij B. V. 1976). This legend is based on Wentworth's scale for grain size (Wentworth 1922) and Dunham's classification for carbonates (Dunham 1962). Colours are described according to the Rock-Color Chart (Geol. Soc. Am. 1970) and are based on dry samples.

The lithology of the rocks penetrated in well 2/4-4 are presented graphically on the appended log (App. 1).

The wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5 were drilled through the Tertiary and bottomed in sediments of Maastrichtian age. The reservoirs were found within sediments which belong to the upper part of the Chalk Group. The Chalk Group is largely composed of pure limestone and has a large lateral extent in the Southern and Central North Sea.

In the wells examined the following lithostratigraphic units are represented:

Group	Formation	Age	
Nordland		Recent to Middle Miocene	
Hordaland		Early Miocene, Oligocene and Eocene	
Rogaland	Balder Sele Lista	Early Eocene to Paleocene	
	Unnamed marl unit (Maureen Fm. equivalent)		Danian
Chalk	Ekofisk		
	Tor	Late Cretaceous	Maastrichtian

The wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5 were drilled to the same stratigraphic depth. The wells 2/4-2, 2/4-4 and 2/4-5 are situated along a north-south running profile across the structure. Of these well 2/4-4 has the best log quality and this well has therefore been preferred as a basis for descriptions and interpretation (App. 1.).

A correlation chart which shows the main trends in the lithology and the gamma ray and sonic logs from the wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5 from the Balder Formation to total depth is presented in Appendix No. 2. Appendix No. 3 shows a lithologic correlation chart for all four wells.

GEOLOGICAL SETTING

The Ekofisk field is located in the Central Trough and its structure is an anticline, uplifted by halokinetical movements of Permian salt. The location of well 2/4-4 relative to the main geological structural features is shown at the top of the appended log. The wells 2/4-1, 2/4-2, 2/4-3 and 2/4-5 are located close to well 2/4-4 (Fig. 2).

LITHOLOGY AND LITHOSTRATIGRAPHY

WELL 2/4-4

Nordland Group, 98 - ? 1737 m

In the interval from seafloor to 622 meters no cuttings samples are available.

The sediments in this group consist mainly of light olive grey clay and silt. In the interval from 700 m to 950 m most of the material seems to be silt. Quartz grains and shell fragments occur throughout this interval. Further down from about 1300 m to 1450 m, the sediment is a brownish clay. From around 1600 m and further down the well, limestone stringers occur. The base of the Nordland Group is tentatively set at 1737 m where there are breaks on the gamma and sonic logs, and there is an increase in limestone stringers.

Hordaland Group, ?1737—2975 m

This interval consists of light olive grey to grey claystones and shales with interbeds of lime mudstone, light grey to pale brown, soft to hard.

In the lowermost part of this group the shales become waxy and varicoloured with greenish and reddish shales in addition to the grey ones.

Rogaland Group, 2975—3122 m

In this group four units can be differentiated: The Balder, Sele and Lista Formations, and an unnamed marl unit, equivalent to the Maureen Formation.

Balder Formation, 2975—2989 m

This interval consists of varicoloured shales as described at the base of the Hordaland Group. In addition there is a minor amount of tuffaceous clay- and siltstones, greenish grey with white specks and a rough textured surface.

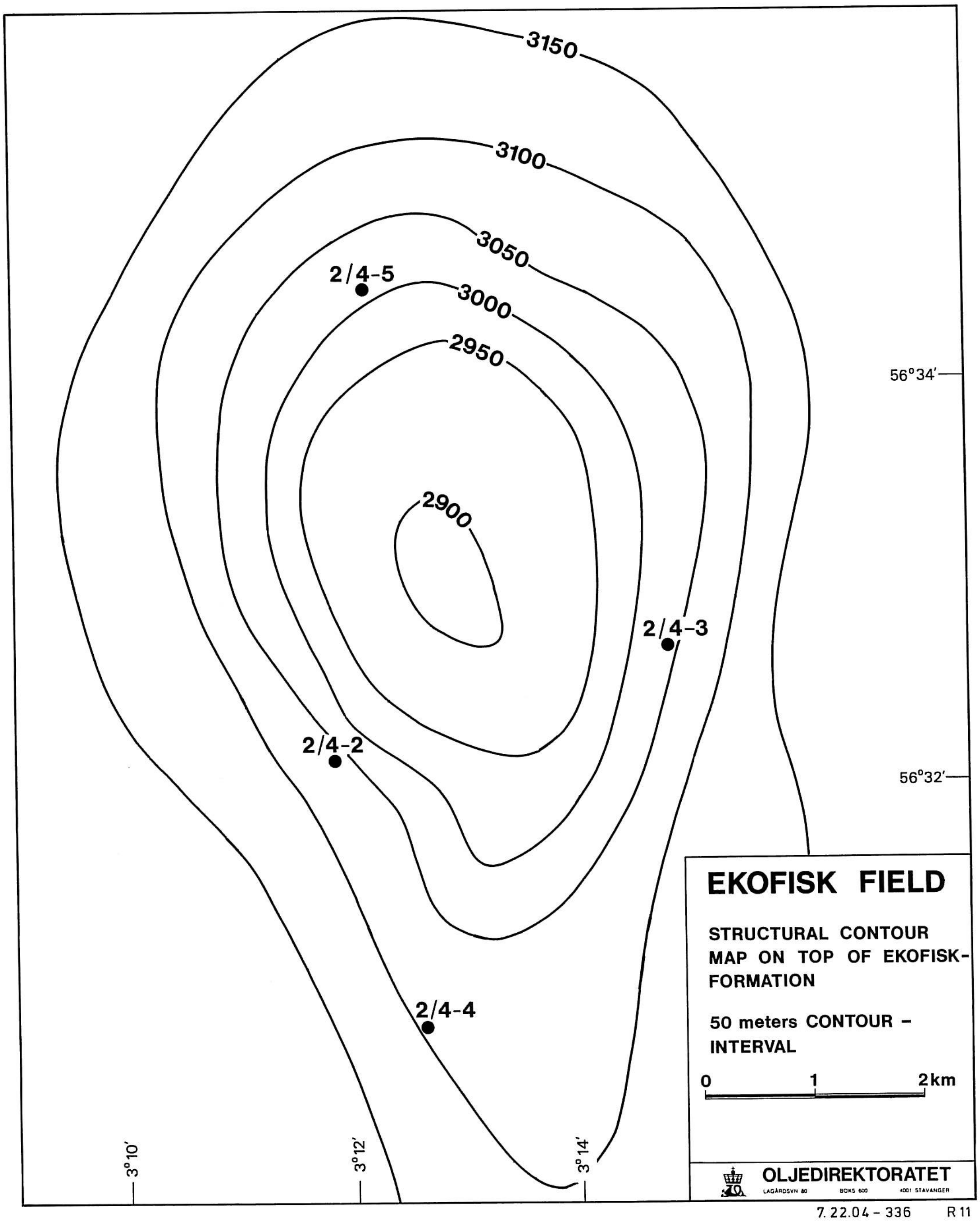


Fig. 2. Structural contour map of the top of the Ekofisk Formation.

Sele Formation, 2989—3052 m
The varicoloured shales are present also in this interval, but the dominating sediment is medium dark shale. Traces of tuffaceous material were found around 3000 m. Lenses of fine grained, translucent, glauconitic and micaceous sandstone occur. At 3037 m and 3045 m there are shifts on both the gamma ray and sonic logs. This interval consists of light to medium grey shales. Traces of lime mudstone and siltstone with glauconite were found. About 3050 m the shale becomes medium grey and there are marked breaks on the gamma ray and sonic logs, which indicate the base of the Sele Formation (Deegan & Scull 1977).

Lista Formation, 3052—3102 m
In this interval the shale is medium grey, and tuffaceous material was no longer observed. Small amounts of fine grained sandstone were registered. The base of this interval is set where the sediment changes from shale to marl.

Marl unit, 3112—3116 m
This unit consists of a light grey marl, but some shale is also present. The boundary to the underlying Chalk Group is set where the marl grades into lime mudstone.

Chalk Group, 3116—3424 m
Within this interval the two uppermost formations of the Chalk Group are present. These are the Tor and Ekofisk Formations.

Ekofisk Formation, 3116—3255 m
The sediment in this interval consists of lime mudstone. In the upper part it is light grey in colour, soft and partly cemented. Some clay seams occur, and chert is present throughout this section. At the base of the Ekofisk Formation there is a medium grey, calcareous shale with burrows (see core description). This interval is also reflected by higher GR-readings.

Tor Formation, 3255—3424 m
In the upper part of this interval the sediment consists of a light grey, fairly soft lime mudstone. Further down it is white, dense and relatively hard, probably due to cementation. The clay content is lower in the Tor Formation than in the Ekofisk Formation.

WELLS 2/4-2, 2/4-3 AND 2/4-5.
The Tertiary down to the Danian seems to be similar in all four wells. In well 2/4-2 the interval between 810 m and 890 m seems to contain more silt and sand than the corresponding intervals in the other wells.
In the wells 2/4-2, 2/4-3 and 2/4-5 it is difficult to distinguish any tuffaceous material in the samples. This may be due to the fact that this sediment dissolves readily when washed. However, the presence of such material is clearly indicated by the logs.
In the wells 2/4-3 and 2/4-5 there is within the Sele Formation a unit of limestone with chert. This unit extends from about 2978 m to 2995 m (subsea) in well 2/4-3, and from about 2910 m to 2938 m (subsea) in well 2/4-5. In well 2/4-2 traces of fine sand are found in a corresponding interval from about 2906 m to 2940 m (subsea). The breaks on the logs are most pronounced in well 2/4-3, but here it coincides with a shift in log runs.

Description of cores
The cores from well 2/4-4 are described on the appended log. The cores from the other wells will be described briefly in the following (Fig. 3).

Well 2/4-2
The recovery of core 2, (3052—3065 m) is only 16 %. The sediment is a light grey, hard lime mudstone with clay seams and burrows. Core 3 (3199—3205 m) consists of a light grey, hard lime mudstone with clay seams. Around 3201 m some silicified parts occur. A 2 cm thick layer of lime mudstone conglomerate is found at 3203 m. The fragments are white

lime mudstone in a light grey lime mudstone matrix. The upper meter of core 4 (3205—3220 m), consists of the same kind of sediment as core 3. At 3205 m there is a lime mudstone conglomerate, about 10 cm thick, consisting of up to 3 cm lime mudstone fragments, which are angular. Stylolites occur close to this conglomerate.

