ROBERTSON RESEARCH INTERNATIONAL LIMITED

REPORT NO. 4049P

WELLFILE

REPORT ON GEOCHEMICAL EVALUATION OF THE 1/9-1 WELL, NORWEGIAN NORTH SEA

PROJECT NO. RRI/767/IID/2441

by

B.S. COOPER

S.H. COLEMAN

W.B. SIMPSON

J.S. BUTTERWORTH

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Prepared by:
Robertson Research International Limited,
Ty'n-y-Coed,
Llanrhos,
Llandudno, Gwynedd, LL30 1SA.

Prepared for:
Statoil,
P.O. Box 300,
Lagardsveien 79,
4001 Stavanger, Norway.

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SUMMARY

A geochemical evaluation has been made of the Statoil 1/9-1 well, Norwegian North Sea. The study incorporates analysis of both source rock potential (organic carbon content, extraction and fractionation) and maturity (light hydrocarbon analysis, spore colouration and vitrinite reflectivity).

The analysed section 460 to 3,690 metres penetrated sediments of Pleistocene-Recent through to Cenomanian age. Oil-prone organic matter reaches the transitional stages of maturity over the approximate interval 2,000 to 3,000 metres. Gas-prone organic matter is only just becoming mature at a depth of 3,500 metres and would not be expected to source any significant quantities of gas from the section.

Both maturation and source rock analyses have indicated the likelihood of migrated hydrocarbons contaminating the section up to a level of around 1,000 metres; this has produced anomalous levels of light and heavy hydrocarbons particularly over the approximate interval 1,200 to 2,000 metres (and possibly at other lower levels).

Source rock evaluation is made difficult by the presence of contamination. The most likely source rock sections in this well, despite their present low level of maturation, are the Miocene, Oligocene and Palaeocene-Eocene grey shales. These are of average to above average organic richness and, where uncontaminated, show characteristics of being oil-prone (abundant sapropel occurs in the Oligocene and Miocene). Some thin grey shales interbedded with the chalk section appear to be good oil sources.

To assist in the interpretation of the contaminated sections it is intended to carry out gas chromatographic analysis to be forwarded as an appendix.

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I

INTRODUCTION

A geochemical study has been undertaken on the interval 460 to 3,690 metres in the 1/9-1 well, Norwegian North Sea, on behalf of Statoil. Levels of maturation have been established using the following methods: light hydrocarbon analysis, including headspace gas analysis on the canned samples available, spore colouration and vitrinite reflectivity. The evaluation of source rock potential of the section has incorporated the use of organic carbon determination, and extraction and fractionation of the C_{15+} hydrocarbon fraction.

Fresh, unwashed ditch cuttings in sealed metal cans were available at intervals of 30 metres over the section 460 to 3,690 metres; this was with the exception of the interval 3,042 to 3,240 metres where conventional coring was carried out. In all, a total of 103 canned samples and one conventional core sample was used for analytical purposes.

Samples for maturation evaluation were selected as follows: headspace gas analysis was carried out on all but 4 of the 104 canned samples, these 4 containing insufficient headspace gas; routine light hydrocarbon analysis was carried out on 28 cuttings samples at a spacing of 90 metres; spore colouration and vitrinite reflectivity analyses were carried out on 25 and 27 samples respectively, again at a spacing of approximately 90 metres. Samples for source rock potential studies were selected as follows: organic carbon determinations were carried out on all of the 104 canned samples, and one sample of shale isolated from some conventional core and on 6 samples of hand-picked lithologies where individual samples comprised mixed lithotypes; full source rock potential analysis was undertaken at approximately 90 metre intervals, generally on samples containing in excess of 0.5% organic carbon (total of 35 samples).

Detailed stratigraphic information is available from the Robertson Research Project No. RRI/767/IIA/1298. The analysed well section penetrates a complete Tertiary section and terminates in sediments of Cenomanian age.

II

RESULTS AND INTERPRETATION

The results of the geochemical evaluation of the 1/9-1 well are presented in Tables 1 to 5 and are represented graphically in Figures 1 to 9 and the enclosures.

A. MATURATION EVALUATION

A.1 LIGHT HYDROCARBONS (Tables 1 and 2, and Figures 1, 2 and 3)

Hydrocarbons present in all the can headspaces were analysed, followed by analysis of the gaseous and gasoline range hydrocarbons in 28 samples of ditch cuttings.

a. Headspace Gas Analysis

Prior to unsealing the canned samples an aliquot of headspace gas was removed and analysed for the gaseous C_1 to C_4 hydrocarbons. The results of these analyses are presented in Table 1 and Figure 1.

The abundance of gaseous hydrocarbons is remarkedly uniform throughout the analysed section, though local variations are apparent; values fall between 10,000 and 100,000 ppm (vol./vol.), these being higher than normally encountered in sediments, particularly for those in the first 1,000 to 2,000 metres of the well. Some of the samples from the chalk sections near the base of the analysed section show lower values of between 1,000 and 10,000 ppm.

The most useful parameter to be obtained from the headspace gas analyses is the proportion of wet gases (C_2 to C_4) in the gaseous hydrocarbon fraction (C_1 to C_4); only methane is found in immature sediments, with the wet gases being generated as maturity is reached. No wet gases are encountered in the section until below 910 metres; below 1,030 metres the proportion of wet gases rises to more than 10%, which would normally indicate that the transition zone from immature to mature sediments has been attained. Below approximately 1,100 metres the proportion of wet gases exceeds 30%, indicative of an early stage of maturity having been reached; with a few minor exceptions this is maintained to the base of the well section. Proportions are high over the interval 1,120 to 2,100 metres (50 to 90%), decreasing slightly to between 40 and 50% over the interval 2,100 to 2,700 metres, and then rising again to between 40 and 90% towards the base of the well section. The latter increase is in accord with an anticipated maturation trend; the rich wet gas zone 1,120 to 2,100 metres is anomalous and is considered to represent the presence of non-indigenous, probably migrant, hydrocarbons.

b. Gaseous Hydrocarbons (C_1 to C_4)

As with headspace gas analysis it is possible to use the proportion of wet gases, in the gaseous hydrocarbons liberated from the ditch cuttings, to estimate the maturity of a section.

Hydrocarbons in the C_1 to C_4 range are present in insignificant proportions over the analysed interval 640 to 1,090 metres; below this depth abundance increases steadily (with some minor peaks) to a maximum of around 1,000 ppb over the interval 1,810 to 2,982 metres. Below the cored interval, the abundance of gaseous hydrocarbons in the Chalk decreases noticeably to less than 100 ppb (with one exception); this lack of hydrocarbons probably reflects the lack of indigenous organic matter in the Chalk, the local maxima possibly representing the presence of migrated hydrocarbons.

The proportions of wet gas (C_2 to C_4) show a general increase from less than 1% to more than 90% over the interval 640 to 1,450 metres, with local maxima at 730 and 1,180 to 1,270 metres. Below 1,540 metres the proportion of wet gases remains at more than 90%; no data was available over the cored section. The Chalk section analysed between 3,240 and 3,690 metres shows rapid variations between 0% and 100% wet gas, this probably relating to the low content of indigenous organic matter.

c. Gasoline Range (C_5 to C_7) Hydrocarbons

Maturity is indicated by the C_5 to C_7 hydrocarbons when the constituent gasolines (Table 2) are found to be present in approximately equal proportions. Immature sediments on the other hand show certain components of marked abundance, but with an overall low total hydrocarbon abundance (less than 100 ppb).

Figure 3 shows a plot of both actual hydrocarbon abundance and abundance relative to an organic carbon content of 1%. Both lines show similar trends, with the corrected version showing less of a variation between maximum and minimum values. Actual gasoline abundance is around 100 ppb down to a depth of 1,000 metres; below this, there is a sharp increase to around 5,000 to 10,000 ppb down to the top of the cored Chalk section at approximately 3,000 metres. The sharp increase in hydrocarbon abundance over the interval 1,090 to 1,270 metres in particular, might be taken to represent the presence of migrated hydrocarbons. Below 3,240 metres the gasoline hydrocarbon abundance is a little more variable, ranging from 100 to approximately 5,000 ppb., the variability probably reflecting the presence of non-indigenous hydrocarbon material in this organically lean section.

An examination of Table 2 shows that the distribution of constituent gasoline hydrocarbons is such as to indicate the onset of the early stages of maturity by depths of as little as 1,000 metres; this again suggests that the presence of migrated hydrocarbons may be distorting the normal distribution of generated hydrocarbons.

A.2 SPORE COLOURATION (Table 3 and Figures 4 and 6)

A total of 25 samples of ditch cuttings was analysed for colouration of indigenous sporomorphs. The spore colour indices used in this report are based on a scale of 1 to 10; values of 3 to 3.5 are taken to represent the transition zone between immature and mature sediments. This scale has been correlated with that of Staplin's thermal alteration index. Reference may be made to our Manual, Report No. 4029P. The well section does not penetrate any more than the zone of early maturity.

a. Interval 550 to 910 metres

Samples in this upper part of the well are characterised by a high humic content and low spore colour values of 1.25 to 1.5; the latter values are indicative of very immature sediments.

b. Interval 1,180 to 1,630 metres

In this interval sapropelic debris is generally the dominant kerogen type, with relatively minor humic components. Spore colour values range from 1.5 to 2 at 1,180 metres to 2.5 at 1,630 metres; these values are indicative of immature sediments.

c. Interval 1,720 to 2,260 metres

Below 1,630 metres amorphous sapropel is the dominant kerogen and some anomalously high (up to 5) spore colours are recorded. Spore colour values range from 2.5 to 3 at 1,720 metres to 3 to 3.5 at 2,260 metres, these values being indicative of the zone of transitional maturity. Some of the high spore colour values may reflect an association with migrated hydrocarbons.

d. Interval 2,350 to 2,622 metres

In this interval sapropel is again the dominant kerogen type, although vitrinite and inertinite are present in increased concentrations. Spore colour values range from 3 to 3.5, with a maximum of 4 at 2,532 metres, indicative of the transitional stages of maturity.

e. Interval 2,712 to 2,982 metres

In this interval humic debris, generally vitrinite, is the dominant kerogen type with spore colour indices averaging 3.5; this indicates that the sediments are in the zone of early maturity.

f. Interval 3,480 to 3,660 metres

Below the cored section only two samples were analysed for spore colouration, at 3,480 and 3,660 metres. Inertinite is the dominant kerogen type with some vitrinite and sapropelic debris. Spore colour values range from 3.5 to 4, indicating an early level of thermal maturity.

An examination of Figure 4 shows a marked inflection between 1,500 and 2,000 metres; values of around 1 are encountered at a depth of 500 metres, increasing to 2 at 1,500 metres, 3 at 2,000 metres and 4 at 3,500 metres. This would indicate that the zone of transitional maturity (spore colour 3-3.5) is attained over the interval 2,000 to 2,500 metres. In view of the apparent rapid increase in index values observed over the interval 1,700 to 2,100 metres, possibly resulting from the passage of heated migrating formation fluids (along a fault?), the top of the zone of transitional maturity is 500 metres higher than expected. The base of the analysed well section is just into the zone of early maturity and it is anticipated that heavy oils could be generated from oil-prone organic matter at these depths.

A.3 VITRINITE REFLECTIVITY (Table 3, Figures 5 and 6 and enclosures)

Vitrinite reflectivity measurements have been carried out on 27 samples of ditch cuttings; most of the measurements were made on kerogen concentrates since many of the cuttings samples were too soft or failed to yield material suitable for measurement. The sample blocks were prepared by mounting the dry cuttings in an epoxy resin, followed by polishing with carborundum and alumina. Kerogen concentrates were prepared by standard palynological techniques followed by mounting in resin and polishing as for the cuttings. The results prsented in Table 3 are those mean values interpreted as being indigenous; the figures in brackets indicate the number of measurements represented by this mean value. A detailed compilation of all the vitrinite data is given in the enclosures, though samples from which no data were obtained are excluded.

Overall a good coverage of the analysed well section has been obtained, with sufficient indigenous vitrinite observed to enable an accurate representation of the thermal history of the sediments to be ascertained. Reworked, caved and low reflecting organic matter are not sufficiently abundant to obscure the interpretation.

Reflectivity levels of indigenous vitrinite in the analysed section increase from around 0.25% at 1,000 metres to 0.4% at 3,000 metres, and 0.55% at the base of the analysed section (3,660 metres). This indicates that the transition from immature to mature sediments occurs over the depth range 2,800 to 3,500 metres (0.4 to 0.5%) in gas-prone organic matter, and over the depth range 2,000 to 2,500 metres (0.3 to 0.35%) in oil-prone organic matter. Gas-prone organic matter at the base of the analysed section is insufficiently mature to source more than limited quantities of gaseous hydrocarbons; optimum generation of gas only occurs at reflectivities in excess of 0.8 to 1.0%.

Examination of the samples in blue light shows a gradual change from yellow-green through yellow to golden yellow/yellow-orange fluorescence with increasing depth; this concurs with the colours observed during the spore colouration analysis.

A.4 COMPARISON OF MATURATION INDICES (Table 3 and Figure 6)

A number of parameters have been used to assess the maturation state of the analysed well section, including light hydrocarbon analysis, spore colouration, and vitrinite reflectivity.

Spore colouration results indicate that the zone of transitional maturity in oil-prone organic matter occurs over the approximate interval 2,000 to 2,500 metres (higher than expected because of inflection). Light hydrocarbon analysis, on the other hand, indicates that hydrocarbon compositions similar to those observed in the zone of transitional to early maturity are encountered from depths of as little as approximately 1,200 metres. However, detailed examination of the light hydrocarbon data indicates that there is a zone of suspected non-indigenous hydrocarbon contamination over at least the interval 1,200 to 2,000 metres; an anomalous zone is also seen over the interval 1,700 to 2,100 metres in the spore colouration analyses, where a rapid increase in the spore colour indices occurs. Both spore colouration and light hydrocarbon analysis indicate that oil-prone organic matter is in the early stages of maturity at the base of the analysed section (3,690 metres).

