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REPORT TITLE

Soure Rock evaluation of Well 24/12-1.

Section I

CONTRACTOR

Statoil

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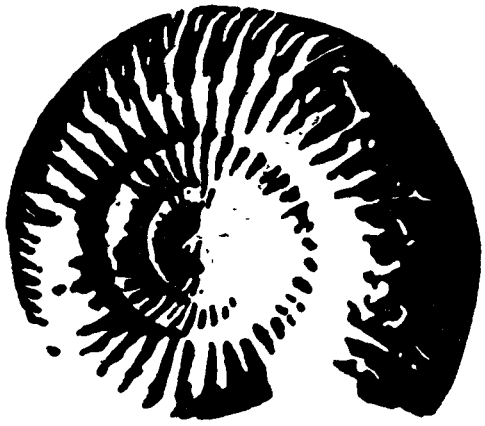

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REPORT TITLE

Soure Rock evaluation of Well 24/12-1.

Section I

CONTRACTOR

Statoil

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SUMMARY

See next page.

KEY WORDS

Source Rock

SUMMARY:

The analysed sequence, 2830 - 3970 m can be divided into nine zones by using the light hydrocarbon datas. A: 2830 - 2860 m, B: 2860 - 2890 m, C: 2890 - 3070 m, D: 3070 - 3250 m, E: 3250 - 3400 m, F: 3400 - 3490 m, G: 3490 - 3580 m, H: 3580 - 3760 m, I: 3760 - 3970 m.
Zone A is a poor, immature source rock. Zone B contain accumulated hydrocarbons. Zone Z is a moderate mature source rock with a fair potential for oil. Zone D and E are fairly similar, they are both moderate mature with a fair/good potential for oil and oil and gas respectively. Zone F is moderate mature with a good potential as a source rock for oil and gas. Zone G can be given the same rating as Zone F while Zone H is found to be moderate mature at the top and mature towards the lower end and has a fair/good potential as a source rock for oil and gas. Zone I is mature at the top while the lower end is at the beginning of the oil window. The rating is divided in three parts. The top part has a good potential as a source rock for oil, the middle part has a fair/good potential as a source rock for oil and gas and the lower part has a good potential as a source rock for oil.

CONTENTS

EXPERIMENTAL

The canned samples were washed with temperated water on a 0,125 mm sieve to remove drilling mud and thereafter dried at 35°C.

Light Hydrocarbons

Aliquotes of the samples were dried at room temperature after washing and sieving. The cuttings with a grain size between 1 and 2 mm were used for light hydrocarbon determination. These were treated with 6N HCl in a closed evacuated system, thereafter flushed with water and the released gas analysed gaschromatographic. The results are shown in Table I.

Total Organic Carbon (TOC)

Aliquotes of the samples were treated with hot 6N HCl to remove carbonates, and then analysed on a Leco 12 carbon determinator, to determine the total organic carbon (TOC). Table II.

Extractable Organic Matter (EOM)

From the TOC results, samples were selected and extracted with DCM in soxhlet apparatus for 48 h., and the amount of extractable organic matter was determined. Table III.

Chromatographic Separation

The extracts were separated on columns packed with 2/3 silica and 1/3 alumina, by eluting with hexane, benzene and methanol. Table III. The saturated fractions were analysed gaschromatographic on a 25 mm glass capillary column, using a Carlo Erba FV 2150 chromatograph. The measurements from the gaschromatograms are shown in Table VII.

Vitrinite Reflectance

Five sidewall cores and six cutting samples were sent for vitrinite reflectance measurements at Geoconsultants, Newcastle upon Tyne. Upon receipt, the samples were soaked in warm water and sieved through 72 mesh

to remove drilling mud. After oven drying at 40°C, they were mounted in Bakelite resin blocks; care being taken during the setting in the plastic to avoid temperatures in excess of 100°C. The samples were then ground, initially on a diamont lap followed by two grades of corundum paper. All grinding and subsequent polishing stages in the preparation were carried out using isopopyl alcohol as lubricant since water leads to the swelling and disintegration of the clay fraction of the samples.

Polishing of the samples was performed on Selvyt cloths using three grades of alumina, 5/20, 3/50 and Gamma, followed by careful cleaning of the surface.

Reflectance determinations were carried out on a Leitz M.P.V. microphotometer under oil immersion, R.I. 1,516, at a wavelength of 546 mm. The field measured was varied to suit the size of the organic particle but was usually of the order of 2 micron diameter.