Below 3206 m and to the base of core 7 there is a soft, pinkish grey lime mudstone with scattered, rounded, light grey nodules, which may be redeposited fragments or they may be a result of cementation.

Core 8 (3265—3280 m) consists of a light grey, hard lime mudstone with horizontal and vertcal burrows. Stylolites are common and some parts are fractured.

Throughout the cores the sediment is bioturbated, and small scale slumping structures occur.

Well 2/4-3

The cores 2 to 7 consist of a soft, pinkish grey lime mudstone. Chert occurs at 3122 m and at 3124 m, and from 3132 m to the base of core 7. In the interval from 3134 m to 3135 m there is a conglomerate which consists of a very light grey wackestone with lime mudstone granules. The wackestone contains foraminifera and other bioclasts, and some chert is present. About 30 cm above the conglomerate there is a 10 cm thick layer with graded bedding. Around 3132 m (core 6) bioturbation and burrows are present.

The cores 8, 9 and 10 consist of an interbedded sediment of soft and hard lime mudstone with seams and layers of clay.The colour varies from very light grey to pale yellowish brown. Chert and some stylolites occur. The upper part of cores 8 and 9 are fractured, core 10 is fractured throughout. Some of the fractures are refilled with calcite.

The cores 11 and 12 consist of soft greyish orange and fractured lime mudstone. In this sediment scattered granules of light grey mudstone and some stylolites occur.

The cores 13, 14 and 15 consist of a hard lime mudstone with clay seams and layers. The colour changes from light grey in the cores 13 and 14 to pinkish grey and white in core 15. Between 3251 and 3252 m (core 13) the sediment is a light grey, bedded wackestone with some clay seams. Some nodules, which may be due to cementation, occur. The number of stylolites increases below 3263 m, and the sediment is disturbed. This may be due to bioturbation and small scale slumping.

Core 16 consists of an interbedded sequence of soft and hard, very pale orange lime mudstone, with stylolites and clay seams. Around 3278 m there are structures which represent slumping.

The cores 17 and 18 consist of a soft, very pale orange to white lime mudstone. The colour changes to white at 3228 m. Scattered nodules of lime mudstone appear occasionally. Stylolites occur, and some smaller parts are fractured.

Well 2/4-5

The cores 1, 2, 3 and 4, (3094—3133 m) consist of a hard, light grey lime mudstone with clay seams and white nodules. The sediment in core 1 is partly silicified. At the top of core 2, a silicified nodular lime mudstone is present (Fig. 4). At around 3101 m there is limestone conglomerate (Fig. 5). Around 3102 m the colour changes to yellowish grey with white nodules, which at around 3108 m are up to 2 cm in diameter. Some fractures, and in core 4 stylolites, are common.

The sediment in core 5 is soft, contains stylolites and is partly fractured. The colour is pale orange.

The cores 6, 7, 8 and 9 (3182—3215 m) consist of a hard, pale orange lime mudstone with soft interbeds. Scattered nodules of light grey lime mudstone and some clay seams occur. Where the clay content is low stylolites are common. The intervals from 3202 m to 3205 m, and 3212 m to 3215 m are fractured.

The upper part of core 10 (3215—3224 m)

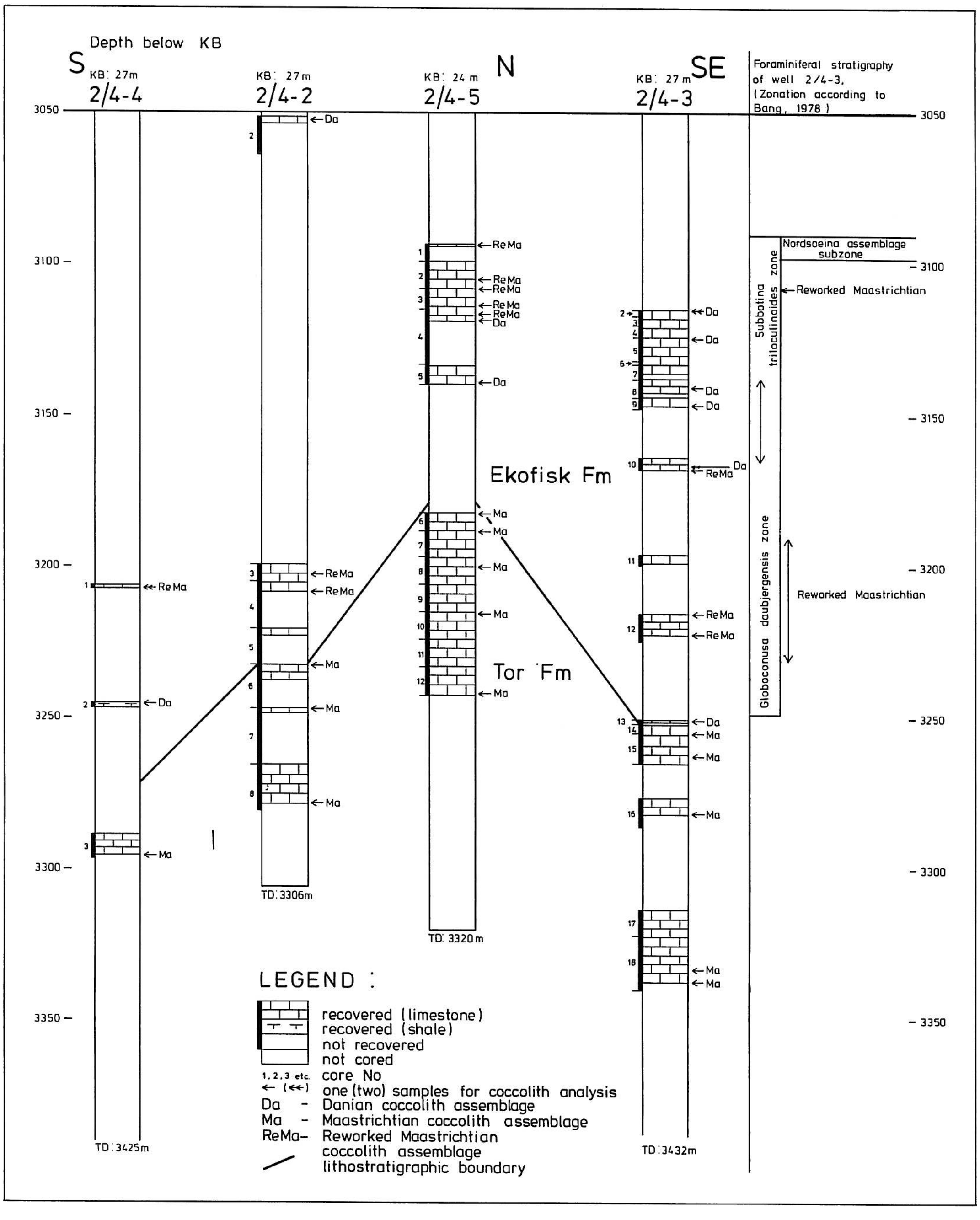


Fig. 3. The cored intervals and depth of the micropalentological analyses in wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5.

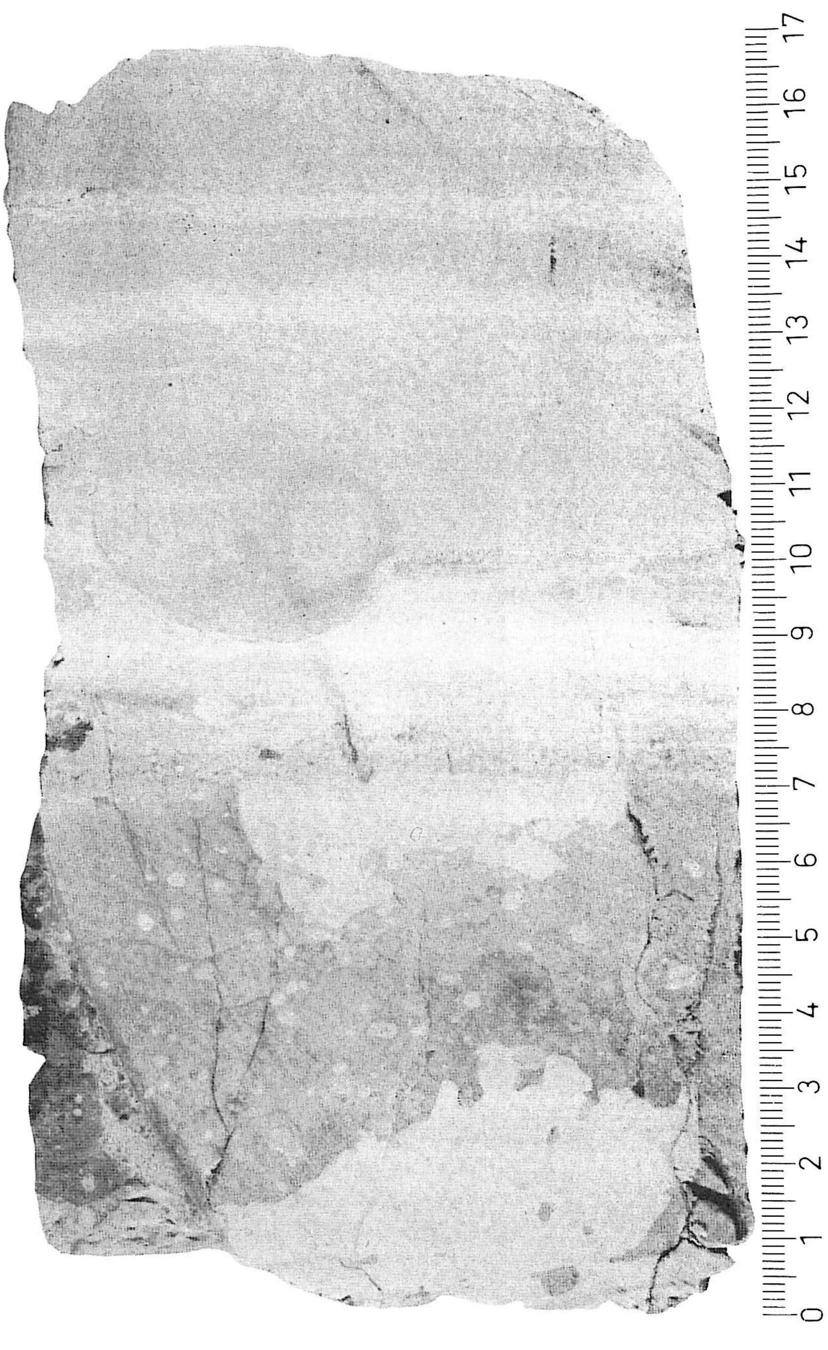


Fig. 4

Nodular, partly silicified lime mudstone from core 2, well 2/4-5.