Vitrinite reflectivity levels reach 0.5% at the base of the analysed section; this indicates that significant quantitites of gaseous hydrocarbons are unlikely to be generated from humic organic matter through the analysed section, since this would require reflectivities of above 0.8 to 1.0%. Reflectivity of vitrinite can be used to estimate the depth to the onset of oil generation from sapropelic organic matter, though it is necessary to have some estimate of the age and thermal history of the sediments, since the degree of maturation of vitrinite is determined both by temperature reached and length of time of heating. The analysed well section comprises both Tertiary and Cretaceous sediments, from which it would be anticipated that a reflectivity level of around 0.30 to 0.35% would have to be attained before any oil generation would be encountered. This corresponds to a depth of not greater than approximately 2,000 to 2,500 metres. This compares fairly well with the spore colouration data. No obvious discontinuity is observed in the reflectivity data at around 2,000 metres.

B. SOURCE ROCK EVALUATION (Tables 4 and 5, and Figures 7, 8 and 9)

The data obtained from the source rock analyses are presented in Tables 4 and 5 and are represented graphically in Figures 7, 8 and 9. Extra copies of the figures are included as enclosures for ease of reference.

The results of the source rock evaluation are discussed in groups identical to those identified in our Biostratigraphy report, since in all but a few minor instances, the geochemical group boundaries equate to those of stratigraphy.

B.1 PLEISTOCENE - RECENT, 430 to 570 metres (Samples 1 to 4)

This interval comprises a medium to dark olive-grey claystone with minor sand and shell. The organic carbon content of the samples ranges from 0.5 to 1.1%, these values are below average for argillaceous lithologies.

Only one sample was submitted for source rock potential analysis from this interval (sample 3). The proportion of the organic matter extractable in organic solvents is anomalously high, at 14.9%, for the low level of maturation established for the section. The abundance of hydrocarbons (146 ppm) and the proportion they form of the extractable organic matter (13%) are also anomalous. The sample is considered to be contaminated by non-indigenous hydrocarbon material and to have no hydrocarbon sourcing potential at the present level of thermal maturity.

B.2 PLIOCENE, 580 to 950 metres (Samples 5 to 17)

This interval comprises a medium to dark olive-grey claystone with minor sand and shell. The organic carbon content of these samples is below average for argillaceous lithologies, falling between 0.34 and 0.59%.

Two samples, 7 and 13, were analysed for source rock potential analysis. The proportion of organic matter extractable in organic solvents is moderately low at 6.7 to 9.9%, which, at the low level of thermal maturity established for this section, suggests a more oil-prone type of organic matter. Hydrocarbon abundance (12 and 33 ppm) and the proportion it forms of the extractable organic matter (3 and 8%) is low, concurring with the low level of maturity.

This section is considered to be insufficiently mature at present to be a significant hydrocarbon source.

B.3 UPPER MIOCENE, 960 to 1,100 metres (Samples 18 to 22)

This interval comprises a medium to dark olive-grey claystone with minor sand and shell. The organic carbon content of the section is below average for argillaceous lithologies, increasing from approximately 0.5 to 0.87% downhole.

Only one sample was analysed for source rock potential analysis (Sample 19). This sample contains 11.8% extractable organic matter; hydrocarbon abundance is 136 ppm, forming some 18% of the extractable organic matter. On the evidence of this one sample the section could be considered to have a fair potential as a source of limited quantities of gas and associated liquid hydrocarbons,but with the level of maturation still being low, contamination must be suspected.

B.4 MIDDLE MIOCENE, 1,110 to 1,670 metres (Samples 23 to 41)

This interval comprises claystones, as described in the overlying intervals, passing into medium to light grey mudstone and shale below 1,360 metres. The organic carbon content of the section is generally average for argillaceous lithologies, with a range between 0.8 and 2.46%; below 1,600 metres, however, there is a marked increase to above average values of 3.3 to 6.6%.

Six samples were analysed for source rock potential analysis over this interval. The proportion of extractable organic matter in these samples is variable at between 4.8 and 29.0%; at least one sample is considered to be contaminated by non-indigenous organic matter. Hydrocarbon abundance is anomalously high, since this section is still immature; values between 438 and 1,403 ppm are recorded. The proportions of hydrocarbons in the extractable organic matter are also anomalously high at 38 to 44%. Although the source rock and light hydrocarbon analysis data suggest that the section is mature and has a good to very good potential as a source for oil, the low level of maturity established by the maturation parameters for both oil- and gas-prone organic matter, suggest that the apparent high oil-sourcing potential is due to the presence of non-indigenous hydrocarbons.

B.5 LOWER MIOCENE, 1,680 to 1,790 metres (Samples 42 to 45)

The interval comprises grey, grey-brown and grey-green mudstones and shales. The organic carbon content of these sediments is above average for argillaceous material, ranging from 2.3 to 4.4%.

Extractability of the organic matter in the two samples analysed for source rock analysis is variable at 5.5 and 20.6%. Hydrocarbon abundance is high at 968 and 1,362 ppm,while the proportion they form of the extractable organic matter is also relatively high at 29 and 40%. It is considered that this section comprises a continuation of the contaminated Middle Miocene unit.

B.6 OLIGOCENE, 1,800 to 2,270 metres (Samples 46 to 61)

This interval comprises a sequence of grey to grey-brown shales and mudstones, these being distinctly darker towards the base of the interval. The organic carbon content of these samples is shown, in Table 4, to fall between 0.76 and 3.40%; some of the data are considered, however, to be unreliable (indicated + on Table 4) and where these were reanalysed during source rock potential analysis the new data are used in Table 4. On this basis the organic carbon content of the section is seen to be average to above average for argillaceous lithologies, falling mainly between 1 and 5%. Some of the organic carbon contents shown in Table 5 differ from their depth equivalents in Table 4; the former are considered more reliable since only a small portion of sample is used in the initial organic carbon analysis.

Six samples were analysed for source rock potential analysis, these containing between 10.7 and 15.5% extractable organic matter. Hydrocarbon abundance is 763 to 1,803 ppm, this forming 15 to 34% of the extractable organic matter. It is considered that this section has a fair to good potential as a source for gas and oil. While contamination may be present to some extent it is not obviously apparent from the data, although the potential for the section is still rather high for the transitional level of maturity attained.

B.7 EOCENE, 2,280 to 2,688 metres (Samples 62 to 75)

The interval comprises light to medium grey and grey-brown, slightly calcareous shales and mudstones. The organic carbon content of these samples is average to just above average at 1.05 to 2.23%.

The six samples analysed for source rock potential analysis contain between 13 and 15.3% extractable organic matter rising as high as 51.8% in one of the likely contaminated samples. Hydrocarbon abundance is high at between 546 and 2,212 ppm and makes up between 22 and 41% of the extractable organic matter. The section appears to represent a good to very good potential source for oil; this appears, however, to be inconsistent with the early levels of thermal maturity established for the section and may well relate to the presence of non-indigenous hydrocarbons (possibly migrated) as suggested for the Middle Miocene unit.

B.8 PALAEOCENE TO LOWER EOCENE, 2,694 to 2,859 metres (Samples 76 to 80)

This interval comprises light to medium grey and grey-brown, slightly calcareous shales and mudstones. The organic carbon contents of these samples is average to just above average for argillaceous lithologies, ranging from 1.4 to 2.8%.

Three samples were analysed for source rock potential and were found to contain between 4.8 and 12.1% extractable organic matter. Hydrocarbon abundance ranges from 190 to 940 ppm and makes up between 25 and 42% of the extractable organic matter. The data show no apparent contamination, the section thus being considered a fair to good potential source for gas and possibly some heavy oil.

B.9 PALAEOCENE, 2,865 to 3,009 metres (Samples 81 and 85)

This interval comprises light to medium grey and grey-brown, slightly calcareous shales and mudstones. The organic carbon content of these samples is slightly variable at 0.94% (Sample 81), 2.16 to 2.33% (Samples 82 to 84) and 4.27% (Sample 85); these values are average to above average for argillaceous lithologies.

Two samples were analysed for source rock potential analysis, these containing 11.1 and 38.4% extractable organic matter. Hydrocarbon abundance is high at 984 and 4086 ppm, the hydrocarbons comprising 38 and 49% of the extractable organic matter. This section appears to represent a good to very good potential source for heavy oil at the early level of maturity established for the section, however, at least one of these samples appears contaminated (sample 82).

B.10 DANIAN, 3,015 to 3,103.2 metres (Samples 86 and 87)

This interval comprises light to medium grey and grey-brown, slightly calcareous shales and mudstones of average organic carbon content for argillaceous lithologies (1.21 to 1.69%).

Only one sample was submitted for source rock potential analysis from this interval, sample 86. This contained 13.5% extractable organic matter, of which, 23% comprised hydrocarbons (total hydrocarbon abundance 526 ppm). The sample is considered to represent a good potential source for gas and heavy oil.

B.11 LATE MAASTRICHTIAN, 3,103.95 to 3,209 metres (Sample 88)

This interval comprises essentially chalk, much of which was represented by conventional core. Although this core was not required for geochemical studies, a small fragment of material was hand-picked from one of several thin interbedded black shale bands and submitted for source rock potential analysis. This sample contained 1.9% organic carbon, average for an argillaceous lithology. A low 3.6% of this organic matter was extractable in organic solvents, only 5% comprising hydrocarbons (total abundance only 36 ppm). This shale appears gas-prone and thus, at the level of thermal maturity established for the section, not a significant hydrocarbon source.

B.12 EARLY MAASTRICHTIAN TO CENOMANIAN, 3,212.98 to 3,690 metres (Samples 89 to 104)

This interval is represented essentially by chalk with varying proportions of interbedded grey, grey-green and grey-black shales. The organic carbon content of these samples, as shown in Table 4, is variable between 0.15

and 2.84%, depending on the relative abundance of shale in each sample. A number of the shale lithologies were individually selected for organic carbon content determination; grey-green shale from 3,390, 3,480 and 3,540 metres contains average amounts of organic carbon at 1.03 to 1.20%; grey-black shale from 3,660 metres contains an above average 3.2% organic carbon; grey and grey-green shales from 3,660 and 3,690 metres have a below average organic carbon content of 0.54 to 0.97%.

Four samples were submitted for source rock potential analysis over this interval, two being chalk and two being shale:

a. The shale samples contain 9.0 to 9.7% extractable organic matter, of which 520 to 772 ppm (28 to 34%) comprises hydrocarbons; these samples show no obvious signs of being contaminated and are considered to represent good potential sources for gas and heavy oil at the early level of maturity established for this section.

b. The two samples of chalk are quite different in their source rock characteristics, though both contain between 91.4 and 108.2% extractable organic matter. The sample at 3,300 metres, with a very high organic carbon content for chalk of 1.32%, shows a high hydrocarbon abundance of 5,486 ppm (45% of extract) and is considered to be contamined by non-indigenous hydrocarbons. The sample at 3,570 metres, with a more average organic carbon content for chalk of 0.19%, shows a much lower hydrocarbon abundance of 175 ppm (9% of extract); this sample is considered to be contaminated by non-indigenous organic matter in view of the high extractability.

III

CONCLUSIONS

From our present study of the 1/9-1 well the following main conclusions can be made:

1. The maturation parameters indicate that oil-prone sapropelic organic matter enters the zone of transitional maturity over the approximate interval 2,000 to 3,000 metres, and is in the early stages of maturity at the base of the analysed section. Gas-prone humic organic matter passes into the early stages of maturity below a depth of approximately 3,500 metres, but is considered insufficiently mature through the remainder of the section to yield any significant hydrocarbons to associated reservoirs.

2. The geochemical analyses indicate that non-indigenous, possibly migrated, hydrocarbons are present over the approximate interval 1,200 to 2,000 metres, and probably to some extent below these depths.

3. Source rock potential of the analysed well section is described in the following groups, based on stratigraphic information obtained under our Project Number RRI/767/IIA/1298.

a. Pleistocene-Recent, 430 to 570 metres: dark olive-grey claystone of below average organic carbon content. Immature, with no potential as a source of hydrocarbons.

b. Pliocene, 580 to 950 metres: medium to dark olive-grey claystone of below average organic carbon content. Insufficiently mature to be a significant hydrocarbon source.

c. Upper Miocene, 960 to 1,100 metres: medium to dark olive-grey claystone of below average organic carbon content. Insufficiently mature to be a significant hydrocarbon source.

d. Middle Miocene, 1,110 to 1,670 metres: medium to dark olive-grey claystone of average organic carbon content, increasing to above average below 1,600 metres. Source rock data suggest this section to be a good to very good potential source for oil; the immature nature of the section suggests, however, that the data may be affected by the presence of non-indigenous hydrocarbons. Potential may be good offstructure at a more advanced level of thermal maturity.

e. Lower Miocene, 1,680 to 1,790 metres: grey, grey-brown and grey-green mudstone and shale of above average organic carbon content. High concentrations of hydrocarbons could suggest the presence of good to very good potential sources for oil; however, the presence of non-indigenous hydrocarbons is suspected in view of the low level of thermal maturity attained over this section.

f. Oligocene, 1,800 to 2,270 metres: grey to grey-brown shale and mudstone of average to above average organic carbon content. No pronounced contamination is suspected in this section,though hydrocarbon abundance is still high for the immature to transitional level of maturity reached; the section is considered to represent, at best, a fair potential source for limited quantities of gaseous hydrocarbons. This may improve to a good potential for oil at higher levels of thermal maturity, particularly in view of the high sapropel content in the samples.

g. Eocene, 2,280 to 2,688 metres: light to medium grey and grey-brown, slightly calcareous mudstone and shale of average to just above average organic carbon content. The apparent good to very good potential as an oil source is inconsistent with the transitional level of maturity established for the section and probably relates to the presence of non-indigenous hydrocarbons.

h. Palaeocene to Lower Eocene, 2,694 to 2,859 metres: light to medium grey and grey-brown, slightly calcareous shale and mudstone of average to just above average organic carbon content. Appears to represent a fair to good potential source for gas and possibly some heavy oil, though of limited quantity in view of the transitional level of maturity attained.

i. Palaeocene, 2,865 to 3,009 metres: light to medium grey and grey-brown, slightly calcareous mudstone and shale of average to above average organic carbon content. Data suggest this section to represent a good to very good potential source for oil, though one at least of the samples is contaminated by non-indigenous hydrocarbon material.

j. Danian, 3,015 to 3,103.2 metres: light to medium grey and grey-brown, slightly calcareous mudstone and shale of average organic carbon content. Just into the early stages of maturity and considered to represent a good potential source for gas and heavy oil.

k. Late Maastrichtian, 3,103.95 to 3,209 metres: most of this interval was represented by conventional core on which no analyses were carried out. However, a sample of black shale, from a thin, interbedded shale unit within the Chalk returned an average organic carbon content. The shale appears gas-prone and is thus insufficiently mature to source significant quantities of hydrocarbons at the established low level of maturity.

l. Early Maastrichtian to Cenomanian, 3,212.98 to 3,690 metres: chalk with varying amounts of interbedded shales, grey, grey-green and grey-black in colour. The chalks analysed for source rock potential are considered to be contaminated by non-indigenous hydrocarbons and organic matter. The interbedded shales, although probably not very thick, are frequently of average to above average organic carbon content; they are considered to represent good potential sources of gas and heavy oil at the early level of maturity established for the section.