The surface of the polished block was searched by the operator for suitable areas of vitrinitic material in the sediment. The reflectance of the organic particle was determined relative to optical glass standards of known reflectance. Where possible, a minimum of twenty individual particles of vitrinite was measured although in many cases this number could not be achieved. The search for vitrinitic material was maintained for approximately 45 minutes on each sample before termination if the operator considered that no more vitrinitic particles were likely to be located.

Visual Kerogen

Samples for visual kerogen were picked from the screening analyses. The samples were crushed, treated with HCl and HF to remove the rock matrix, centrifuged and mounted on slides.

Maturity of the individual samples was determined by visual estimation of the colours of pollen, spores, cuticles, wood remains, and finely dispersed organic matter.

The colour tones are given according to Burgess's index (Burgess, J.D., 1974. Geol.Soc.Amer.Spec.Paper, 153, 19-30).

RESULTS AND DISCUSSION

Light hydrocarbons

From the C_1 - C_4 hydrocarbon abundance, wetness of the gas and the isobutane / n butane (i C_4/nC_4) ratio, we can divide the analysed section 2830 - 3970 m into nine zones.

A: 2830 - 2860 m
B: 2860 - 2890 m
C: 2890 - 3070 m
D: 3070 - 3250 m
E: 3250 - 3400 m
F: 3400 - 3490 m
G: 3490 - 3580 m
H: 3580 - 3760 m
I: 3760 - 3970 m

A: 2830 - 2860: This zone, which consists of only one sample, shows a fair potential, but the iC_4/nC_4 rates indicates the zone to be immature.

B: 2860 - 2890: Again a zone with only one sample. There are large amounts of light hydrocarbons and a marked drop i the iC_4/nC_4 ratio. This together with an increase in the wetness of the gas is an indication of migrated hydrocarbons.

C: 2890 - 3070: This zone shows a fair/good potential but the gas is dry and the iC_4/nC_4 ratio rather high, an indication of immaturity.

D: 3070 - 3250: This zone shows a marked drop in the abundance of light hydrocarbons compared with zone C. The wetness and iC_4/nC_4 ratio are rather similar to zone C. The zone has a fair potential but is probably immature.

E: 3250 - 3400: This zone is similar to zone D for the light hydocarbon abundance and wetnes, but a marked increase in the iC_4/nC_4 ratio separates it out as an individual zone.

F: 3400 - 3490: This zone shows a marked increase in the light hydrocarbon abundanse and wetness of the gas together with a decrease of the iC_4/C_4 ratio. This indicates a good potential, with a higher maturity than the abovelying zones.

G: 3490 - 3580: This zone has a very high iC_4/nC_4 ratio, together with a low wetness of gas. This indicates immaturity. The potential is fair good.

H: 3580 - 3760: In this zone we mainly find a good/fair potential but with indications of immaturity.

I: 3760 - 3970: The abundance of light hydrocarbons indicates a fair potential. An increase in the wetness of the gas together with a decrease in the iC_4/nC_4 ratio indicates a higher maturity than the zone above.

Total Organic Carbon (TOC)

Total organic carbon (TOC) was measured on all the samples. Where significant amounts of different lithologies were found, TOC was measured on the different lithologies.

A: 2830 - 2860 m: Two different lithologies recorded, limestone and claystone. The limestone has a poor potential while the claystone has some higher TOC values, and shows a fair potential.

B: 2860 - 2990 m: As in zone A, but with some higher TOC values. Light hydrocarbon measurements have indicated this zone to contain migrated hydrocarbons.

C: 2890 - 3070 m: The top of this zone is found to have two lithologies as the zones above, but the amount of limestone decreases towards the bottom of the zone and from 2980 m, mainly marl is found. The TOC values for the marl indicate this zone to have a fair potential.

D: 3070 - 3250 m: The top sample of this zone consists of approximately 50 % marl and 50 % limestone, while the rest of the zone is mainly marl. The TOC values varies from 0.6 - 0.3 % which indicate a poor to fair potential for this zone.

E: 3250 - 3400 m: Again we find a zone with mixed lithologies of marl and limestone. The TOC values of the marl samples show an increase with increasing depth. The zone has a fair potential but increasing to good towards the bottom of the zone.

F: 3400 - 3490 m: This zone is very similar to zone E and on the whole the TOC values indicate a good potential for the marl samples.

G: 3490 - 3580 m: The lithology of this zone is very similar to the two zones above with a mixture of marl and limestone. The TOC values of the marl samples show a marked decrease with increasing depth. The values indicate a good potential at the top of the zone decreasing to fair towards the bottom of the zone.