consists of the same kind of sediment as described above. Around 3220 m it changes to a soft, pale orange lime mudstone with seams and infills of clay and clasts of light grey limestone. Some stylolites occur. This sediment continues in core 11 (3224—3233 m). In the

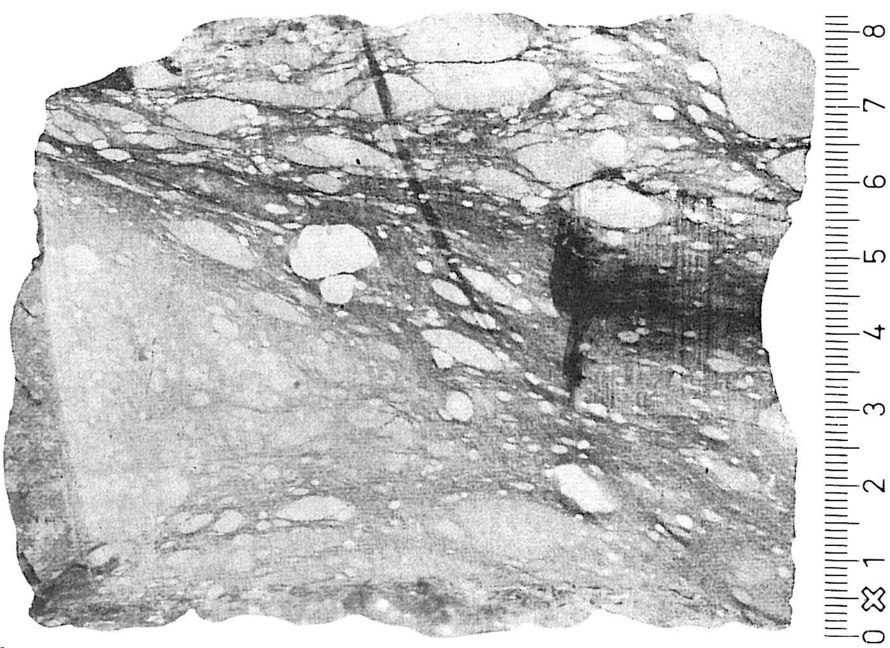


Fig. 5

Limestone conglomerate from core 2, well 2/4-5.

upper part of this core horizontal and vertical burrows occur.

In core 12 (3224—3233 m) the sediment is the same as in the cores 6 to 10, but the colour is white. Stylolites are common.

THE RESERVOIRS

The Ekofisk structure is an anticlinal trap uplifted by movements of Permian salt. The drilling of the subject wells revealed that the structure is a large oil and gas field, with the reservoirs in the Ekofisk and Tor Formations. Before production of oil and gas started in 1971 the reserves were 694×10^6 tons of oil and $174 \times 10^9 Nm^3$ of gas. Of this, 139×10^6 tons of oil and 104×10^9 Nm^3 of gas were recoverable. By the end of the year 1978 54×10^6 ton of oil and 10×10^9 Nm^3 of gas had been produced (Norw. Petr. Direct. 1979).

The reservoir rock is a soft, light grey to pale orange lime mudstone. The sediment is heavily burrowed. Factures are common. Layers with clay seams and stylolites occur. The two reservoirs are separated by a hard, grey and dense lime mudstone at the bottom of the Ekofisk Formation. This sediment is very argillaceous, and solution seams and flattened burrows are present. Stylolites are also common within this bed and close to it.

Relative to depth and burial, the porosity figures in the Central Trough are very high. Examinations of several wells in the area show that the porosity generally decreases with depth. In the Ekofisk Formation a porosity of 40 % is common, but 25 to 35 % is the average. This is also the case for the subject wells. There is considerable variations from layer to layer.

In the four subject wells there is a significant decrease in porosity (to less than 5 %) in the hard, grey and argillaceous limestone at the base of the Ekofisk Formation. This is also seen in other wells in the Central Trough.

The argillaceous and dense interval is often called «Danian tight».

In the upper part of the Maastrichtian, the porosity increases again, and is in the range of 20 to 30 %, decreasing downwards in the section.

Scanning electron microscopy has shown that the porosity in the limestone from the Central Trough is primary porosity.

Matrix permeability is very low in the area, and even in the most porous parts, matrix permeabilities are not more than 3 md, generally the permeabilities are less than 1 md (Scholle 1977a).

The secondary permeability is high due to fracturing.

DISCUSSION

The wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5 were all drilled into lime mudstone of Maastrichtian age.

According to several authors the lime mudstone in the Central Trough is made up of coccolithic ooze and planktonic foraminifera. The major part of the pore space has remained uncemented. These lime mudstones, despite 3000 m of burial, look very much the same as onshore lime mudstones which have been buried to less than 1000 m (Scholle 1977a). The unusually good preservation of the primary porosity has been explained by several authors (Hancock & Scholle 1975, Scholle 1977a, 1977b, Siedlecka and Snarvold 1978). Factors that seem to be important for the preservation of primary porosity, are:

1) Burial with overpressuring, 2) Early oil emplacement, 3) Influence of pore water chemistry, and 4) The primary composition of the sediment, especially the clay content. According to Scholle (1977a) the two first mentioned factors are important for the limestone from the North Sea.

Micropaleontological analyses which have been carried out at the NPD clearly show that resedimentation did occur during the Paleocene.

Analyses of the coccolith flora have been carried out by Ulleberg (1974). Only samples from cores have been studied (Fig. 3). The lithological boundary between the Ekofisk and the Tor Formations corresponds to the biostratigraphic boundary between the Danian and Maastrichtian. The Maastrichtian flora is generally poor because of the diagenesis of the limestone. Usually only resistant species like *Arkhangelskiella cymbiformis* and species of *Micula* occur. Other common species are *Cribrosphaerella ehrenbergi, Kamptnerius magnificus, Prediscosphaera cretacea, Markalius circumradiatus* and *Eiffellithus turriseiffeli.* In the upper Maastrichtian *Neophrolithus frequens* has been found, but is very rare.

There is a very distinct break in the coccolith flora at the Maastrichtian/Danian boundary. The base of the Danian is characterized by species of *Thoracosphaera* and *Markalius inversus.* In the middle of the Danian, *Cruciplacolithus tenuis* is present, and further up *Chiasmolithus danicus* occurs.

In the upper part of the Danian limestone, species of *Neochiastozygus* normally are present. Furthermore the analyses of the coccolith flora reveal a marked influx of well preserved reworked Maastrichtian species in the Danian. These reworked species seem to occur as beds in the limestone section.

Analyses of foraminifera from drill bit cuttings in well 2/4-3, have been carried out by Aase Moe at the NPD. Below 3090 m the fauna consists of diagnostic Danian planktonic foraminifera. The planktonic foraminifera zonation of North Sea Danian (Bang 1978) can be used for the Danian in this well. The *Globoconusa daubjergensis* zone is recovered in the lower part of the Danian. The analyses show that within this zone, at around 3200 m, the fauna is dominated by upper Maastrichtian species. *Neoflabellina, Praebulimina, Bolivina, Heterohelix, Pseudotextularia, Globigerinelloides, Globotruncana and Rugoglobigerina* are important generas in this reworked bed.

Furthermore the analyses of foraminifera in well 2/4-3 receovered that the *Subbotina triloculinoides* zone with the *Nordsoeina* assemblage subzone, is found below 3090 m. The *Nordsoeina* assemblage subzone is found in the marl facies, the equivalent to the Maureen Formation.

In the sample excamined at 3109 m the Upper Cretaceous genus *Psedutextularia* is present, which reveals reworked sediments at this depth.

Several lime mudstone conglomerates are found in the cores of the subject wells. These conglomerates are probably debris flow conglomerates and occur together with the reworked floras and faunas mentioned above. These conglomerates are good lithological indications of the reworking. This interpretation is in agreement with theories about considerable resedimentation of the upper part of the Chalk Group (Perch-Nielsen, Ulleberg and Evensen 1979, Watts, Lapre, Van Schijndel-Goester and Ford, in prep). The conglomerates are found in the Danian in the subject wells. In other wells from the Ekofisk area conglomerates are in addition, also observed in the Maastrichtian (Perch-Nielsen, Ulleberg and Evensen 1979).

One of the conglomerates seems to overlay the tight zone of very argillaceous lime mudstone and shale at the base of the Ekofisk Formation. This conglomerate is found in several wells in the Ekofisk area, and may be an important horizon for correlations.

The source areas for these reworked sediments were probably areas uplifted by halokinesis in the Central Trough, or the uplifted blocks near the margins (Ziegler 1978). An indication that the uplifted areas were further south in the Central Trough is given in Fig 6. In well 2/11-1 in the Valhall field (Norw. Petr. Direct. 1977a) all the Danian and much of the Maastrichtian sediments are eroded. The profile also shows a considerable increase of the limestone sequence to the north.

The considerable increase in clay content at the base of the Ekofisk Formation, may be due to transport from areas exposed by the world-wide regression at the transition between the Cretaceous and the Tertiary (Vail, Mitchum and Thompson 1977). Another possible explanation of this relatively high clay content is that the coccolith production was reduced, simultaneously with increasing clay influx. Further up in the Ekofisk Formation the clay content is lower, but still higher than in the Tor Formation.

The early Paleocene Laramide movements resulted in a renewed rapid subsidence of the troughs, with uplifting and erosion of their flanks and deposition of siliciclastic material (Ziegler 1978). The erosion of the uplifted areas resultet in reworking of Danian and Maastrichtian limestones in the upper Paleocene.

In the Sele Formation, from 2990 m to 3009 m (subsea) in well 2/4-3, a reworked Danian and Maastrichtian foraminiferal fauna is found. *Bolivinoides* sp., *Heterohelix* spp., *Psedutextularia* sp. *Rugoglobigerina rugosa* (Plummer), *Osangularia lens* Brotzen, *Anomalina velascoensis* Cushmann, and *Lamarckina* sp., are present in this fauna.