4. We have concluded that contamination, probably by migrated hydrocarbons, is frequent in the section of mudstones, shales and claystones between 1,000 and 2,000 metres depth, but we are constrained to explain how such relatively impermeable sediments could achieve such high hydrocarbon contents. In explanation we can only suggest that the hydrocarbons or the fluids containing hydrocarbons were introduced at high pressure and that they are not far distant from their main migrationary pathway. A possible mechanism for the phenomenon is the presence of a fault zone fairly close to

the drilled section. The non-linearity of spore colour indices between 1,700 and 2,300 metres may also indicate the presence of an intermittently open fracture, there being no other evidence of a fault in this part of the section and the depth being probably too shallow for overpressuring to have developed.

TABLE 1A

HEADSPACE GAS ANALYSIS DATA

COMPANY: STATOIL WELL: 1/9-1 LOCATION: NORWEGIAN N. SEA

SAMPLE DEPTH (METRES)	TOTAL C_1-C_4 GAS (ppm v/v)	PERCENT C_1	PERCENT C_2	PERCENT C_3	PERCENT iso C_4	PERCENT n-C_4
460	35500	100.00	-	-	-	-
490	25400	99.90	0.10	-	-	-
520	32300	99.98	0.01	0.01	-	-
550	17300	99.90	0.01	trace	-	-
580	23300	99.98	0.02	-	-	-
610	30800	99.98	0.01	0.01	trace	-
640	7700	99.40	0.60	-	-	-
670	13900	99.30	0.60	0.10	-	-
700	6900	99.75	0.20	0.03	-	-
730	16700	99.94	0.01	0.05	-	-
760	49500	99.85	0.01	0.12	0.01	trace
790	12700	99.50	0.08	0.35	0.03	0.03
820	9800	99.50	0.38	0.12	trace	-
850	15800	99.40	0.45	0.15	0.03	0.01
880	23100	99.60	0.05	0.30	0.06	0.02
910	26800	98.20	0.93	0.72	0.09	0.06
940	21600	98.60	0.80	0.50	0.09	0.05
970	43800	97.00	1.27	1.40	0.22	0.13
1000	48200	95.30	1.60	2.20	0.50	0.40
1030	13500	84.70	2.30	7.50	2.70	2.80
1060	55000	72.00	2.30	22.80	1.00	1.90
1090	21400	70.40	8.60	9.70	3.50	7.80
1120	142000	22.50	15.60	27.00	10.70	24.20
1150	208000	12.30	10.40	37.70	13.40	26.20
1180	124000	18.70	12.10	33.50	10.90	24.80
1210	71000	33.40	10.40	24.40	9.50	22.30
1240	47000	70.90	8.00	11.90	3.10	6.10
1270	61000	57.70	9.00	15.70	5.60	12.00
1300	39000	54.80	11.70	14.00	6.30	13.20
1330	24000	55.60	10.40	16.40	5.50	12.10
1360	8000	29.50	9.90	24.40	11.00	25.20
1390	8000	70.90	10.40	9.60	2.60	6.50
1420	13000	38.20	11.90	21.50	8.40	20.00
1450	13000	62.90	9.20	12.80	4.60	10.50
1480	17000	37.40	11.10	24.20	8.60	18.70
1510	43000	44.10	10.50	18.40	7.20	19.80
1540	30000	50.30	12.70	19.30	5.90	11.80
1570	49000	36.40	13.50	25.20	8.10	16.80
1600	58000	20.60	16.10	32.20	10.30	20.80
1630	179000	35.00	13.40	14.00	18.20	19.40
1660	112000	35.00	21.30	22.20	8.40	13.10
1690	64000	21.30	13.50	40.10	8.80	16.30
1720	32000	37.60	15.90	25.50	7.80	13.20
1750	64000	47.80	11.80	20.20	6.60	13.60
1780	74300	47.80	23.60	26.70	0.60	1.30
1810	124000	39.60	14.70	16.50	9.80	19.20
1900	17000	89.20	2.60	4.00	1.80	2.40

TABLE 1B

HEADSPACE GAS ANALYSIS DATA

COMPANY: STATOIL WELL: 1/9-1 LOCATION: NORWEGIAN N. SEA

SAMPLE DEPTH (METRES)	TOTAL C_1-C_4 GAS (ppm v/v)	PERCENT C_1	PERCENT C_2	PERCENT C_3	PERCENT iso C_4	PERCENT n-C_4
1930	72000	39.50	25.10	28.20	3.40	3.70
1960	81000	52.20	20.40	25.20	0.80	1.40
1990	80000	45.40	22.70	25.50	3.10	3.30
2020	81000	51.40	21.30	1.90	8.80	16.50
2050	117000	42.00	15.60	17.40	9.00	16.00
2080	105000	47.20	17.60	19.70	0.80	14.60
2110	103000	48.00	17.70	19.70	5.30	9.20
2140	63000	52.80	16.20	19.70	3.60	7.70
2230	100000	48.60	18.10	20.40	4.80	8.10
2260	65000	53.70	18.50	19.70	3.90	4.20
2320	73000	62.90	13.50	15.30	3.30	5.00
2350	63000	62.00	14.00	16.00	3.70	4.30
2380	73000	67.60	12.10	12.50	2.80	5.00
2410	97000	50.60	16.00	21.10	4.50	7.80
2440	8100	62.40	13.40	13.20	6.20	4.80
2470	16800	61.20	17.40	10.20	6.10	5.10
2502	25600	54.20	19.50	15.70	5.70	4.90
2532	23300	46.10	19.00	20.00	8.30	6.60
2562	17700	32.00	25.00	26.30	7.90	8.80
2592	90400	41.80	17.10	19.10	12.60	9.40
2622	64000	50.20	18.80	17.20	7.40	6.40
2652	32200	59.90	15.40	14.40	5.20	5.10
2682			NO	GAS		
2712	10500	34.00	17.50	24.20	11.90	12.40
2742	121100	50.30	15.20	17.50	10.10	6.90
2772			NO	GAS		
2802	27100	38.70	18.00	23.80	10.30	9.20
2832	11300	54.00	17.20	16.90	6.20	5.70
2862	2500	42.50	21.90	21.40	6.50	7.70
2892	138600	27.30	22.60	25.90	14.90	9.30
2922	58500	50.20	20.40	17.20	6.20	6.00
2952	41700	34.80	16.60	24.80	12.70	11.10
2982	26500	31.70	17.20	26.70	12.60	11.80
3012	37300	32.60	19.70	24.10	12.20	11.40
3042	18500	20.40	19.30	30.30	16.50	13.50
3240			NO	GAS		
3270	5300	41.30	11.70	21.50	6.60	18.90
3300	4300	64.40	13.00	12.30	2.70	7.60
3330			NO	GAS		
3360	23000	17.50	19.80	31.90	7.10	23.70
3390	87000	26.90	24.70	28.20	4.70	15.50
3420	80000	26.40	20.70	27.50	5.90	19.50
3450	4.80	31.60	18.40	22.90	5.90	21.10
3480	1.60	64.80	12.40	12.30	2.10	8.30
3510			NO	GAS		
3540	0.64	46.20	12.40	17.80	5.70	17.80
3570			NO	GAS		
3600	0.09	22.40	13.50	26.80	8.50	28.90
3630	0.08	15.20	8.30	27.80	10.90	37.80
3660			NO	GAS		
3690			NO	GAS		

TABLE 2 (A)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

	% C_1 to C_4 (GASEOUS HYDROCARBONS)							
DEPTH (METRES)	460	550	640	730	820	910	1000	1090
C_1	-	*	97	36	-	66	100	50
C2	-	*	3	18	-	34	tr	50
C_3	-	*	tr	28	-	*	tr	*
iso-C_4	-	*	tr	18	-	*	*	*
n-C_4	-	*	tr	*	-	*	*	*
TOTAL (P.P.B.)	-	*	29	11	-	3	14	2

	% C_5 to C_7 (GASOLINE RANGE HYDROCARBONS)							
ISO-PENTANE	-	6	4	tr	4	7	14	4
N-PENTANE	-	tr	4	tr	4	10	14	4
2,2-DIME.BUTANE	-	*	1	*	*	*	tr	1
CYCLOPENTANE	-	*	1	3	tr	tr	*	2
2,3-DIME.BUTANE	-	*	2	*	*	*	tr	3
2-ME.PENTANE	-	3	7	5	1	3	3	4
3-ME.PENTANE	-	3	5	5	8	5	5	10
N-HEXANE	-	6	10	8	7	7	8	14
ME-CYCLOPENTANE	-	6	7	6	13	5	8	12
CYCLOHEXANE	-	17	21	9	13	8	18	12
2-ME.HEXANE	-	8	9	9	9	8	10	7
3-ME.HEXANE	-	6	6	9	7	8	3	4
1,3-DIME.CYC.PENT.(T)	-	*	3	*	3	*	tr	2
1,3-DIME.CYC.PENT.(C)	-	*	3	*	3	*	tr	2
3-ETHYLPENTANE	-	3	4	8	4	7	3	3
N-HEPTANE	-	31	6	11	7	8	3	5
BENZENE	-	*	tr	18	tr	14	3	*
DIME.PENTANE	-	*	2	*	3	*	tr	3
ME.CYCLOHEXANE	-	11	5	9	13	10	8	8
TOTAL ABUNDANCE P.P.B	-	36	854	64	105	60	37	5157

TABLE 2 (B)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

	% C_1 to C_4 (GASEOUS HYDROCARBONS)							
DEPTH (METRES)	1180	1270	1360	1450	1540	1630	1720	1810
C_1	1	5	46	10	2	3	4	1
C_2	1	tr	10	2	tr	tr	1	1
C_3	17	8	10	11	2	21	22	13
iso-C_4	13	12	20	17	20	21	21	18
n-C_4	68	75	14	60	76	55	52	67
TOTAL (P.P.B.)	574	109	48	103	292	146	214	4540

	% C_5 to C_7 (GASOLINE RANGE HYDROCARBONS)							
ISO-PENTANE	12	11	8	7	5	30	24	21
N-PENTANE	22	16	16	9	10	28	28	9
2,2-DIME.BUTANE	1	1	4	1	1	1	1	1
CYCLOPENTANE	2	1	4	1	1	1	1	3
2,3-DIME.BUTANE	2	2	4	*	1	1	1	2
2-ME.PENTANE	10	5	8	6	8	8	7	10
3-ME.PENTANE	6	5	3	4	5	4	4	8
N-HEXANE	14	13	13	9	14	8	9	13
ME-CYCLOPENTANE	10	10	13	4	6	4	5	8
CYCLOHEXANE	5	11	tr	6	9	4	5	6
2-ME.HEXANE	3	4	5	9	8	2	3	3
3-ME.HEXANE	2	3	9	7	6	2	2	3
1,3-DIME.CYC.PENT.(T)	1	1	1	*	2	tr	tr	1
1,3-DIME.CYC.PENT.(C)	1	1	1	*	2	1	1	1
3-ETHYLPENTANE	1	2	1	4	4	1	1	2
N-HEPTANE	2	4	6	14	7	2	3	2
BENZENE	tr	1	1	tr	tr	tr	tr	tr
DIME.PENTANE	1	1	1	2	2	tr	tr	1
ME.CYCLOHEXANE	5	8	2	17	9	3	5	6
TOTAL ABUNDANCE P.P.B	8262	11240	698	5385	13331	28462	17861	16716

TABLE 2(C)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

	% C_1 to C_4 (GASEOUS HYDROCARBONS)							
DEPTH (METRES)	1900	1990	2080	2170	2260	2350	2440	2532
C_1	tr	2	1	-	-	-	4	2
C_2	tr	tr	tr	-	-	-	2	1
C_3	12	5	2	-	-	-	26	21
iso-C_4	18	18	19	-	-	-	16	17
n-C_4	70	75	78	-	-	-	52	59
TOTAL (P.P.B.)	1856	434	755	-	-	-	1087	808

	% C_5 to C_7 (GASOLINE RANGE HYDROCARBONS)							
ISO-PENTANE	12	14	15	4	8	13	8	8
N-PENTANE	20	22	20	10	16	23	13	9
2,2-DIME.BUTANE	1	*	1	tr	1	*	tr	2
CYCLOPENTANE	1	1	6	1	1	tr	1	tr
2,3-DIME.BUTANE	1	*	1	1	1	*	1	2
2-ME.PENTANE	9	10	7	7	11	12	8	6
3-ME.PENTANE	6	6	5	5	6	6	4	4
N-HEXANE	13	15	13	14	12	19	11	11
ME-CYCLOPENTANE	8	7	4	7	7	5	5	6
CYCLOHEXANE	7	6	4	7	7	5	6	9
2-ME.HEXANE	4	4	4	7	6	5	8	7
3-ME.HEXANE	3	3	3	5	5	tr	7	5
1,3-DIME.CYC.PENT.(T)	1	*	1	2	2	*	2	2
1,3-DIME.CYC.PENT.(C)	1	*	1	2	2	*	2	3
3-ETHYLPENTANE	2	2	1	3	2	1	2	4
N-HEPTANE	4	5	6	12	7	6	12	9
BENZENE	1	tr	tr	tr	tr	tr	tr	tr
DIME.PENTANE	1	*	1	1	2	*	tr	2
ME.CYCLOHEXANE	5	6	4	12	4	5	10	11
TOTAL ABUNDANCE P.P.B	22114	14130	9347	11762	13619	6711	7648	7578