H: 3580 - 3760 m: This zone has only one lithology, marl. The TOC values vary from 0.9 - 1.6 which indicate this zone to have a fair - good potential.

I: 3760 - 3970 m: The TOC values for this zone have a wide spread with an extremely high value of 5.08 % TOC at 3790 m. This might be caused by contamination. The bottom part of the zone has a fair potential while the middle part of the zone has a fair/good potential.

Extractable Organic Matter (EOM) and Chromatographic Separation.

A: 2830 - 2860 m: No samples were extractable from this zone.

B: 2860 - 2890 m: Due to lack of material no samples were extracted from this zone.

C: 2890 - 3070 m: One sample from this zone, 2950 - 2980 m, was extracted. The sample was found to have a good abundance of hydrocarbons, Table IV, Fig. 3, but the gaschromatogram of the saturated fraction shows this to be mainly diesel from the drilling mud.

D: 3070 - 3250 m: One sample trom this zone, 3130 - 3160 m, was extracted. Again the sample was found to have a good abundance of hydrocarbons. Table IV, Fig. 3. The gaschromatogram of the satured fraction again shows evidence of diesel from the drilling mud with a very strong front biased chromatogram and the amount of n-alkanes deminishes rapidly after nC_{18}. However, the ratio of hydrocarbons to non hydrocarbons is not as high as in the sample above, and this may be an indication of an increase of non additives in this samples.

E: 3250 - 3400 m: One sample from this zone, 3370 - 3400 m, was extract, composition and chromatogram of the saturated fraction are very similar to the sample above, an indication that the source for the EOM is of the same type.

F: 3400 - 3490 m: No samples were extracted from this zone.

G: 3490 - 3580 m: Two samples from this zone, 3490 - 3520 and 3520 -3550 m were extracted. Both the extracted samples show a good abundance of hydrocarbons, Table IV, Fig. 3, and their composition of organic matter is very similar. The amount of higher end hydrocarbons is more than in the samples above, but the gaschromatograms are still front biased, Fig. 4. This would indicate an amorphous/algal origin. The gaschromatograms show a strong peak between n-C_{19} and n-C_{20}. This compound, which as yet has not been identified, is not usual in the extract of sediments, especially not in such a high concentration. However, we would like to mention that this type of chromatogram, with a major peak between nC_{19} and nC_{20} has been previous found in some samples from the North Sea.

H: 3580 - 3760 m: Two samples from this zone, 3640 - 3670 m and 3730 - 3760 m were extracted. This sample from 3640 -3670 m shows a good abundance of hydrocarbons, while the one from 3730 - 3760 m shows a fair abundance. The composition of the extract is very similar for the two samples, Table VI, while minor differences are found in the gaschromatograms of the saturated fraction. However, the gaschromatograms are both front biased with a unimodal distribution. The component which showed up between nC_{19} and nC_{20} in the gaschromatogram of the samples above is again formed in these samples, but not as prominently.

I: 3760 - 3970 m: Three samples from this zone 3790 - 3820 m and 3940 - 3970 m were extracted. The sample from 3790 - 3820 shows a good abundance of hydrocarbons, sample 3850 - 3880 m shows a poor abundance while the sample from 3940 -3970 m shows a good/rich abundance, Table IV, Fig. 3. The composition of the extract varies significantly Table VI and the gaschromatograms of the saturated fraction show large differences between the different samples, Fig. 4.The gaschromatogram of the sample from 3790 - 3820 m is quite similar to the sample above (3730 - 3760 m). The gaschromatogram of the sample from 3850 - 3880 m is still front biased, but the heavier compounds from nC_{20} - nC_{29} are more prominent than in the

samples above. The carbon preference index (CPI) is larger than in the samples above where the CPI indicates an input of of herbacious/woody material. It is noticable that the component between nC_{19} and nC_{20} in the gaschromatograms is again very prominent.

The gaschromatogram of the sample from 3940 - 3970 m is different from the sample above. This sample has a large sterane hump, Fig. 4, but it is still front biased and the component between nC_{19} and nC_{20} has disappeared. The sterane hump indicates an input from amorphous material, and that the sample is not mature.

Vitrinite Reflectance

Eleven samples, five sidewall cores and six cutting samples, were analysed for vitrinite reflectance. These samples showed to be rather difficult, with some poor results. The samples are found to be either barren, or to contain a lot of reworked material and additives.

In the following we will describe the individual samples, and together with the reflectance values, other information from the analyses will be given.