The reworked fauna is found in an interval where the drill bit cuttings contain limestone and chert. This lithology is clearly reflected by the logs. Similar log motifs are found in the Sele Formation of the wells 2/4-2, 2/4-4 and 2/4-5. It is therefore probable that these intervals represent reworked sediments also in these wells. This reworked unit in the Sele Formation is found in other wells in the Central Trough. In well 1/3-1 (Fig. 6), 50 m of reworked Maastrichtian limestones are recovered (Norw. Petr. Direct. 1978). In this paper a new interpretation of the Paleocene in well 1/3-1 is carried out, Fig 6.

Volcanic activity in the North Sea region reached its climax by the transition between Paleocene and Eocene, scattering tuffaceous material over much of the North Sea area. The widespread tuffaceous units are represented in the Sele and the Balder Formations. The rest of the Tertiary in the wells 2/4-2, 2/4-3, 2/4-4 and 2/4-5 is made up of fine grained, mainly clastic sediments deposited in a subsiding basin.

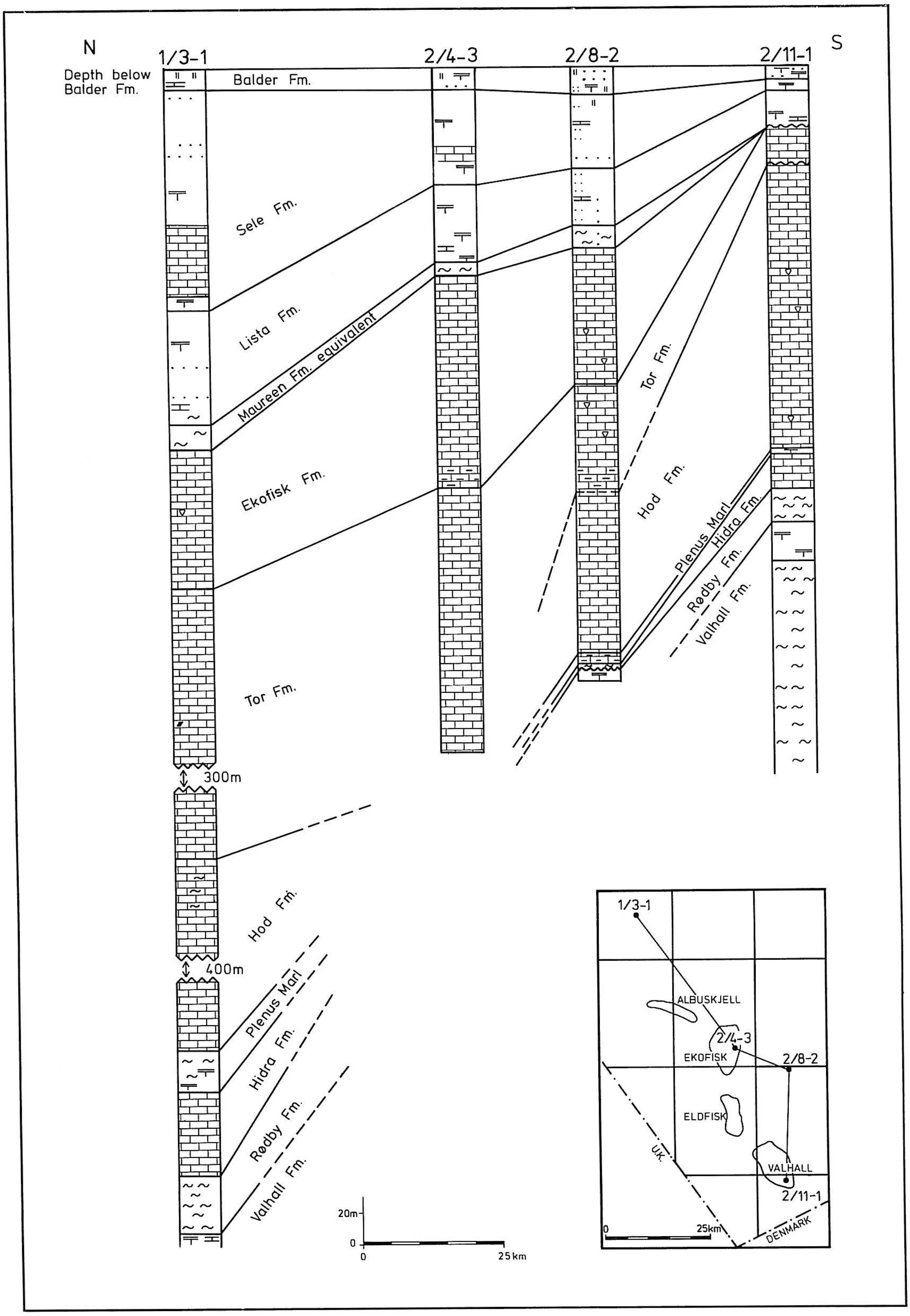


Fig. 6. Correlation between well 2/4-3 and previously released wells, 1/3-1, 2/8-2 and 2/11-1 (Norw. Petr. Direct 1977a, 1977b, 1978).

Summary

The wells 2/4-1, 2/4-2, 2/4-3, 2/4-4 and 2/4-5 were the first five wells drilled in the Ekofisk area. The wells are geologically located in the Central Trough.

The objectives of the wells were to test the Tertiary and the Upper Cretaceous. When well 2/4-1 reached 1662 m, it flowed oil and gas from Lower Miocene limestone, and the well was plugged and abandoned. The four other wells revealed oil and gas in Danian and Maastrichtian lime mudstone.

The reservoirs consist of soft, porous lime mudstones, mainly made up of coccolith ooze and planktonic foraminifera. One of the reservoirs is in the Ekofisk Formation, the other is in the Tor Formation. The two reservoirs are separated by a grey, hard, argillaceous and dense lime mudstone at the base of the Ekofisk Formation. Further up in this formation the clay content is lower, but still higher than in the Tor Formation. Bioturbation and slumping are common in both formations.

In the Danian, lime mudstone debris flow conglomerates and Maastrichtian coccolith floras and foraminiferal faunas show that reworking did occur. The upper part of the Danian consists of a marl facies, the equivalent to the Maureen Formation. At the base of the Paleocene, the influx of clasic material increases, and foraminiferal analyses show that reworking of Danian and Maastrichtian sediments has taken place. Varicoloured shales and traces of tuffaceous material indicate the volcanic activity at the transition between Paleocene and Eocene.

The rest of the Tertiary consists of fine grained clastic sediments.