TABLE 2 (D)

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

	% C_1 to C_4 (GASEOUS HYDROCARBONS)							
DEPTH (METRES)	2622	2712	2802	2892	2982	3240	3330	3420
C_1	1	2	6	tr	1	74	18	1
C_2	3	1	2	1	3	13	4	1
C_3	29	18	25	18	29	13	18	3
iso-C_4	14	12	13	20	14	*	8	14
n-C_4	53	67	54	61	53	*	52	81
TOTAL (P.P.B.)	746	671	133	2686	892	8	27	496

	% C_5 to C_7 (GASOLINE RANGE HYDROCARBONS)							
ISO-PENTANE	8	7	6	14	5	4	6	7
N-PENTANE	11	12	9	16	9	6	14	24
2,2-DIME.BUTANE	tr	tr	tr	1	tr	tr	1	1
CYCLOPENTANE	1	1	1	1	1	tr	1	1
2,3-DIME.BUTANE	1	*	tr	1	1	tr	2	1
2-ME.PENTANE	6	5	5	9	4	5	3	10
3-ME.PENTANE	4	3	3	6	3	3	3	5
N-HEXANE	9	11	5	15	14	19	14	21
ME-CYCLOPENTANE	7	9	8	4	5	6	5	5
CYCLOHEXANE	7	6	6	4	6	6	5	3
2-ME.HEXANE	8	5	7	6	7	8	6	4
3-ME.HEXANE	8	4	6	4	5	6	5	3
1,3-DIME.CYC.PENT.(T)	2	2	3	1	2	tr	1	1
1,3-DIME.CYC.PENT.(C)	3	2	3	1	2	tr	tr	tr
3-ETHYLPENTANE	4	3	5	1	3	4	3	2
N-HEPTANE	10	13	16	9	16	16	15	6
BENZENE	1	1	1	tr	1	*	1	tr
DIME.PENTANE	1	tr	1	1	1	tr	1	2
ME.CYCLOHEXANE	9	16	15	6	16	17	14	4
TOTAL ABUNDANCE P.P.B	10095	1666	5150	17104	4103	109	762	4543

TABLE 2E

GASEOUS AND GASOLINE HYDROCARBON DATA

CLIENT: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

	% C_1 to C_4 (GASEOUS HYDROCARBONS)							
DEPTH (METRES)	3510	3600	3690					
C_1	75	100	11					
C_2	tr	tr	tr					
C_3	tr	tr	18					
iso-C_4	tr	tr	11					
n-C_4	25	tr	60					
TOTAL (P.P.B.)	4	3	27					

	% C_5 to C_7 (GASOLINE RANGE HYDROCARBONS)							
ISO-PENTANE	1	7	11					
N-PENTANE	2	16	21					
2,2-DIME.BUTANE	2	1	1					
CYCLOPENTANE	1	1	1					
2,3-DIME.BUTANE	2	1	1					
2-ME.PENTANE	4	2	9					
3-ME.PENTANE	3	4	5					
N-HEXANE	12	18	16					
ME-CYCLOPENTANE	2	4	4					
CYCLOHEXANE	2	4	3					
2-ME.HEXANE	12	8	6					
3-ME.HEXANE	11	6	4					
1,3-DIME.CYC.PENT.(T)	*	1	1					
1,3-DIME.CYC.PENT.(C)	*	1	0					
3-ETHYLPENTANE	3	2	2					
N-HEPTANE	27	14	8					
BENZENE	tr	1	1					
DIME.PENTANE	1	1	1					
ME.CYCLOHEXANE	15	8	5					
TOTAL ABUNDANCE P.P.B	490	3905	1863					

TABLE 3

MATURATION EVALUATION DATA

COMPANY STATOIL WELL: 1/9-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	SAMPLE TYPE	GENERALISED LITHOLOGY	MAXIMUM PALAEOTEMPERATURE °F	VITRINITE REFLECTIVITY %	SPORE COLOURATION (1-10)	LIGHT HYDROCARBONS
4. 550	Ctgs	CLYST	-	0.24(11)	1.25	
10. 730	"	"	-	0.21(6)	1.5	Immature
16. 910	"	"	-	*	1.5	
25. 1180	"	"	-	0.24(2)	1.5 - 2	
28. 1270	"	"	-	0.20(18)	1.5 - 2	
31. 1360	"	SH/MDST	-	*	2	
34. 1450	"	"	-	0.30(2)	2	Transitional
37. 1540	"	"	-	0.28(3)	2	to early
40. 1630	"	"	-	0.21(24)	2.5	maturity
43. 1720	"	"	-	0.27(22)	2.5 - 3	or
49. 1900	"	"	-	0.33(27)	3	contaminatio
52. 1990	"	"	-	0.28(20)	3 - 3.5	
55. 2080	"	"	-	0.34(53)	3	
58. 2170	"	"	-	0.37(25)	3 - 3.5	
61. 2260	"	"	-	0.35(48)	3 - 3.5	
64. 2350	"	"	-	0.40(24)	3 - 3.5	
67. 2440	"	"	-	0.34(37)	3	
70. 2532	"	"	-	0.39(23)	4	
73. 2622	"	"	-	0.39(32)	3.5	
76. 2712	"	"	-	0.45(2)	3.5	
79. 2802	"	"	-	0.33(2)	3.5	Early
82. 2892	"	"	-	0.35(23)	3.5	Mature
85. 2982	"	"	-	0.38(9)	3.5 - 4	
92. 3330	"	SH + CHK	-	0.52(9)	-	
97. 3480	"	"	-	0.47(10)	3.5 - 4	
99. 3540	"	"	-	0.55(6)	-	
103. 3660	"	"	-	0.54(13)	3.5 - 4	

TABLE 4

ORGANIC CARBON DATA

COMPANY: STATOIL WELL: 1/9-1 LOCATION: NORTH SEA

TOC

SAMPLE DEPTH (METRES)	ORGANIC CARBON %	SAMPLE DEPTH (METRES)	ORGANIC CARBON %	SAMPLE DEPTH (METRES)	ORGANIC CARBON %
1. 460	-	41. 1660	3.30	81. 2862	0.94
2. 490	0.93	42. 1690	4.20	82. 2892	2.16-
3. 520	1.10-	43. 1720	4.30	83. 2922	2.17
4. 550	0.50	44. 1750	4.40-	84. 2952	2.33-
5. 580	0.45	45. 1780	2.31-	85. 2982	4.27
6. 610	0.47	46. 1810	2.00-	86. 3012	1.69-
7. 640	0.59-	47. 1840	2.32	87. 3042	1.21
8. 670	0.46	48. 1870	2.76	88. 3188.15	1.90-
9. 700	0.42	49. 1900	2.42-	89. 3240	0.15
10. 730	0.34	50. 1930	2.68	90. 3270	0.18
11. 760	0.46	51. 1960	2.92	91. 3300	1.32-
12. 790	0.44	52. 1990	2.90-	92. 3330	2.84-
13. 820	0.50-	53. 2020	2.51	93. 3360	1.85
14. 850	0.46	54. 2050	1.14	94. 3390	0.83
15. 880	0.47	55. 2080	1.88-	95. 3420	0.71
16. 910	0.41	56. 2110	+	96. 3450	0.95
17. 940	0.50	57. 2140	+	97. 3480	-
18. 970	0.51	58. 2170	3.40-	98. 3510	0.16
19. 1000	0.54-	59. 2200	1.04	99. 3540	-
20. 1030	0.50	60. 2230	4.14-	100. 3570	0.19-
21. 1060	0.81	61. 2260	+	101. 3600	0.17
22. 1090	0.87	62. 2290	1.26	102. 3630	0.15
23. 1120	1.21	63. 2320	1.82	103. 3660	1.72-
24. 1150	1.41	64. 2350	+	104. 3690	-
25. 1180	1.66-	65. 2380	+		
26. 1210	1.91	66. 2410	1.05-	94A. 3390	1.03
27. 1240	1.04	67. 2440	2.21	97A. 3480	1.20
28. 1270	1.10-	68. 2470	2.22-	99A. 3540	1.09
29. 1300	2.12	69. 2502	2.54	103A. 3660	3.20
30. 1330	2.46	70. 2532	2.23-	103B. 3660	0.54
31. 1360	1.22-	71. 2562	2.17	104A. 3690	0.97
32. 1390	1.80	72. 2592	1.58-		
33. 1420	1.75	73. 2622	2.68		
34. 1450	1.57-	74. 2652	1.88-		
35. 1480	1.86	75. 2682	3.19		
36. 1510	0.80	76. 2712	1.40-		
37. 1540	1.58-	77. 2742	1.89		
38. 1570	1.55	78. 2772	2.80-		
39. 1600	3.30	79. 2802	1.63		
40. 1630	6.60-	80. 2832	1.63-		

Unreliable Results +

Sample submitted for Source Rock Analysis (may have different values in Table 5) -

TABLE 5A

SOURCE ROCK EVALUATION DATA

COMPANY: STATOIL WELL: 1/9-1 LOCATION: NORWEGIAN NORTH SEA

(-SAT) = ARO EOM HC SAT

SAMPLE DEPTH METRES OR NOTATION		SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS PPM OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
3.	520	Ctgs	CLYST, med to dk ol-gy +mnr SND&SHELL	0.77	1150	14.9	146	13	55
7.	640	"	"	0.44	435	9.9	33	8	63
13.	820	"	"	0.61	410	6.7	12	3	100
19.	1000	"	"	0.64	755	11.8	136	18	55
25.	1180	"	"	1.66	1180	7.1	474	40	57
28.	1270	"	"	1.10	3190	29.0	1403	44	55
31.	1360	"	MDST/SH, med gy	1.22	1480	12.1	563	38	55
34.	1450	"	"	1.57	1035	6.6	438	42	60
37.	1540	"	MDST/SH, med to lt gy	1.58	2570	16.3	974	38	49
40.	1630	"	"	6.66	3170	4.8	1291	41	47
44.	1750	"	"	4.40	2425	5.5	968	40	47
45.	1780	"	MDST/SH, gy-brn/gy-gn	2.30	4750	20.6	1362	29	52
46.	1810	"	"	3.60	5370	14.9	1803	34	46
49.	1900	"	"	3.83	4690	12.2	1217	26	53
52.	1990	"	"	3.64	5645	15.5	1451	26	56
55.	2080	"	"	3.07	4045	13.2	763	19	54
58.	2170	"	"	5.70	6090	10.7	934	15	52
60.	2230	"	"	4.14	4660	11.3	1085	23	60
63.	2320	"	"	1.82	2425	13.3	546	22	60
66.	2410	"	"	1.05	5435	51.8	2212	41	71
68.	2470	"	SH/MDST, lt to med gy/ gy-brn, sl calc	2.22	2880	13.0	625	22	66
70.	2532	"	"	2.23	3170	14.2	1291	41	47
72.	2592	"	"	1.58	2425	15.3	968	40	47
74.	2652	"	"	1.88	4360	23.2	1669	38	74
76.	2712	"	"	1.40	1690	12.1	715	42	57
78.	2772	"	"	2.80	2355	8.4	940	40	32
80.	2832	"	"	1.63	775	4.8	190	25	54
82.	2892	"	"	2.16	8295	38.4	4086	49	74
84.	2952	"	"	2.33	2585	11.1	984	38	66
86.	3012	"	"	1.69	2275	13.5	526	23	63
88.	3188.15	Core	SH, gy-blk	1.90	675	3.6	36	5	100
91.	3300	Ctgs	CHK, gy-wht-brn	1.32	12060	91.4	5486	45	62
92.	3330	"	SH, gy-gn+mnr CHK	2.84	2760	9.7	772	28	81
100.	3570	"	CHK, gy/gy-wht	0.19	2055	108.2	175	9	64

TABLE 5B

SOURCE ROCK EVALUATION DATA

COMPANY: STATOIL   WELL: 1/9-1   LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES) OR NOTATION	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TOTAL EXTRACT PPM	EXTRACT % OF ORGANIC CARBON	HYDRO-CARBONS P.P.M. OF ROCK	HYDRO-CARBONS % OF EXTRACT	TOTAL ALKANES % HYDRO-CARBONS
103. 3660	Ctgs	SH, gy-blk+mnr CHK +SH, gy-gn calc	1.72	1545	9.0	520	34	70
94A. 3390	Hand	SH, gy-gn	1.03	-	-	-	-	-
97A. 3480	Picked	"	1.20	-	-	-	-	-
99A. 3540	Samples	"	1.09	-	-	-	-	-
103A.3660	"	SH, gy-blk	3.20	-	-	-	-	-
103B.3660	"	SH, gy-gn	0.54	-	-	-	-	-
104A.3690	"	SH, gy	0.97	-	-	-	-	-

FIGURE 1

HEADSPACE GAS ($C_1 - C_4$) HYDROCARBONS

COMPANY : STATOIL   WELL : 1/9-1   LOCATION · NORWEGIAN N. SEA

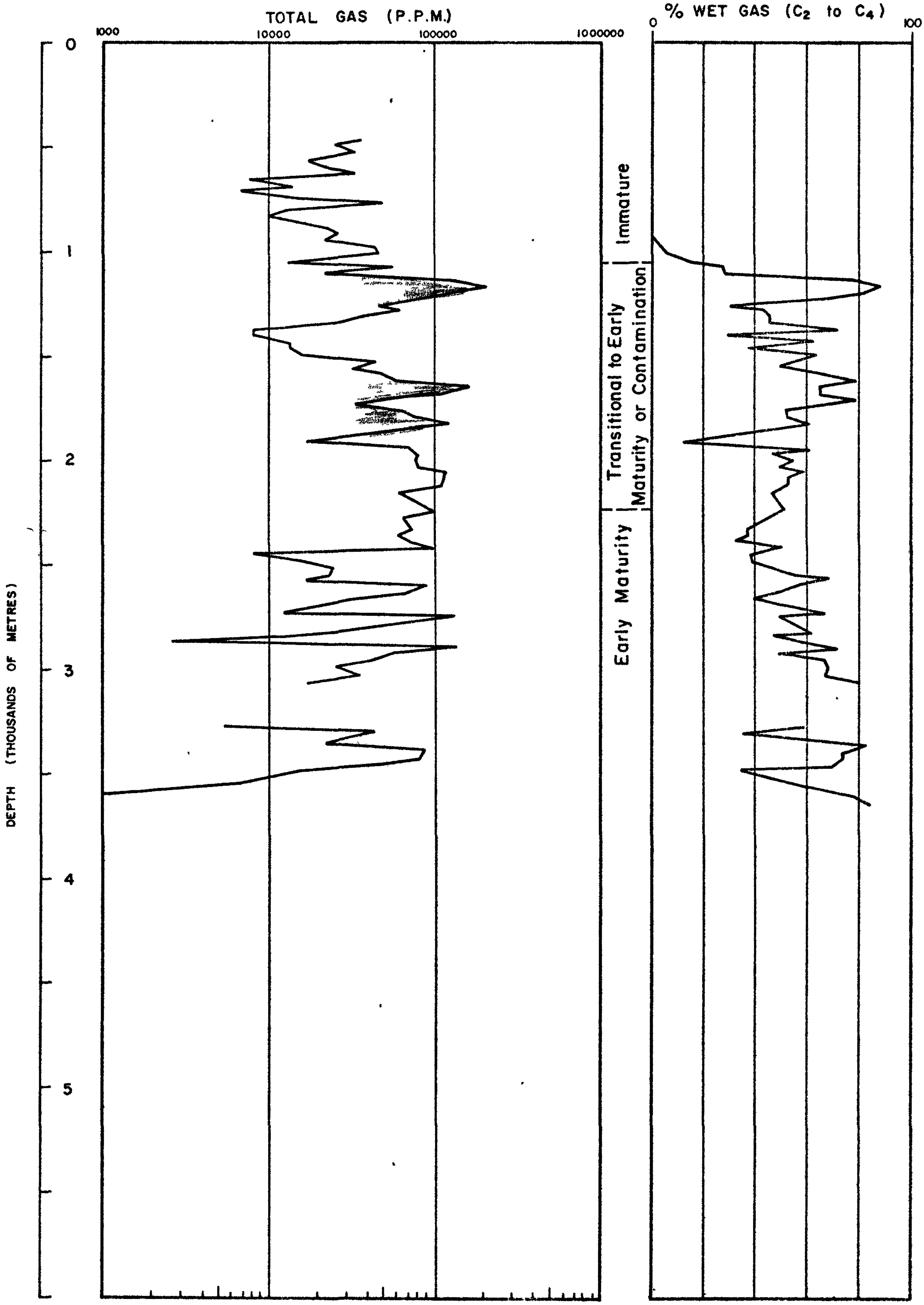


FIGURE 2

GASEOUS ($C_1 - C_4$) HYDROCARBONS

COMPANY : STATOIL   WELL : 1/9-1   LOCATION : NORWEGIAN N.SEA

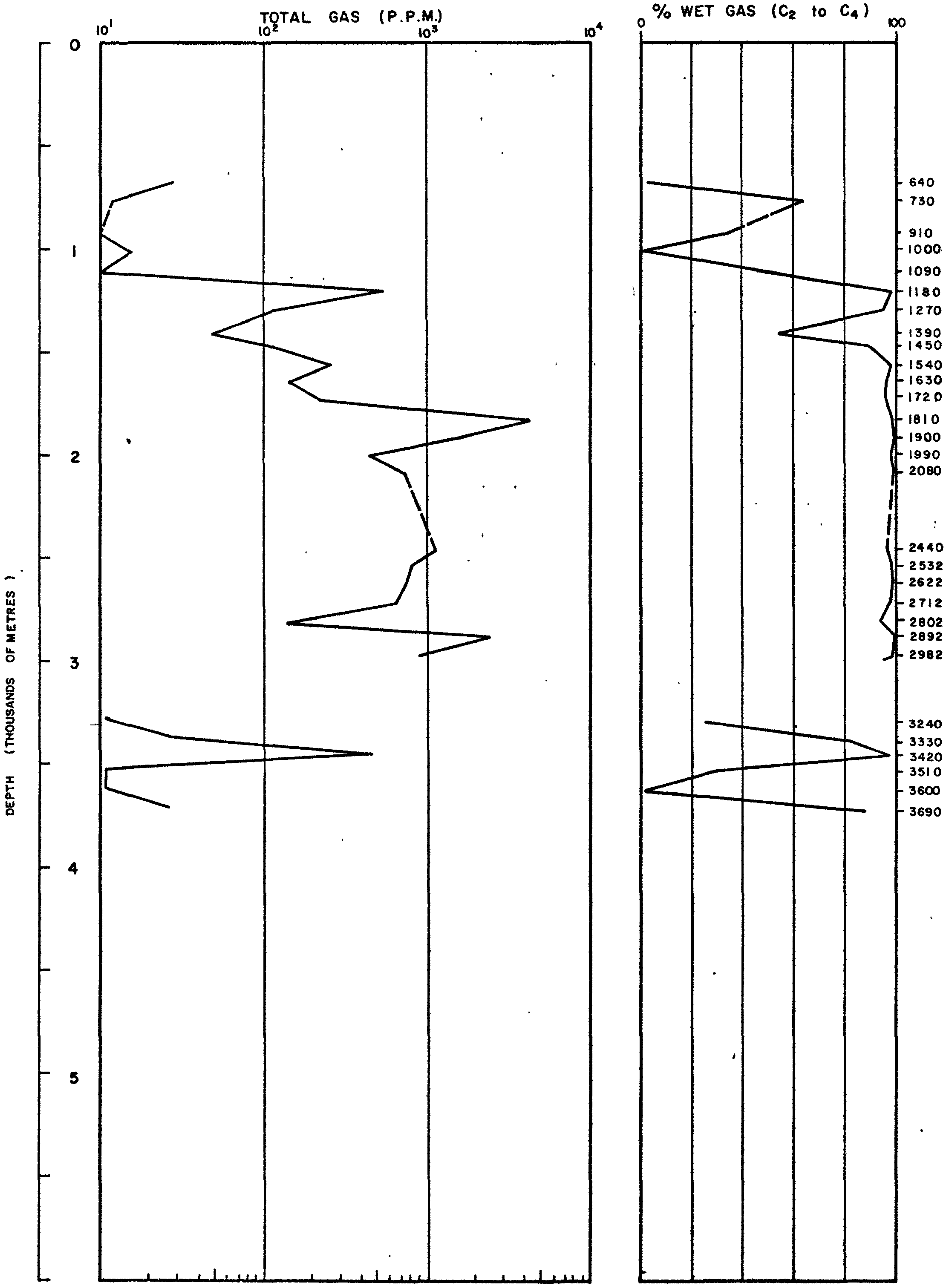
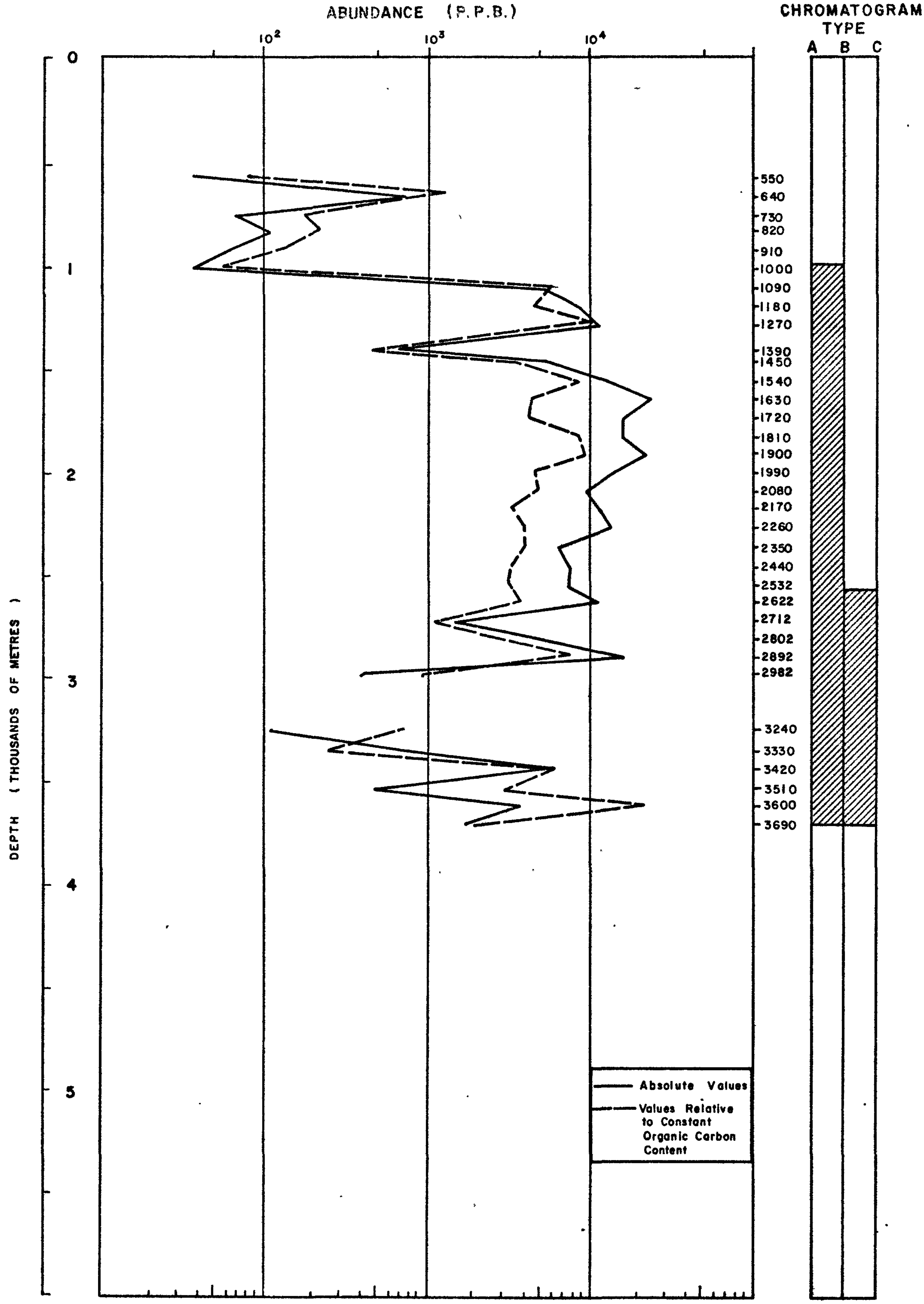