Fig. 7: Interpreted Seismic Record. Line: PG-0312

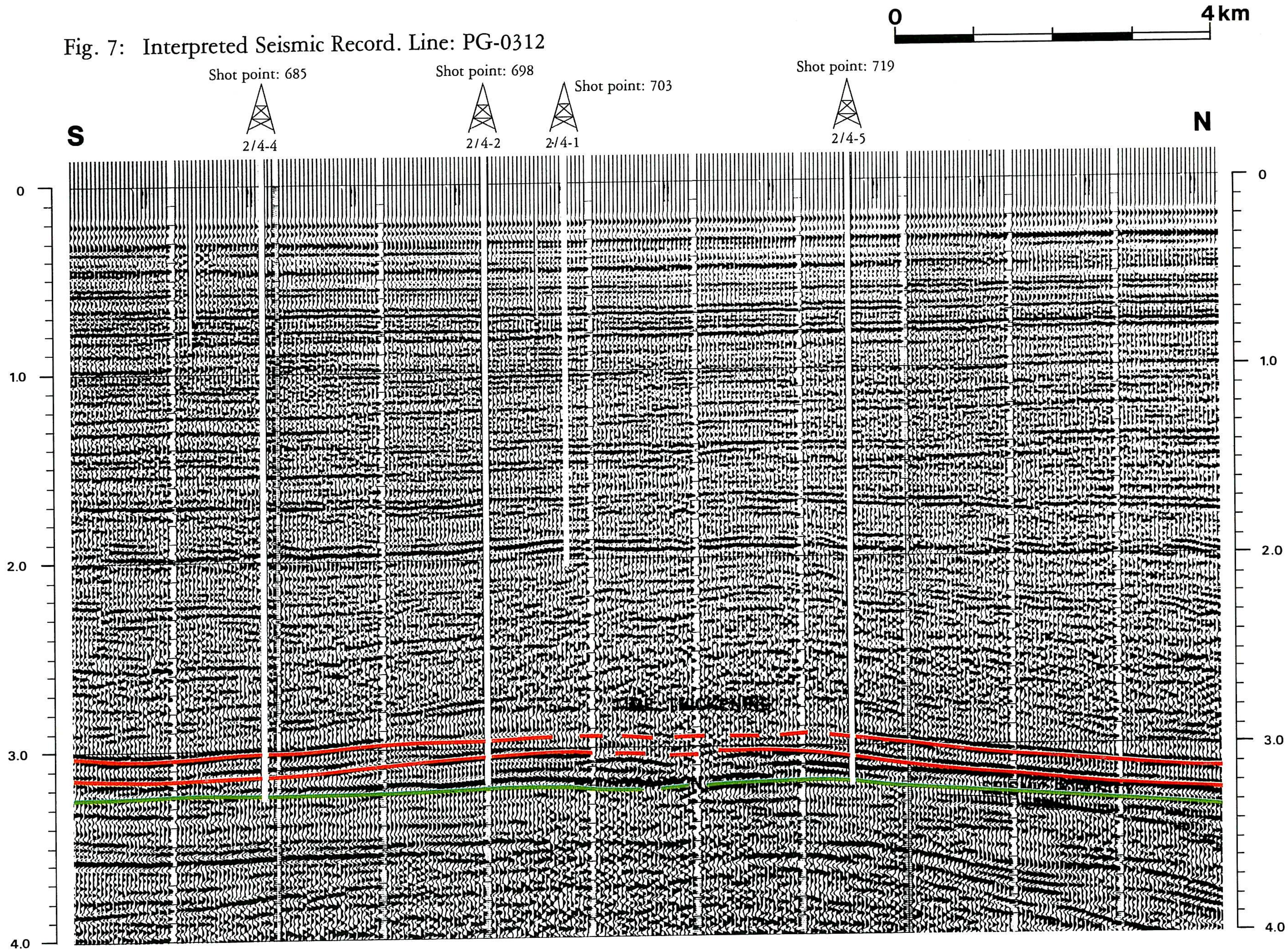
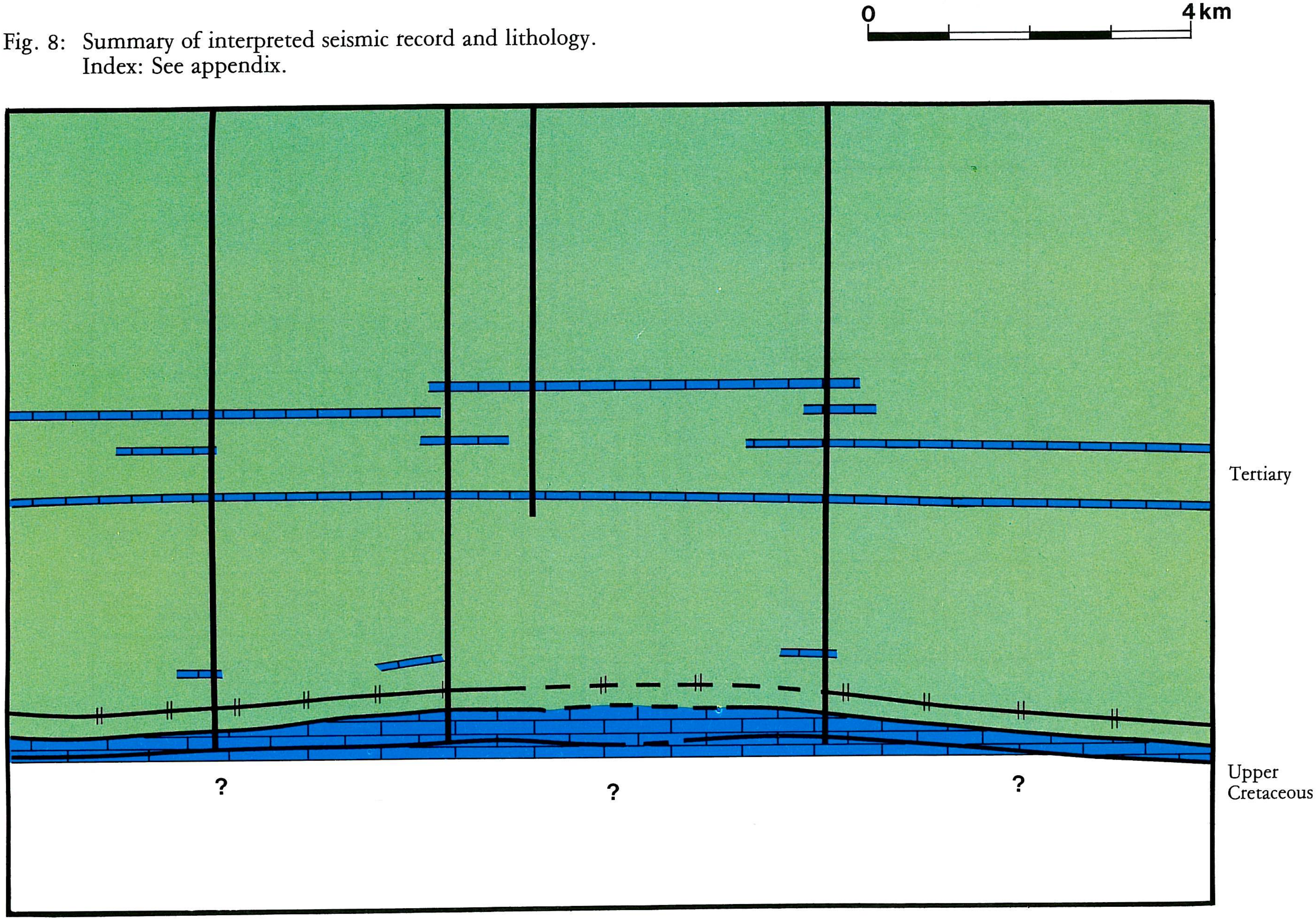


Fig. 8: Summary of interpreted seismic record and lithology.
Index: See appendix.



TABLES WELLS
2/4-1, 2/4-2, 2/4-3, 2/4-4 and 2/4-5

Tables 1

CASINGS

Casing depth / Well no	30" m	20" m	13 3/8" m	9 5/8" m	7" m	5" m	Total depth m
2/4-1		146	623				1662
2/4-2	132	581	1607	2366	3159	3294	3305
2/4-3	131	607	1629	3007	3389		3432
2/4-4	135	598	1639	3094	3424		3425
2/4-5	129	573	1639	3028	3319		3320

Table 2a

MUD PROGRAMME

Well 2/4-1

Mud properties						Remarks
Depth below KB m	Weight g/cc	Weight ppg	Funnel visc sec	Filt loss cm³	% oil	
762	1.45	12.1	38	8.2		The well was drilled to a depth of 1662 m, then plugged and abandoned due to kicking.
1116	1.57	13.1	45	6.8		
1426	1.59	13.3	44	6.6		

Table 2b

MUD PROGRAMME

Well 2/4-2

Mud properties						Remarks
Depth below KB m	Weight g/cc	Weight ppg	Funnel visc sec	Filt loss cm³	% oil	
786	1.63	13.6	44	6.7	4	The hole was drilled with no returns to a depth of 619 m using seawater and spotting high visc. mud as needed.
1134	1.65	13.8	53	5.3	2	
1180	1.68	14.0	50	5.6	3	
1649	1.71	14.3	46	5.4		
2548	1.50	12.5	50	6.2	5	
2804	1.60	13.4	46	5.8	3	
3051	1.68	14.0	57			
3054	1.70	14.2	50	4.4		
3060	1.62	13.5				
3075	1.59	13.3				
3086	1.57	13.1				
3097	1.72	14.4	48	4.4	4	
3136	1.70	14.2	50	4.4	3	

Table 2c MUD PROGRAMME Well 2/4-3

Depth below KB m	Weight g/cc	Weight ppg	Funnel visc sec	Filt loss cm^3	% oil	Remarks
738	1.56	13.0	45	6.0		Drilled with seawater and no returns to a depth of 610 m spotting with visc. mud as needed.
1009	1.63	13.6	48	5.6	2	
1268	1.70	14.2	46	5.0	2	
1667	1.71	14.3	54	7.4	4	
2155	1.71	14.3	58	4.9	4	
3033	1.68	14.0	42			
3079	1.71	14.3	44	4.2	4	
3152	1.71	14.3	45	4.0	5	

Table 2d MUD PROGRAMME Well 2/4-4

Depth below KB m	Weight g/cc	Weight ppg	Funnel visc sec	Filt loss cm^3	% oil	Remarks
750	1.54	12.9	43	8.9	2	The hole was drilled to a depth of 653 m with no returns using seawater and spotting with high visc. mud as needed.
1009	1.66	13.9	45	6.4	2	
1238	1.68	14.0	45	5.6	5	
1366	1.69	14.1	45	4.9	6	
1567	1.68	14.0	48	4.4	6	
1747	1.71	14.3	46	5.1	4	
1853	1.71	14.3	50	3.6	4	
2304	1.71	14.3	49	3.1	5	
3155	1.71	14.4	42	3.9	3	
3264	1.7	14.3	44	3.8	3	
3405	1.71	14.3	44	3.1	3	

Table 2c MUD PROGRAMME Well 2/4-5

Depth below KB m	Weight g/cc	Weight ppg	Funnel visc sec	Filt. loss cm^3	% oil	Remarks
658	1.52	12.7	46	5.2		To a depth of 585 m the hole was drilled with seawater with no returns. Spotting with high visc. mud as needed.
747	1.53	12.8	40	5.2		
853	1.58	13.2	41	6.8		
945	1.69	14.1	49	6.4		
1222	1.70	14.2	43	5.8		
1280	1.71	14.3	46	5.6		
1673	1.69	14.1	85	12.0		
1841	1.71	14.3	51	5.9		
3078	1.72	14.4	59	5.2		
3277	1.71	14.3	47	4.4		

Table 3

DRILL STEM TESTS (DST)

Well no	Test no	Depth below KB m	Choke size	Recovery OIL BPD	GAS MMC FGD	Other fluids/Remarks*	Final shut-in pressure psi	Final flow pressure psi
2/4-2	4	3159—3196	34/64	1071	5,9	37,2° API DST nos 1,2 and 3 at the same depth were failures	7057	5771
»		3051—3258	25/64	2999	3,327	37,7° API, 1109 GOR (Compl. test)		
2/4-3	1	3352—3362	1"			240 BPD formation water	7051	5358
»	2	3331—3341	1"			360 BPD formation water	5226	4995
»	3	3316—3319	3/4"	2030	2,070	34° API, 1020 GOR, 21 BWPD	7130	3993
»	4	3267—3295	1 1/8'	2064	2,225	36,6° API, 1078 GOR	7092	3401
»	5	3234—3243	3/4"	1085	1,284	34,6° API, 1184 GOR	7555	2816
»	6	3194—3225	1/4"	1046	1,265	35,3° API, 1209 GOR	7480	6604
»	6	3194—3225	3/4"	3832	4,587	34,2° API, 1197 GOR	6989	4827
»	7	3139—3149	25/64	1185	1,422	35,5° API, 1200 GOR	6958	4010
»	8	3124—3139 3149—3155	1"	2054	2,800	35,1° API, 1362 GOR	6871	2942
»	9	3124—3155 3194—3225	1"	3744	4,697	33,2° API, 1254 GOR	7006	5039
»	10	3116—3024	1"			Flowed 15 bbls water then died	6886	4679
2/4-4	1	3274—3283	1"			250 BWPD	7066	4650
»	2	3246—3255	1"			100' gas cut mud		4854
	3	3233—3236	1"			30 BWPD	7060	4437
»	4	3219—3225	two 3/4"	1040	0,962	34,2° API, 925 GOR	7083	2259
»	5	3176—3200	two 3/4"	2719	2,744	35,3° API, 1009 GOR	7095	6638
»	6	3162—3167	open			Reversed out 1/4 bbls oil, 2 bbls oil and gas cut mud.	6844	
»	7	3127—3157	two 3/4"	686	0.969	35,0° API, 1412 GOR	6772	1398
»	8	3127—3157 3162—3167 3176—3200	two 3/4"	3779	4,010	35,6° API, 1023 GOR	7074	4366
2/4-5	1	3164—3203	3/8"	4411	5,855	37,3° API, 1362 GOR	7126	6068
»	1a	3177—3186	21/64	2687	3,454	36,9' API, 1285 GOR	7149	7086
»	2	3106—3143	21/64	3022	4,005	37,1° API, 1325 GOR	6984	6754
»	3	3088—3093				Malfunction		
»	4	3042—3075	3/8"	2586	3,254	37,3° API, 1258 GOR	6218	4968