FIGURE 3

GASOLINE RANGE ($C_5 - C_7$) HYDROCARBONS

COMPANY: STATOIL   WELL: 1/9-1   LOCATION: NORWEGIAN N. SEA



A, IMMATURE ; B, TRANSITIONAL; C, OIL-LIKE

FIGURE 4

MATURATION INDICES AGAINST DEPTH

COMPANY : STATOIL WELL : 1/9-1 LOCATION : NORWEGIAN N. SEA

SPORE COLOURATION

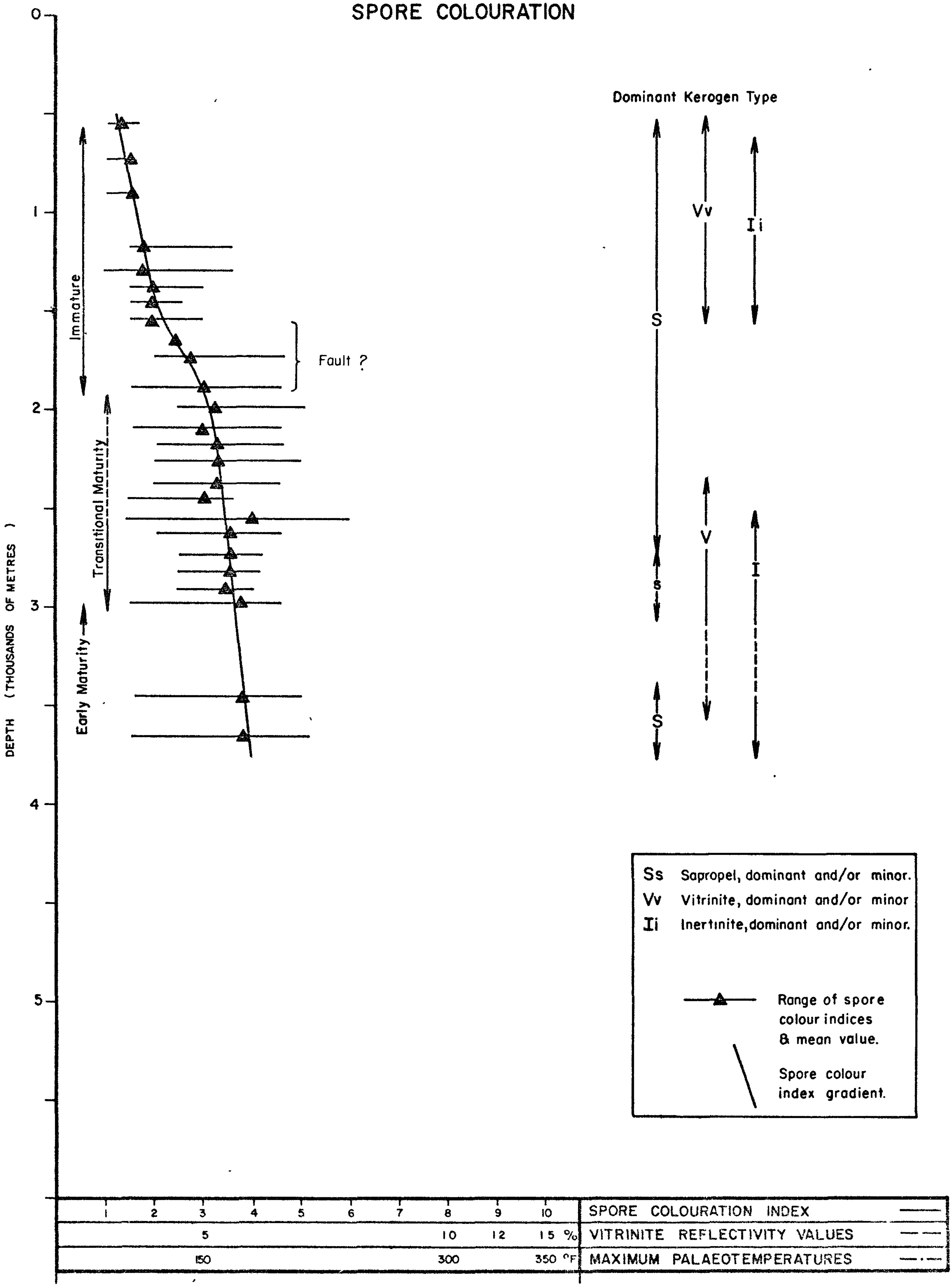


FIGURE 5

MATURATION INDICES AGAINST DEPTH

COMPANY : STATOIL WELL : 1/9-1 LOCATION : NORWEGIAN N.SEA

VITRINITE REFLECTIVITY

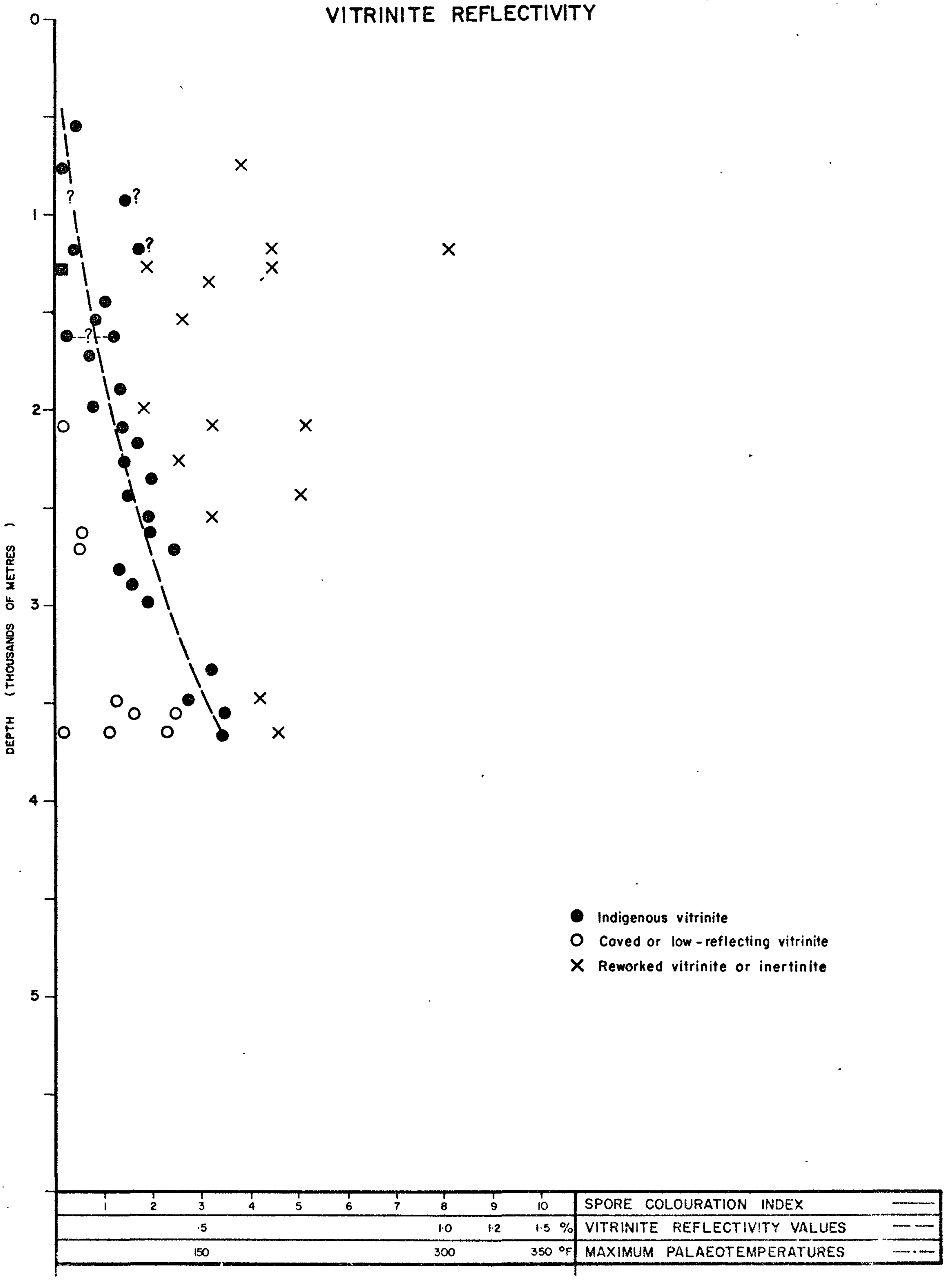


FIGURE 6

MATURATION INDICES AGAINST DEPTH

COMPANY: STATOIL | WELL: 1/9-1 | LOCATION: NORWEGIAN N. SEA

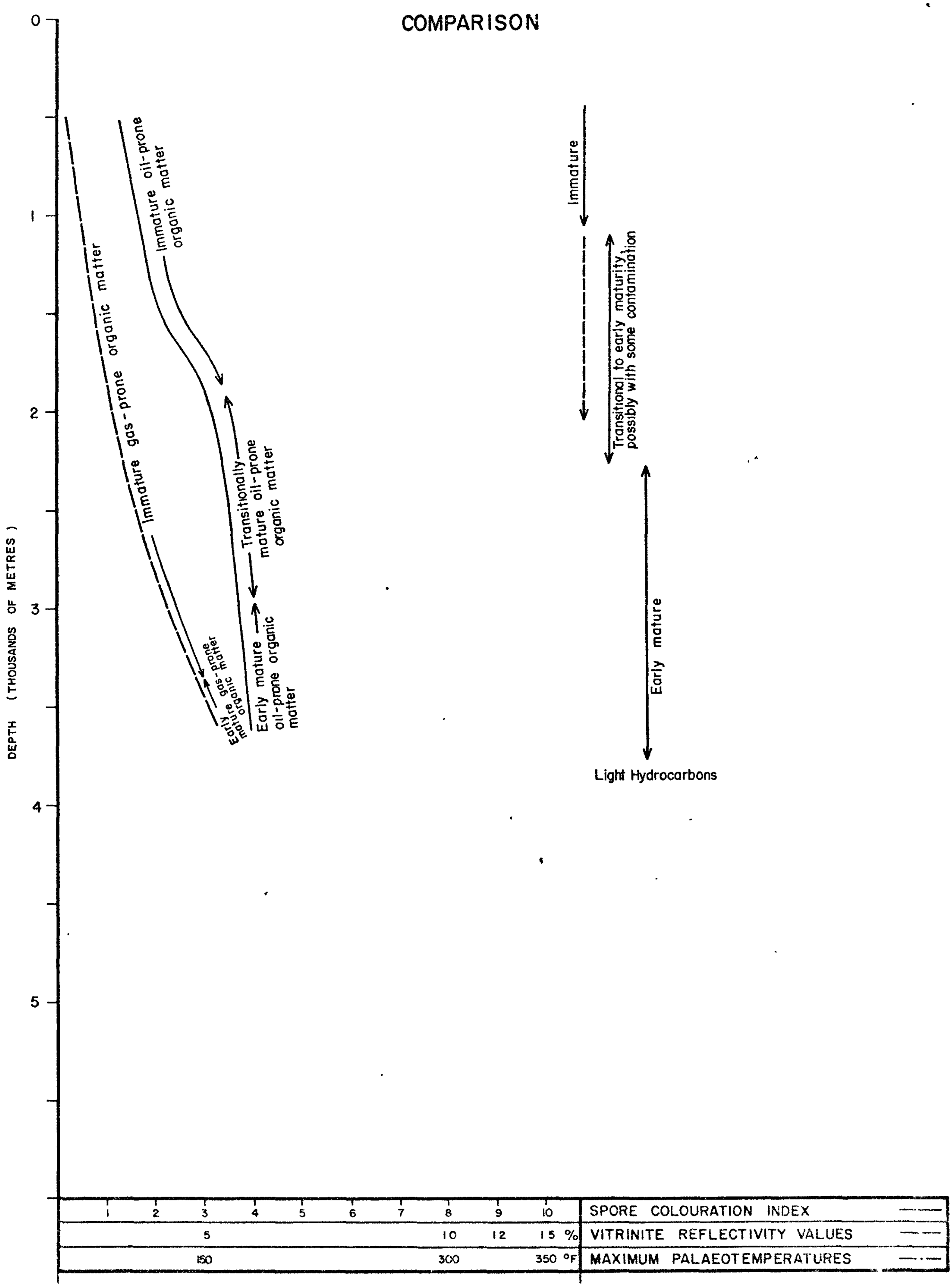


FIGURE 7

TYPE OF HYDROCARBON PRODUCT FROM SOURCE ROCKS

COMPANY : STATOIL WELL : 1/9-1 LOCATION : NORWEGIAN N. SEA

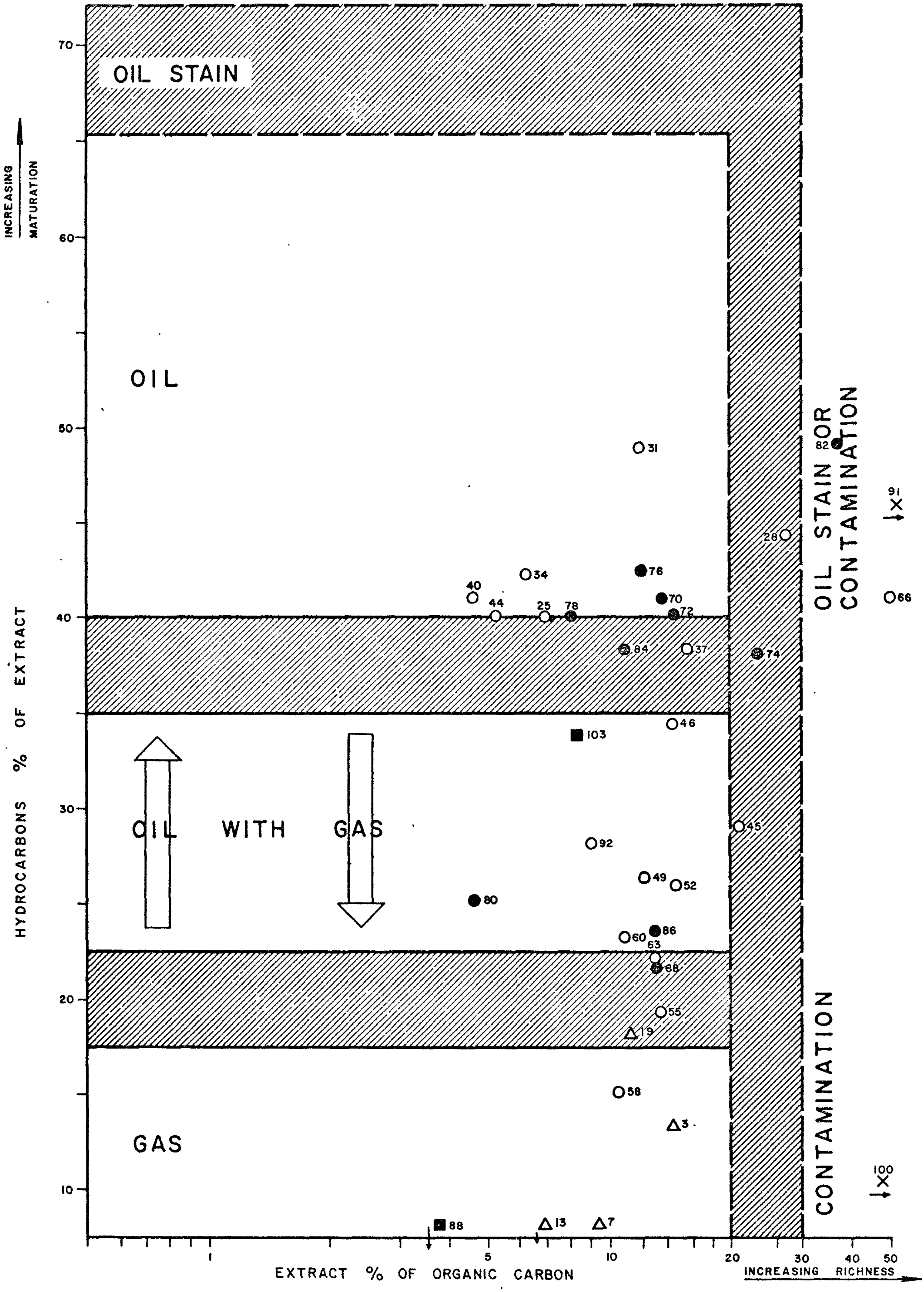
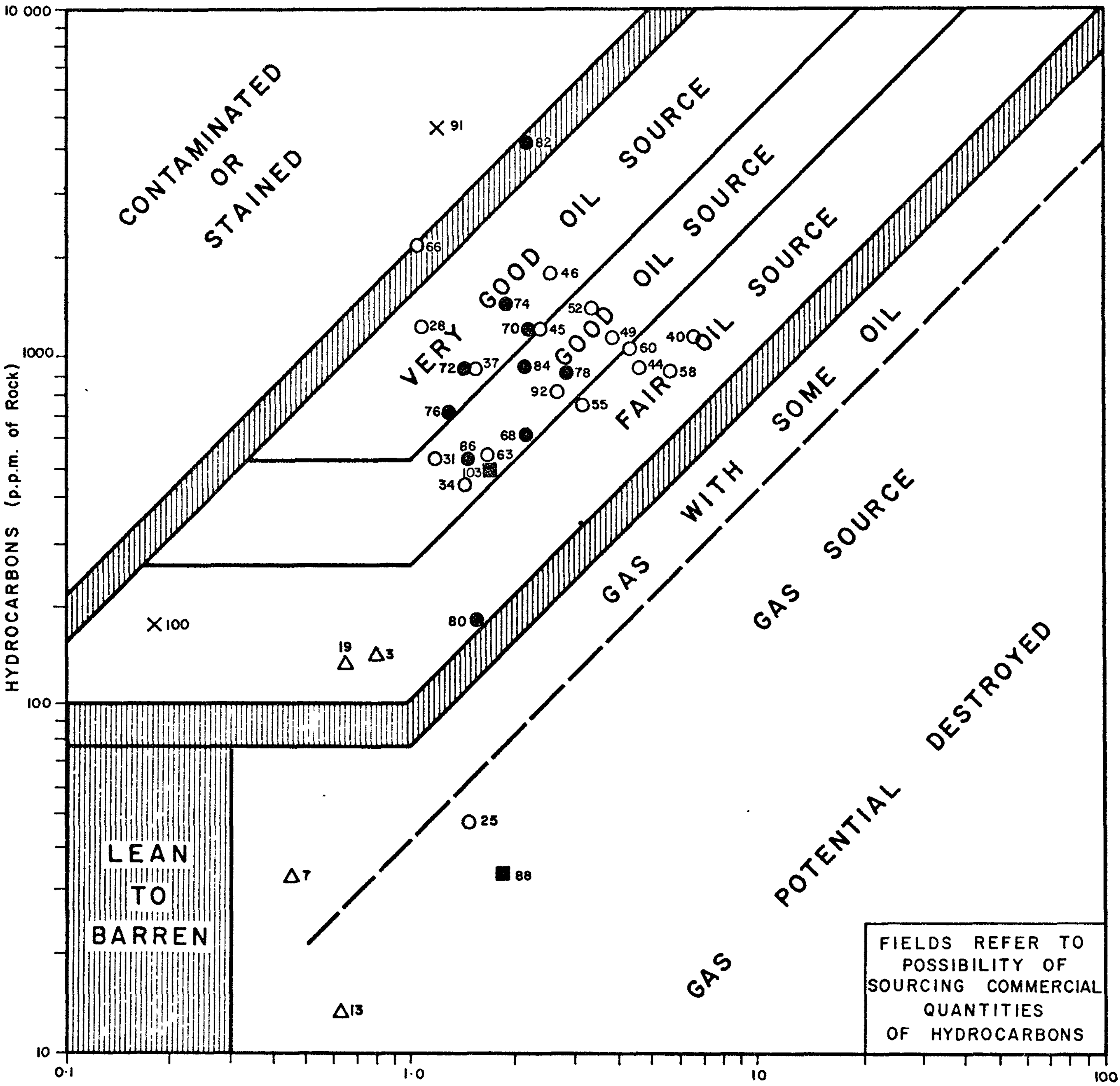


FIGURE 8

MATURE SOURCE ROCK RICHNESS

COMPANY : STATOIL WELL : 1/9-1 LOCATION : NORWEGIAN N. SEA



LEGEND

△ CLYST, med to dk ol-gy

○ SH/MDST, med to lt gy, gy-gn and gy-brn

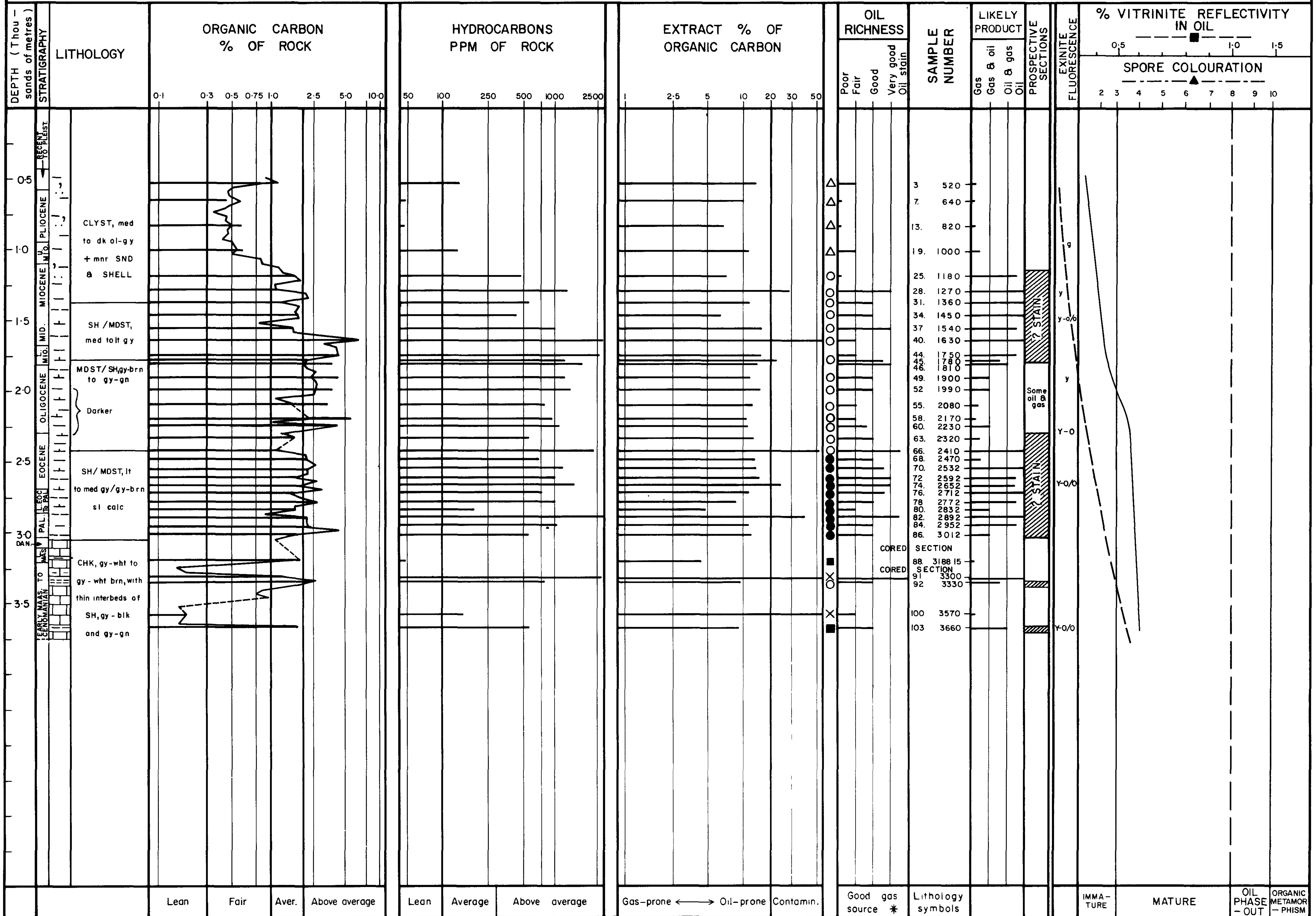
● SH/MDST, lt to med gy/gy-brn, sl calc.

■ SH, blk to dk gy

✕ CHK

SOURCE ROCK SUMMARY CHART

COMPANY : STATOIL WELL : 1/9-1 LOCATION : NORWEGIAN NORTH SEA



Drawing No. 049P/2441/3703

FIGURE 9

APPENDIX I

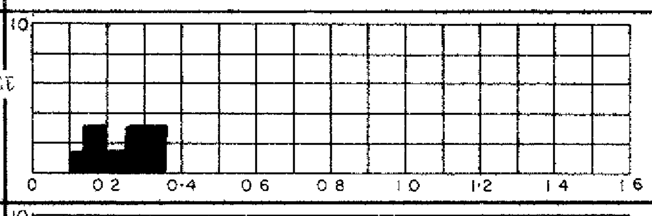
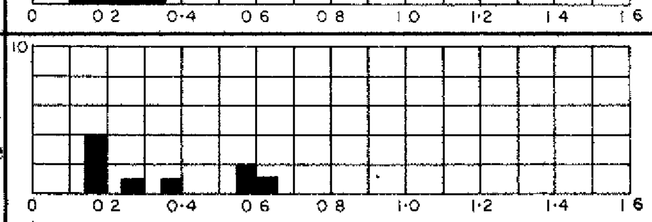
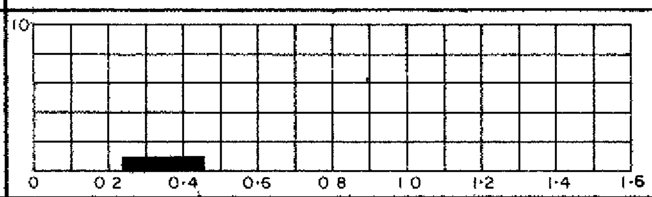
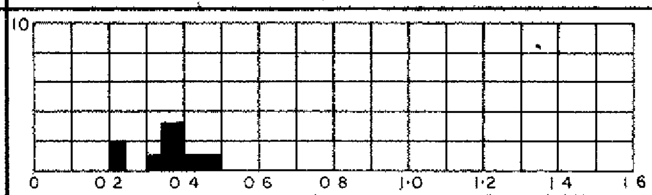
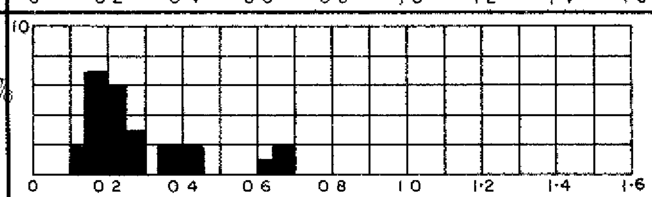
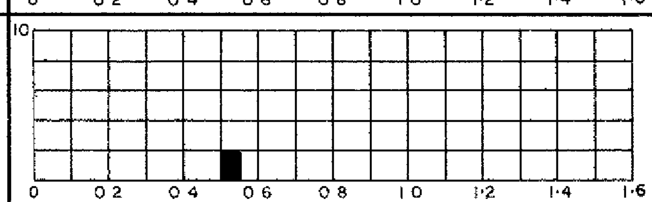
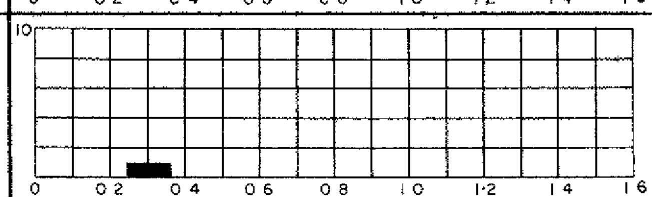
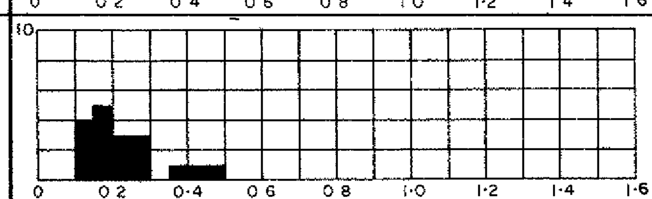
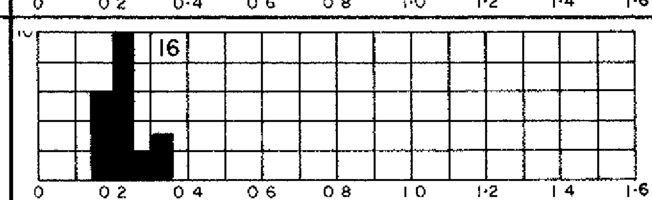
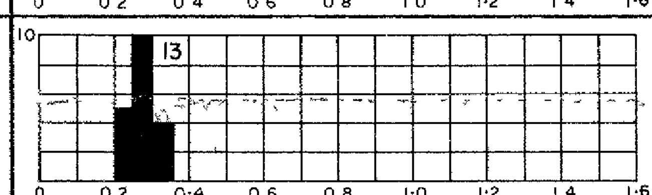
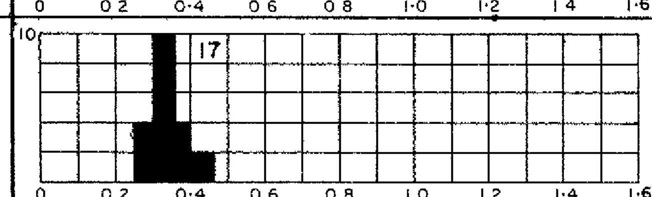
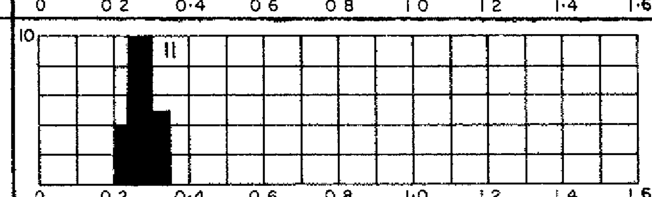
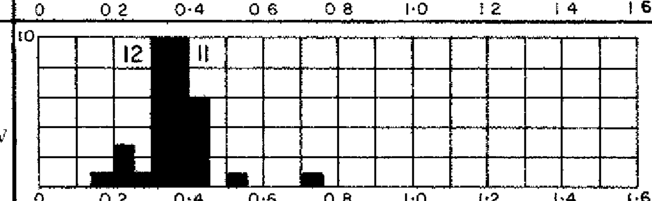
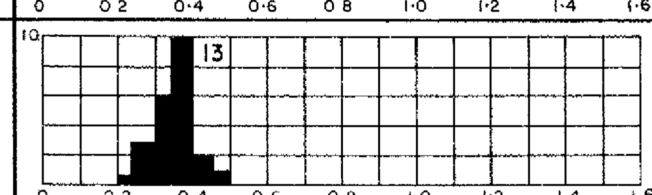
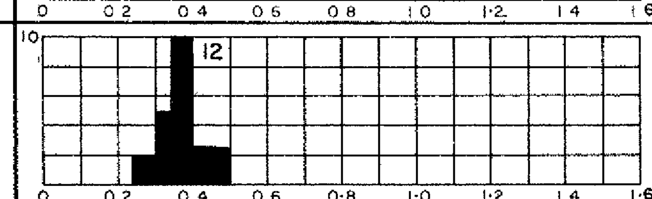
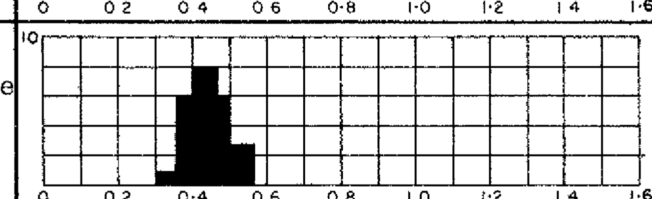
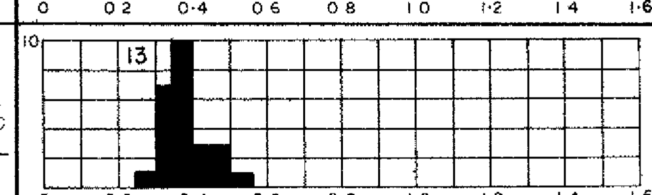
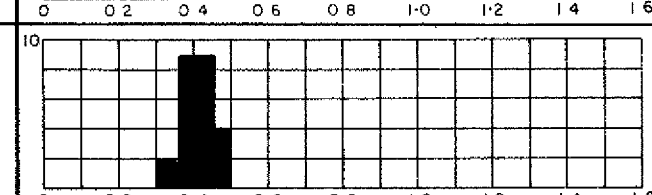
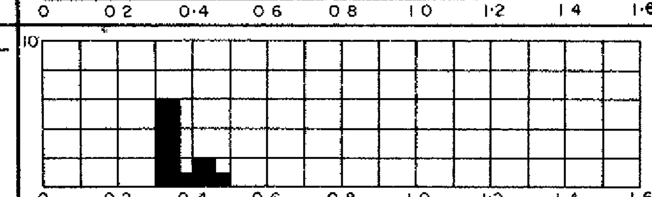
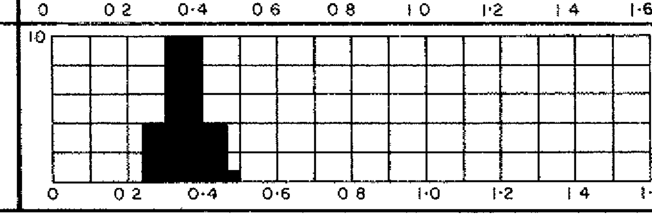
ABBREVIATIONS USED IN ANALYTICAL DATA SHEETS