* bbl = barrel
BPD = barrels of oil per day.
BWPO = barrels of water per day
GOR = gas oil ratio

Table 4 AVAILABLE LOGS

Type of logs	Well no.: 2/4-2			Well no.: 2/4-3			Well no.: 2/4-4			Well no.: 2/4-5		
	Interval m	1/200	1/500	Interval m	1/200	1/500	Interval m	1/200	1/500	Interval m	1/200	1/500
GR	98— 580	x	x	98— 607	x	x	91— 599	x	x	115— 568	x	x
GR/BHC	580—3302	x	x	670—3425	x	x	599—3424	x	x	568—3319	x	x
IES	580—3305	x	x	607—3428	x	x	599—3425	x	x	561—3320	x	x
FDC-C	2865—3305	x	x	1629—3428	x		2743—3427	x	x	3030—3322	x	x
LL-7	2865—3304	x	x	3007—3428	x	x	3093—3427	x	x			
MLL-ML	2865—3305	x	x	3007—3428	x	x	3093—3427	x	x	3030—3322	x	x
SNP	2865—3304	x	x	3007—3428	x	x	3093—3427	x	x	1639—3322	x	x
CDM	1724—3156	x	x	610—3428		x	3093—3424		x	2963—3322	x	x
SRS	580—3302	1/1000	x	607—3425	1/1000	x	598—3424	1/1000	x	568—3319	1/1000	x
Mud	Sea floor-3306		x	Sea floor-3432		x	Sea floor-3426		x	Sea floor-3320		x
T	12—3306	x	x									
CDR	1695—3156			606—3429			599—3102			1639—3046		
CBL	2295—3155	x	x				3002—3409	x	x	3033—3322	x	
GR/NL				2935—3373	x	x	3002—3413	x	x			
CAL							599—1648	x	x			

Table 5a DRILL BIT CUTTINGS Well 2/4-1

Depth below KB	Sample interval
m	m
628— 701	6
701— 713	12
713— 756	6
756— 768	12
768— 774	6
774— 799	12
799— 908	9
908— 921	12
921— 927	6
927—1155	9
1155—1173	18
1173—1375	9
1375—1387	12
1387—1423	9
1423—1439	15
1439—1530	9
1530—1548	18
1548—1554	6
1554—1640	12

Table 5b DRILL BIT CUTTINGS Well 2/4-2

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
622— 841	6	2268—2280	12
841— 853	12	2280—2286	6
853— 896	6	2286—2298	12
896— 908	12	2298—2316	6
908— 914	6	2316—2329	12
914— 927	12	2329—2341	6
927—1103	6	2341—2353	12
1103—1122	18	2353—2371	18
1122—1177	6	2371—2457	6
1177—1187	12	2457—2469	12
1189—1304	6	2469—2475	6
1304—1323	18	2475—2557	9
1323—1402	6	2557—2563	6
1402—1414	12	2563—2710	9
1414—1439	24	2710—2716	6
1439—1457	6	2716—2761	9
1457—1469	12	2761—2829	6
1469—1481	6	2829—2841	12
1481—1494	12	2841—2877	6
1494—1573	6	2877—2890	12
1573—1585	12	2890—2963	6
1585—1615	6	2963—2975	12
1615—1634	3	2975—3048	6
1634—1652	6	3048—3066	18
1652—1655	3	3066—3072	6
1655—1661	6	3072—3109	3
1661—1664	3	3109—3115	6
1664—1682	18	3115—3118	3
1682—1725	6	3118—3124	6
1725—1737	12	3124—3133	3
1737—1823	6	3133—3158	6
1823—1847	12	3158—3176	18
1847—1908	6	3176—3181	5
1908—1932	12	3181—3186	3
1932—1963	6	3186—3189	3
1963—1981	18	3189—3191	2
1981—2024	6	3191—3197	3
2024—2048	12	3197—3201	4
2048—2079	6	3201—3203	2
2079—2103	12	3203—3207	4
2103—2207	6	3207—3221	14
2207—2219	12	3221—3222	1
2219—2231	6	3222—3236	14
2231—2243	12	3236—3286	50
2243—2268	24	3286—3304	3

Table 5c DRILL BIT CUTTINGS Well 2/4-3

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
628— 677	12	933—1127	12
677— 683	6	1127—1158	30
683— 694	12	1158—1231	12
694— 701	6	1231—1256	24
701— 719	18	1256—1377	12
719— 805	12	1377—1396	6
805— 829	24	1396—1402	3
829— 902	12	1402—1408	6
902— 933	30	1408—1423	15

Table 5c DRILL BIT CUTTINGS Well 2/4-3

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
1423—1442	9	2384—2438	9
1442—1448	6	2438—2457	18
1448—1457	9	2457—2612	9
1457—1463	6	2612—2618	6
1463—1491	9	2618—2645	9
1491—1497	6	2645—2658	12
1497—1503	3	2658—2777	9
1503—1545	6	2777—2780	3
1545—1564	9	2780—2816	9
1564—1612	6	2816—2835	18
1612—1618	3	2835—2880	9
1618—1631	6	2880—2888	7
1631—1640	9	2888—2896	8
1640—1652	12	2896—2978	9
1652—1664	6	2978—2990	12
1664—1676	12	2990—3008	9
1676—1689	6	3008—3014	6
1689—1719	30	3014—3024	9
1719—1725	6	3024—3108	6
1725—1737	12	3108—3149	40
1737—1743	6	3149—3155	3
1743—1756	12	3155—3156	1.5
1756—1828	6	3156—3162	3
1828—1871	43	3162—3173	11
1871—1878	6	3173—3179	3
1878—1890	12	3179—3188	9
1890—1920	6	3188—3191	3
1920—1939	9	3191—3196	5
1939—1987	12	3196—3202	6
1987—2006	18	3202—3203	1,5
2006—2012	6	3203—3213	3
2012—2121	9	3213—3228	15
2121—2158	18	3228—3246	3
2158—2164	6	3246—3267	21
2164—2182	9	3267—3271	3
2182—2188	6	3271—3292	21
2188—2207	9	3292—3310	6
2207—2213	6	3310—3341	30
2213—2225	12	3341—3359	6
2225—2243	9	3359—3374	8
2243—2262	18	3374—3392	9
2262—2326	9	3392—3399	6
2326—2344	18	3399—3408	9
2344—2371	9	3408—3426	6
2371—2384	12	3426—3431	5

Table 5d DRILL BIT CUTTINGS Well 2/4-4

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
628— 664	12	1116—1135	20
664— 689	24	1135—1189	8
689— 713	12	1189—1234	9
713— 762	24	1234—1253	18
762— 872	12	1253—1289	9
872— 896	24	1298—1308	18
896— 981	12	1308—1314	6
981—1006	24	1314—1369	9
1006—1116	12	1369—1375	6

Table 5d DRILL BIT CUTTINGS Well 2/4-4

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
1375—1457	9	2655—2670	15
1457—1481	12	2670—2743	12
1481—1500	9	2743—2758	15
1500—1527	27	2758—2795	12
1527—1545	18	2795—2804	9
1545—1573	9	2804—2829	12
1573—1591	18	2829—2848	20
1591—1646	9	2848—2859	11
1646—1804	6	2859—2932	12
1804—1817	12	2932—2938	6
1817—1847	6	2938—2957	18
1847—1865	9	2957—3018	12
1865—1878	6	3018—3027	9
1878—1881	3	3027—3039	6
1881—1890	9	3039—3078	40
1890—1981	6	3078—3097	6
1981—2006	24	3097—3100	3
2006—2164	12	3100—3106	6
2164—2173	9	3106—3109	3
2173—2222	12	3109—3176	6
2222—2237	15	3176—3182	3
2237—2249	12	3182—3188	6
2249—2256	6	3188—3197	3
2256—2268	12	3197—3203	6
2268—2278	11	3203—3206	3
2278—2292	14	3206—3210	2
2292—2414	12	3210—3298	3
2414—2423	9	3298—3301	12
2423—2435	12	3301—3304	3
2435—2448	6	3304—3377	6
2448—2618	12	3377—3411	3
2618—2633	15	3411—3417	6
2633—2655	12	3417—3423	3

Table 5e DRILL BIT CUTTINGS Well 2/4-5

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
594— 695	9	1341—1344	3
695— 722	27	1344—1356	6
722— 869	9	1356—1359	3
869— 896	27	1359—1402	6
896— 914	9	1402—1414	12
914—1042	37	1414—1339	6
1042—1052	9	1439—1445	3
1052—1070	18	1445—1512	6
1070—1134	9	1512—1518	3
1134—1152	18	1518—1609	6
1152—1189	9	1609—1622	12
1189—1204	15	1622—1628	6
1204—1222	9	1628—1640	12
1222—1234	6	1640—1646	6
1234—1247	12	1646—1673	9
1247—1289	6	1673—1686	12
1289—1292	3	1686—1704	9
1292—1305	12	1704—1807	6
1305—1317	3	1807—1817	9
1317—1341	6	1817—1865	12

Table 5e — DRILL BIT CUTTINGS — Well 2/4-5

Depth below KB	Sample interval	Depth below KB	Sample interval
m	m	m	m
1865—1875	9	2737—2743	18
1875—1887	12	2743—2749	6
1887—1908	12	2749—2765	15
1908—1917	9	2765—2777	12
1917—1966	12	2777—2822	9
1966—2021	9	2822—2871	12
2021—2033	12	2871—2886	15
2033—2039	6	2886—2896	9
2039—2131	9	2896—2908	12
2131—2179	12	2908—2917	9
2179—2210	15	2917—2932	15
2210—2219	9	2932—2950	9
2219—2268	12	2950—2954	3
2268—2282	14	2954—2966	6
2282—2295	13	2966—2970	5
2295—2304	9	2970—2981	11
2304—2377	12	2981—2996	15
2377—2393	15	2996—3021	6
2393—2414	21	3021—3024	3
2414—2463	12	3024—3036	6
2463—2478	15	3036—3042	3
2478—2487	9	3042—3054	6
2487—2490	3	3054—3060	3
2490—2505	15	3060—3091	6
2505—2515	9	3091—3146	55
2515—2563	12	3146—3182	6
2563—2655	9	3182—3246	64
2655—2691	12	3246—3301	6
2691—2707	15	3301—3313	12
2707—2713	6	3313—3319	6
2713—2731	9	3319—3320	1
2731—2737	6		

Table 6a — WET SAMPLES — Well 2/4-1

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
628— 701	6	38	38	2	5
701— 713	12	46	46	1	2
713— 756	6	59	59	4	7
756— 768	12	61	61	3	5
768— 774	6	73	73	3	4
774— 799	12	55	55	4	7
799— 881	9	70	70	5	7
881— 899	18	47	47	2	4
899— 908	9	39	39	2	5
908— 921	12	75	75	4	5
921— 948	27	30	30	3	10
948— 954	6	22	22	1	5
954— 957	3	39	39	1	3
957— 963	6	64	63	2	3
963— 966	3	53	53	1	2
966— 972	6	47	47	1	2
972—1155	9	39	39	2	5
1155—1147	12	34	34	5	15
1147—1210	9	37	37	6	16

* This table shows the average percentage of the wet samples retained after washing through a 75 μ sieve and dried.