Alg	-	Algae	Mtl	-	Mottled
Aren	-	Arenaceous	Musc	-	Muscovite
Arg	-	Argillaceous	NS	-	No sample
Bit	-	Bitumen/bituminous	Occ	-	Occasional
Bl	-	Blue	Ol	-	Olive
Blk	-	Black	Ool	-	Oolite/oolitic
Brn	-	Brown	Orng	-	Orange
Calc	-	Calcareous	Pnk	-	Pink
Carb	-	Carbonaceous	Pop	-	Population
Chk	-	Chalk	Pp	-	Purple
Cht	-	Chert	Pyr	-	Pyrite/pyritic
Cgl	-	Conglomerate	Qtz	-	Quartz
Cly	-	Clay	Ref	-	Reflectivity
CMT	-	Cement	Sap	-	Sapropel
Crs	-	Coarse	Sft	-	Soft
Ctgs	-	Ditch cuttings	Sh	-	Shale
Dk	-	Dark	Shly	-	Shaly
Dol	-	Dolomite	Sil	-	Siliceous
F	-	Fine	Slt	-	Silt
Fer	-	Ferruginous	Sltst	-	Siltstone
Flu	-	Fluorescence	Slty	-	Silty
Fm	-	Formation	Snd	-	Sand
Foram	-	Foraminifera	Sndy	-	Sandy
Fr	-	Friable	Sst	-	Sandstone
Frags	-	Fragments	SWC	-	Sidewall core
Glc	-	Glauconite	Tr	-	Trace
Gn	-	Green	V	-	Very
Gy	-	Grey	Vgt	-	Variegated
Gyp	-	Gypsum	Vit	-	Vitrinite
Hd	-	Hard	Wht	-	White
Inert	-	Inertinite	Yel	-	Yellow
Lam	-	Laminae/laminated	-	-	Sample not analysed
LCM	-	Lost circulation material	*	-	No results obtained
Lig	-	Lignite/lignitic	Gy-gn	-	Greyish green
Lst	-	Limestone	Gn/gy	-	Green to/and grey
Lt	-	Light	Gn-gy	-	Greenish grey
Mdst	-	Mudstone			
Med	-	Medium			
Mic	-	Micaceous			
Mnl	-	Mineral			
Mnr	-	Minor			

VITRINITE REFLECTIVITY DATA SUMMARY CHART I No. 30

COMPANY : STATOIL WELL [illegible]-1 LOCATION : NORWEGIAN NORTH SEA

WELLFILE

DEPTH METRES	LITHOLOGY & MINERALOGY	TYPE OF ORGANIC MATTER	HISTOGRAM SHOWING REFLECTIVITY VALUES/NO. OF MEASUREMENTS	R (av) (%)	NO OF PARTICLES	FLUORESCENCE
5[illegible]	Kerogen concentrate Abundant mineral matter	Rare poor quality vitrinite. Some reworked vitrinite at 1.1%. Most apparent indigenous material at around 0.25-0.30%		0.18 0.29 (0.24	5 6 11)	None Occ yel unidentified fragments (composite)
730	Kerogen concentrate	Poor sample. Occasional inertinite, with some reworked vitrinite at 0.55% - 0.60% General large fragments of vitrinite, some containing fluorescent spores		0.17 0.28 0.35 (0.21 0.58	4 1 1 1) 3	Occ yel unidentified fragments. (composite)
910	Kerogen concentrate Occ pyrite	Sparse. Rare organic matter. some vitrinite and inertinite		0.30 0.39	2 2	Occ yel yel-gr spores and algae.
1180	Kerogen concentrate Mostly pyrite and mineral matter	Rare inertinite, with some vitrinite at around 0.35%; some reworked vitrinite at 0.6% and 1.01%		0.24 0.38 0.64 1.01	2 6 1 1	Occ yel golden yel spores and algae
1270	Kerogen concentrate	Abundant but rather poor quality. Some low reflecting vitrinite at 0.1 - 0.2% indigenous values around 0.25%		0.20 0.39 0.65	18 4 3	Very pale yel algae, resin and spores, relatively abundant.
1360	Kerogen concentrate	Lean. Rare fusinite and reworked vitrinite at 0.5%. No definite indigenous vitrinite		0.51	2	Moderate to abundant fluorescent particles of uncertain nature. Some yel-or spores.
1450	Kerogen concentrate Mainly mineral matter	Rare organics. Occasional particles of vitrinite and inertinite		0.30	2	Yel-or to or spores and algae Moderate to abundant.
1540	Kerogen concentrate Abundant mineral matter and pyrite	Abundant inertinite and some vitrinite; latter at 0.25 - 0.30%. low reflecting at 0.15 - 0.20%. reworked coal at 0.47% resinite? at 0.13%		0.18 0.28 0.47	12 3 1	Moderate to abundant yel-or to or fragments. Some particles may be resinite.
1630	Kerogen concentrate Orange mineral matrix.	Occasional inertinite. Abundant vitrinite, mainly telinite, with some collinite, at 0.20-0.25%. Some brighter collinite at 0.3%		0.21? 0.31?	24 3	Fair to moderate content of dull yel-or to or fragments, spores and algae. Possible contamination present as spherical lemon yel blocks.
1720	Kerogen concentrate Occasional pyrite and mineral matter.	Rich in poor quality particles. Mainly humic, as collinite. Reflectivity not less than 0.3%		0.27 (min)	22	Rare. Yel-or fragments.
1900	Kerogen concentrate Low pyrite and mineral matter	Abundant, mostly humic; finely divided and dispersed collinite. Difficult to locate good particles for measurement. Reflectivity approx 0.30-0.35%, but probably slightly higher.		0.33	27	Fair abundance of dull yel-or fragments.
1990	Kerogen concentrate.	Mainly humic debris. Occasional small particles of collinite in dull grey matrix. Reflectivity approx 0.3%. Occasional semifusinite at 0.4%		0.28 0.38	20 2	Fair to moderate content of dull yel-or spores.
[illegible]30	Grey shales.	Abundant humic material, particularly vitrinite (collinite & telinite) at 0.35%. Some semifusinite at 0.5%. Occasional low reflecting vitrinite at 0.15%. Vitrinite slightly corroded.		0.21 0.34 0.53 0.71	5 29 1 1	Dull yel mineral fluorescence Faded yel, yel-or spores. moderately abundant.
2080	Kerogen concentrate Some pyrite	Abundant, fine grained, mainly collinite at 0.35%. Occasional spores and inertinite		0.35 (0.34	24 53)	Fair abundance of yel-or spores and algae. (composite)
2170	Kerogen concentrate Abundant mineral matrix	Abundant fine grained in mineral matrix Mainly collinite, finely disseminated, at approx. 0.35-0.40%. Some spores and inertinite.		0.37	25	Fair abundance of dull yel-or spores and fragments.
2260	Grey shale White barren shale with pyrite White limestone.	Plentiful organic matter as vitrinite and semifusinite; rounded particles of collinite and dispersed fragments of tellinite		0.34	24	Deep yel, yel-or spores, moderately abundant. Some difuse yel mineral fluorescence
2260	Kerogen concentrate	Abundant organic matter as coagulated masses with some mineral inclusions. A few good vitrinite particles at 0.35-0.40% Some larger fusinitised particles at 0.4% - 0.45%		0.35 0.45 (0.35	24 3 48)	Low abundance of dull yel-or fragments. (composite)
2350	Kerogen concentrate Rare mineral matter	Abundant vitrinite as small particles in matrix of vitrinite like material and pyrite. Occasional inertinite.		0.40	24	Low abundance of dull dull yell-or fragments.
2440	Yellow orange-silty shale White slightly calcareous shale Orange calcareous shale	Occasional collinite and inertinite at 0.35-0.40% Barren and pyritic Barren except for occasional traces of fusinite.		0.35 (0.32 (0.41	9 6) 3)	Rare golden yell, or spores Some yel-brn mineral fluorescence
2440	Kerogen concentrate, low mineral content	Abundant organic matter, but much as lacey, low-reflecting material. Rare vitrinite at 0.35%. Some inertinite at 0.60%		0.34 0.34	28 37)	Occ yel-or spores and fragments (composite)

REF: RRI 767 HD 2441 DRAWING NO. 543P, 2441 [illegible] DATE: FEBRUARY, 1977

VITRINITE REFLECTIVITY DATA SUMMARY CHART II No 30

WELL FILE

COMPANY: STATOIL | WELL 1 ?-1 | LOCATION: NORWEGIAN NORTH SEA

DEPTH (Metres)	LITHOLOGY & MINERALOGY	TYPE OF ORGANIC MATTER	HISTOGRAM SHOWING REFLECTIVITY VALUES/NO. OF MEASUREMENTS	R (av) (%)	NO OF PARTIC-LES	FLUORESCENCE
2532	Kerogen concentrate	Abundant organic matter and indigenous collinite. Also some low reflecting material (? sapropel)		0.39 0.52	23 2	Fair abundance of dull yel-or fragments.
2622	Mainly white calc shale with pyrite. Rare orange-brown calc shale	Occasional inertinite Some low reflecting vitrinite;occasional telinite at 0.25-0.35% or 0.35-0.4%		0.26 0.36	2 2	Occasional yel spores. Yel-or fluorescent mineral background.
[illegible]	Kerogen concentrate, much pyrite and mineral matrix.	Abundant lacey ? sapropel. Fair proportion of humic material, rare inertinite and some small particles vitrinite at 0.4%		0.38 (0.39)	30 32)	Fair to moderate abundance of yel-or or spores and algae (composite.)
2719	Kerogen concentrate, rich in mineral matrix.	Occasional inertinite. Abundant vitrinite (telinite), often as large fragments with spore inclusions; low reflecting vitrinite at 0.25%. Best at 0.44%		0.25 0.45	21 2	Fair abundance of yel-or spores and fragments.
2802	Grey white shale, pyritic Orange shale Grey brown siltstone	Occasional inertinite Barren Some vitrinite at around 0.33%		0.33	2	Abundant mineral fluorescence. Some yel-or fragments.
2892	Kerogen concentrate.	Abundant low reflecting vitrinite. frequently dispersed in mineral matrix. Some inertinite. Rare vitrinite at 0.35 - 0.4%		0.27 0.35 0.45 (0.35	4 15 4 23)	Fair abundance of or resin and spore fragments. composite
2982	Light grey limestone Grey-brown pyritic shale	Barren Barren		-	-	Abundant yel spores in shale
2982	Kerogen concentrate	Abundant anomalous low reflecting large particles of collinitic appearance Ro 0.2%. Relatively rare vitrinite and inertinite observed. Vitrinite has Ro of.33% - 63%. Inertinite Ro. 0.7%		0.34 0.47 (0.38	6 3 4)	Golden yel, yel-or spores and fragments (composite)
3330	Barren white pyritic shale White slightly calc siltstone	Some inertinite Some inertinite and vitrinite at 0.45 - 0.50%. Coal contaminant at 0.25 - 0.30%		0.52	9	Yel yel-or spores Some mineral fluorescence
3480	White shale, pyritic White siltstone, occasional pyrite	Occasional inertinite Vitrinite and inertinite; ~~material at 0.45-~~ 0.50%. Semifusinite at around 0.6% Occasional variegated shale		0.32 0.47 0.61	2 10 4	Yel/yel-or spores in some ctgs. Most ctgs barren
2540	Grey-white shale and siltstone	Inertinite Good vitrinite at 0.55%		0.37 0.45 0.55	2 4 6	Yel, yel-or spores and ? cuticle
3560	Chalk Grey-brown shale, pyritic	Barren, occasional brown stain Occasional inertinite and organic stringers (telinite at 0.45%) with high degree fluorescence.		-	-	Yel-or or spores and algae
3660	Kerogen concentrate abundant mineral matter	Abundant inertinite. Some semifusinite at 0.65%. Possible vitrinite at 0.55-0.60%. Low reflecting vitrinite at 0.2 - 0.3%		0.20 0.31 0.43 0.54 0.66	2 5 4 13 3	Rare dull or, yel-or

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