Table 6b WET SAMPLES Well 2/4-2

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
847— 860	12	296	292	29	10
860— 945	6	236	233	13	6
945— 975	12	147	145	5	3
957— 981	24	269	265	7	3
981—1049	6	375	363	13	3
1049—1122	73	320	314	10	3
1122—1177	6	314	309	20	6
1177—1189	12	278	273	13	5
1189—1286	6	212	205	21	10
1286—1323	12	123	118	19	15
1323—1329	6	76	73	17	22
1329—1341	12	45	45	4	9
1341—1366	6	76	73	9	12
1366—1378	12	100	96	21	21
1378—1402	6	73	71	18	25
1402—1414	12	55	53	10	18
1414—1439	24	107	102	24	22
1439—1445	6	139	132	29	21
1445—1469	12	139	131	17	12
1469—1475	3	110	107	35	32
1475—1481	6	101	97	55	54
1481—1494	12	56	54	33	59
1494—1573	6	137	132	20	15
1573—1585	12	90	86	6	7
1585—1615	6	70	66	7	10
1615—1634	3	142	137	9	6
1634—1652	6	188	181	35	19
1652—1655	3	210	200	21	10
1655—1661	6	185	177	15	8
1661—1664	3	270	250	11	4
1664—1683	18	185	177	6	3
1683—1725	6	143	136	31	23
1725—1737	12	79	74	46	58
1737—1762	6	123	116	51	41
1762—1774	12	115	109	39	33
1774—1780	6	95	91	31	33
1780—1792	12	116	101	43	37
1792—1829	6	96	92	32	33
1829—1841	12	72	68	33	46
1841—1902	6	119	113	33	37
1902—1920	18	66	63	20	30
1920—1663	6	83	79	23	28
1963—1981	18	78	73	15	19
1981—2024	6	119	112	30	25
2024—2048	12	197	190	33	17
2048—2079	6	254	248	64	25
2079—2103	24	339	332	87	26
2103—2134	6	232	226	49	21
2134—2146	12	275	268	70	25
2146—2207	6	226	219	52	23
2207—2219	12	194	188	71	37
2219—2231	6	136	132	57	42
2231—2243	12	247	240	42	17
2243—2268	24	230	224	53	23
2268—2286	18	130	126	18	14
2286—2298	12	205	200	35	17
2298—2316	6	253	246	50	20
2316—2329	12	170	165	11	6
2329—2347	6	190	184	55	29
2347—2365	18	214	208	27	13
2365—2451	6	82	78	25	30
2451—2463	12	150	148	59	39
2463—2475	6	76	76	25	33

Table 6b WET SAMPLES Well 2/4-2

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
2475—2557	9	103	102	41	40
2557—2563	6	102	100	48	47
2563—2566	3	149	147	66	44
2566—2573	6	122	120	53	43
2573—2591	18	117	116	50	43
2591—2664	9	180	165	73	41
2664—2853	189	223	221	115	52
2853—2883	6	133	132	35	26
2883—2896	12	141	140	55	39
2896—2963	6	213	212	82	38
2963—2975	12	103	103	29	28
2975—2981	6	198	198	21	11
2981—2993	12	206	205	32	16
2993—2999	3	98	98	22	22
2999—3048	6	205	204	50	24
3048—3066	18	149	149	91	61
3066—3072	6	119	119	53	45
3072—3084	3	156	156	111	71
3084—3090	6	130	130	104	80
3090—3103	3	178	178	128	72
3103—3109	6	179	179	129	72
3109—3115	3	216	216	109	50
3115—3124	5	178	178	112	63
3124—3133	3	149	149	69	46
3133—3158	6	166	166	66	40
3158—3181	23	63	63	19	30
3181—3184	3	215	215	118	55
3184—3189	3	138	138	80	58
3189—3191	2	353	353	165	47
3191—3197	3	94	94	72	77
3197—3286	88	55	55	43	78
3286—3304	3	46	46	37	80

* This table shows the average percentage of the wet samples retained after washing through a 75 µ sieve and dried.

Table 6c WET SAMPLES Well 2/4-3

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
628— 677	12	47	47	1	2
677— 683	6	14	14	1	7
683— 695	12	24	24	2	8
695— 701	6	24	24	2	8
701— 719	18	8	8	0,5	6
719— 805	12	23	23	1	4
805— 829	24	22	22	1	5
829— 902	12	17	17	1	6
902— 933	30	17	17	1	6
933—1128	12	19	19	1	5
1128—1158	30	13	13	1	8
1158—1231	12	25	25	2	8
1231—1256	24	35	35	2	6
1256—1378	12	23	23	3	13
1378—1396	6	10	10	2	20
1396—1402	3	24	24	7	29
1402—1408	6	35	35	6	17
1408—1423	15	14	14	3	21

Table 6c | WET SAMPLES | Well 2/4-3

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
1423—1442	9	24	24	4	17
1442—1448	6	53	53	8	15
1448—1457	9	12	12	2	17
1457—1463	6	36	36	8	22
1463—1490	9	22	22	4	18
1490—1497	6	11	11	3	27
1497—1503	3	15	15	2	13
1503—1545	6	24	24	2	8
1545—1564	9	19	19	2	11
1564—1612	6	31	31	1	3
1612—1618	3	52	52	3	6
1618—1631	6	16	16	2	13
1631—1640	9	7	7	0	0
1640—1652	12	7	7	1	14
1652—1664	6	10	10	1	10
1664—1676	12	17	17	2	12
1676—1689	9	9	1	1	11
1689—1719	30	31	31	4	13
1719—1725	6	24	24	3	13
1725—1737	12	37	37	8	22
1737—1743	6	12	12	2	17
1743—1756	12	27	27	12	44
1756—1829	6	23	23	13	57
1829—1871	43	23	23	11	48
1871—1878	6	13	13	8	62
1878—1890	12	32	32	15	47
1890—1920	6	13	13	7	54
1920—1948	9	18	18	10	56
1948—1963	15	13	13	6	46
1963—1987	6	15	15	7	47
1987—2006	18	6	6	3	50
2006—2012	6	20	20	14	70
2012—2121	9	22	22	12	55
2121—2158	18	28	28	10	36
2158—2164	6	27	27	10	37
2164—2182	9	9	9	5	56
2182—2188	6	9	9	3	33
2188—2207	9	9	9	4	44
2207—2225	18	66	66	14	21
2225—2371	9	24	24	6	25
2371—2384	12	116	115	13	11
2384—2394	9	50	50	12	24
2394—2411	18	57	57	12	21
2411—2438	9	68	68	15	22
2438—2457	18	50	50	10	20
2457—2612	9	28	28	6	21
2612—2618	6	20	20	3	15
2618—2646	9	37	37	11	30
2646—2658	12	31	31	8	22
2658—2777	9	47	46	21	45
2777—2780	3	46	45	18	39
2780—2816	9	40	39	18	45
2816—2835	18	43	42	42	9
2835—2880	9	32	31	8	25
2880—2888	7	43	42	10	23
2888—2896	8	35	35	6	17
2896—2996	9	39	39	14	36
2996—3008	6	44	44	16	36
3008—3018	9	79	78	22	28
3018—2109	6	13	13	3	23
3109—3149	40	8	8	4	50
3149—3155	3	13	13	11	85
3155—3156	1,5	29	29	18	62

Table 6c

WET SAMPLES

Well 2/4-3

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
3156—3162	3	21	21	15	71
3162—3173	11	24	24	18	86
3173—3179	6	20	20	16	80
3179—3188	9	16	16	10	63
3188—3194	3	13	13	9	69
3194—3202	8	29	29	22	76
3202—3203	1,5	40	40	27	68
3203—3213	3	33	33	20	61
3213—3228	15	3	3	1	33
3228—3231	3	22	22	15	68
3231—3237	6	22	22	17	77
3237—3243	3	25	25	11	44
3243—3249	6	35	35	12	34
3249—3267	18	12	12	7	58
3267—3271	3	30	30	24	80
3271—3292	21	30	30	24	80
3292—3298	6	50	50	35	70
3298—3310	12	28	28	18	64
3310—3341	30	14	14	8	57
3341—3359	6	15	15	9	60
3359—3374	8	30	30	15	50
3374—3392	9	27	27	16	59
3392—3405	6	30	30	18	60
3405—3408	3	9	9	5	56
3408—3420	12	2	2	1	50
3420—3426	6	6	6	5	83
3426—3431	5	6	6	5	83

* This table shows the average percentage of the wet samples retained after washing through a 75 μ sieve and dried.

Table 6d

WET SAMPLES

Well 2/4-4

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
628— 713	12	140	121	5	4
713— 762	24	101	91	4	4
762—1116	12	115	111	5	4
1116—1143	27	140	137	3	2
1143—1151	8	85	83	2	2
1151—1181	15	126	118	3	2
1181—1189	8	110	103	3	3
1189—1234	9	92	90	2	2
1234—1253	18	109	108	3	3
1253—1262	9	70	64	2	3
1262—1280	18	134	126	4	3
1280—1289	9	105	103	4	4
1289—1308	18	138	116	3	2
1308—1314	6	61	59	2	3
1314—1369	9	174	150	4	2
1369—1375	6	173	163	5	3
1375—1384	9	118	116	4	3
1384—1402	18	126	123	5	4
1402—1457	9	113	104	4	4
1457—1481	12	134	121	5	4

Table 6d WET SAMPLES Well 2/4-4

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
1481—1500	9	117	104	7	6
1500—1527	27	171	153	9	5
1527—1545	18	34	34	4	12
1545—1573	9	88	84	4	5
1573—1591	18	110	101	3	3
1591—1646	9	107	102	3	3
1646—1853	6	140	121	24	17
1853—1871	18	93	89	14	15
1871—1878	6	121	119	6	5
1878—1881	3	184	157	26	14
1881—1890	9	261	192	13	5
1890—1981	6	246	192	26	11
1981—2006	24	186	146	17	9
2006—2164	12	147	127	13	9
2164—2173	9	132	103	10	8
2173—2185	12	143	116	12	8
2185—2222	12	164	127	15	9
2222—2237	15	203	161	18	9
2237—2249	12	264	196	23	9
2249—2256	6	268	200	23	9
2256—2268	12	184	147	29	16
2268—2278	11	157	132	17	11
2278—2292	14	189	151	27	14
2292—2414	12	166	138	30	18
2414—2423	9	162	130	37	23
2423—2655	12	214	179	46	22
2655—2670	15	158	133	53	34
2670—2743	12	257	209	60	23
2743—2771	27	258	212	47	18
2771—2795	12	256	210	72	28
2795—2804	9	173	149	69	40
2804—2829	12	235	197	94	40
2829—2847	18	189	155	56	30
2847—2969	12	213	191	55	26
2969—2993	18	288	256	62	22
2993—3018	12	126	121	31	25
3018—3027	9	159	155	31	19
3027—3033	6	296	169	94	32
3033—3060	27	67	66	22	33
3060—3085	12	246	239	55	22
3085—3091	6	229	223	41	18
3091—3100	9	64	64	7	11
3100—3115	15	169	163	55	33
3115—3176	12	155	155	64	41
3176—3182	6	166	166	79	48
3182—3191	9	122	122	50	41
3191—3197	6	153	153	81	53
3197—3206	9	194	194	100	52
3206—3213	3	172	172	93	54
3213—3219	6	152	152	87	57
3219—3226	7	225	225	130	58
3226—3231	5	196	196	90	46
3231—3249	6	176	176	88	50
3249—3258	3	173	172	84	49
3258—3289	6	143	143	72	50
3289—3304	15	138	138	70	51
3304—3353	12	130	130	73	56
3353—3377	6	136	136	60	44
3377—3411	3	169	169	81	48
3411—3417	6	132	132	71	54
3417—3423	3	129	129	72	56

* This table shows the acerage percentage of the wet samples retained after washing through a 75 u sieve and dried.

Table 6e — WET SAMPLES — Well 2/4-5

Depth below KB	Sample interval	Average weights in g			Average % retained
m	m	Gross	Dried	Retained*	
594— 686	9	407	361	9	2
686— 933	247	357	351	43	12
933—1006	9	263	214	3	1
1006—1042	36	301	244	4	1
1042—1052	9	234	203	5	2
1052—1070	18	200	171	3	1,5
1070—1143	9	207	181	4	2
1143—1161	18	147	128	4	3
1161—1189	9	197	178	3	1,5
1189—1204	15	165	219	6	2
1204—1222	9	183	161	7	4
1222—1234	6	243	211	10	4
1234—1247	12	209	179	6	3
1247—1292	6	244	215	11	5
1292—1305	12	291	233	5	2
1305—1317	3	207	181	9	4
1317—1341	6	244	210	14	6
1341—1344	3	261	213	17	7
1344—1356	6	271	215	9	3
1356—1359	3	219	180	14	5
1359—1408	6	244	210	10	4
1408—1420	12	186	180	23	12
1420—1439	6	226	185	17	8
1439—1445	3	186	180	12	6
1445—1512	6	257	210	10	4
1512—1518	3	282	225	9	3
1518—1536	6	227	193	9	4

* This table shows the average percentage of the wet samples retained after washing through a 75 µ sieve and dried.

Table 7 — CONVENTIONAL CORES

Well no.:	Core no	Interval	Recovery		Well no.:	Core no	Interval	Recovery	
		m	m	%			m	m	%
2/4-2	1	1664—1679	15	100	2/4-3	14	3252—3255	3	100
»	2	3051—3065	2	14	»	15	3255—3264	9	100
»	3	3199—3204	4	80	»	16	3277—3286	5	56
»	4	3204—3220	4	25	»	17	3313—3322	9	100
»	5	3220—3232	3	25	»	18	3322—3340	15	83
»	6	3232—3247	5	33					
»	7	3247—3265	2	11	2/4-4	1	3207—3208	0,7	70
»	8	3265—3280	13	87	»	2	3245—3246	0,4	40
2/4-3	1	1705—1717	0,6	4	»	3	3289—3298	8	89
»	2	3115—3117	2	100	2/4-5	1	3094—3099	0,3	6
»	3	3117—3120	3	100	»	2	3099—3108	9	100
»	4	3120—3124	4	100	»	3	3108—3115	7	100
»	5	3124—3132	8	100	»	4	3115—3133	4	22
»	6	3132—3133	1	100	»	5	3133—3139	6	100
»	7	3133—3138	3	60	»	6	3182—3188	6	100
»	8	3138—3144	4	67	»	7	3188—3197	9	100
»	9	3144—3148	3	75	»	8	3197—3206	8,5	94
»	10	3164—3167	3	100	»	9	3206—3215	9	100
»	11	3196—3199	3	100	»	10	3215—3224	9	100
»	12	3216—3225	7	78	»	11	3224—3233	9	100
»	13	3251—3252	0,6	60	»	12	3233—3242	9	100

Abbreviations

ab	= above
abn	= abundant
amr	= amorphous
ang	= angular
Anhd	= Anhydrite
arg	= argillaceous
Bar	= Barremian
Bc	= Breccia
bd	= bedded
becom	= becoming
BHC-Sonic	= Bore Hole Compensated — Sonic Log
BHP	= Bottom Hole Pressure
BHC-C	= Bore Hole Compensated Sonic with Caliper Log
Biot	= Biotite
Biv	= Bivalve
bl	= blue
Bld	= Boulders
blk	= black
Blm	= Belemnite
brit	= brittle
brn	= brown
CAL	= Caliper
Calc	= Calcite
calc	= calcareous
carb	= carbonaceous
Cbl	= Cobbles
CBL	= Cement Bond Log
CDM	= Continuous Dipmeter
Cgl	= Conglomerate
Chk	= Chalk
Chl	= Chlorite
Cht	= Chert
Cl	= Clay
cl	= clayey
Clst	= Claystone
cmt	= cement
col	= colour(ed)
cont	= contorted
conv	= convolute
crs	= coarse
crm	= cream
csg	= casing
DIR	= Directional log
distr	= distribute(ion)
dk	= dark
dns	= dense
Dol	= Dolomite
dol	= dolomitic
DLL	= Dual Laterolog
dsk	= dusky
Ech	= Echinoid
f	= fine
FDC	= Formation Density log
fib	= fibrous
filt	= filtration
fis	= fissile
fl	= floor
Fld	= Feldspar
frag	= fragment
fri	= friable
Foram	= Foraminifera
Fos	= Fossils
Gast	= Gastropode
glac	= glacial
Glc	= Glauconite
glc	= glauconitic
Gn	= Gneiss
gn	= green
Gran	= Granules
gran	= granular
GR	= Gamma Ray log
Gr	= Granite
grd	= graded
grns	= grains
Gvl	= Gravel
gvl	= gravelly
gy	= grey
Gyp	= Gypsum
h	= horizontal
hd	= hard
HDT	= High Resolution Dipmeter
hom	= homogeneous
IES	= Induction Electrical Survey
ig	= Igneous
Ill	= Illite
incr	= increasing
intbd	= interbedded
irreg	= irregular
Kaol	= Kaolin
KB	= Kelly Bushing
Kimm	= Kimmeridgian
lam	= laminated
LCM	= Lost Circulation Material
Lig	= Lignite
lig	= lignitic
lith	= lithic
LL	= Laterolog
lns	= lens
Ls	= Limestone
lse	= loose
lt	= light
m	= medium
matr	= matrix
met	= metamorphic
mdst	= mudstone
mic	= micaceous
mid	= middle
ML-C	= Microlog - Caliper
MLL-C	= Microlaterolog — Caliper
mod	= moderate
Mrl	= Marl
mrl	= marly
mtl	= mottled
Musc	= Muscovite
NL	= Neutron Log
nod	= nodular
n.s.	= no sample
o	= oil
occ	= occasional(ly)
olv	= olive
orng	= orange
pa	= pale
Pbl	= Pebble
pel	= pellet
Pelc	= Pelecypod
pkst	= packstone
pk	= pink
plast	= plastic
Pleist	= Pleistocene
por	= porosity, porous
ppg	= lb/gallon
predom	= predominant
pres	= pressure
psi	= lb/sq. in.
purp	= purple
Pyr	= Pyrite
pyr	= pyritic
Qtz	= Quartz
qtz	= quartzitic
rec	= recovery
red	= red(dish)
Rk	= Rock
rnd	= rounded
S	= Sand
s	= sandy
sc	= scattered
Sch	= Schist
sec	= second
sft	= soft
Sh	= Shale
Si	= Silica
Sid	= Siderite
Sks	= Slickenside
Slt	= Silt
slt	= silty
Sltst	= Siltstone
SNP	= Sidewall Neutron Porosity
sph	= sphericity
spic	= spicules
SRS	= Seismic Reference Survey
srt	= sorted
Sst	= Sandstone
stnd	= stained
strgs	= strings
Styl	= Stylolite
suc	= sucrose(ic)
surf	= surface
text	= texture
TD	= Total Depth
Tf	= Tuff
tf	= tuffaceous
tot	= total
trsl	= translucent
trsp	= transparent
TS	= Temperature Survey
v	= vertical
visc	= viscosity
vn	= vein
vy	= very
w	= with
wkst	= wackestone
wh	= white
xln	= crystalline
yel	= yellow

Examples of quantitative expressions: (for sand)
(s) - slightly sandy, s - moderately sandy, $\underline{s}$ - very sandy

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