2830 - 2860 m: Limestone and calcareous shale, Ro = 0.37 (3), Ro = 0.73 (5) and Ro = 1.58 (5). The sample has a low organic content, confined mainly in the calcareous shale. The organic content is mainly present as small particles of reworked material pluss small ragged vitrinite wisps and traces of bitumen. U V light shows a light orange fluorescence from spores and a low exinite content. The Ro = 0.37 is probably the correct value while the two higher Ro values of 0.73 and 1.58 are from reworked material.

2950 - 2980 m: Chert and shale, Ro = 0.43 (5). The sample contains only a trace of organic material in the form of small gnarled particles of vitrinite pluss some reworked material with very high Ro values. (Not measured). U V light shows no sign of organic fluorescence.

3164 m: Limestone, Ro = 0.67 (1), Ri = 1.67 (19). The sample has a low organic content, almost exclusively small gnarled particles of reworked material. Only a single teneous wisp of lower Ro material is found. U V light shows a dull yellow/orange fluorescence from spores and a trace of exinite.The higher Ro value of 1.67 is definitely from reworked material, and we assume the one reading with Ro = 0.67 also to be reworked.

3250 - 3280 m: Shale, Ro = 1.11 (5). The sample is almost barren. Only five particles of organic matter are found. These fine particles are isolated particles of vitrinite and inertinite with a trace of bitumen wisps. U V light shows a good fluorescense and one orange spore. Only a trace of exinite is found.
The Ro = 1.11 found for this sample is definitely from reworked material. No true vitrinite is found.

3370 - 3400 m: Limestone and subordinate coal. Ro = 0.39 (23), Ro = 0.79 (1). The limestone in this sample is barren. However the sample also contain a few small particles of coal with variable reflectance. The reflectance value vary from 0.28 - 0.79. U V light shows a fluorescence from hydrocarbons plus a greenOYellow flourescence from spores and resin in the coal. Only a trace of exinite content is found. The higher reflectance value of 0.79 could be from reworked material, while the lower values could be from mudadditives or cavings. With such a spread in reflectance values, it is difficult to draw any conclusion, but we do expect that the lowest values of 0.28 - 0.40 might be from additives, while the higher values of 0.45 - 0.55 might be from coal within the sediment. The six particles within these limits will give a Ro = 0.49. However, we would point out that this is only an assumtion.

3490 - 3520 m: Cherty shale and coal, Ro = 0.35 (23).
The cherty shale in the sample is barren, and all the measurements are done on coal particles. All the reflectance values are low, so this might be a mud additive. U.V light shows hydrocarbons which disolve in the immersion oil.

3668 m: Limestone and calcareous shale, Ro = 1.00 (20). The sample has a low to moderate organic content, almost exclusively with high R_o values, and it is probably reworked material. U V light shows a high orange fluorescence from spores and a low exinite content.

3730 - 3760 m: Cherty shale and coal, Ro = 0.38 (18), Ro = 0.62 (8). The cherty shale is barren. The coal in the sample have two levels of reflectance. U V light shows orange fluorescence from spores and resin in coal and a trace of exinite.
The coal with the low Ro value could be from mudadditive or cabings while the coal with Ro = 0.62 could show the true vitrinite value for this depth.

3795 m: Shale, Ro = 0.67 (5), R = 1.64 (15). The sample has a low to moderate organic content with small gnarled particles of vitrinite and inertinite with high reflectance value. A few granular-looking wisps of vitrinite with low reflectance value are also found. U V light shows a couple of orange fluorescing, spore species and a trace of exinite. The high reflectance value, Ro = 1.64 is from reworked material, while the lower reflectance value, Ro = 0.67 might be the true refectance for this depth level.

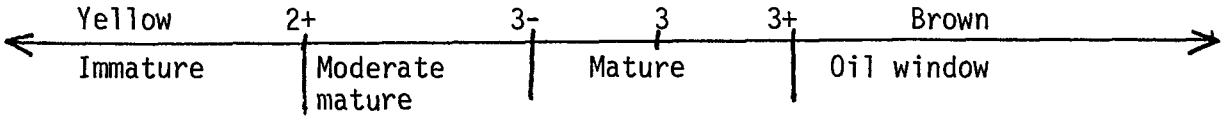
3850 m: Shale, Ro = 1,58 (20). The shale is rather pyritic and has a low to moderate organic content with small, angular particles of vitrinite. All the particles have a high reflectance value and are reworked. U.V light shows a medium orange fluorescence from spores and a low to moderate exinite content.
Even without any reflectance readings of true vitrinite in this sample, the fluorescence from the spores is that good and definite that we would set the reflectance value for this sample to between 0.6 and 0.7.

3973 m: Shale, Ro = 0.52 (1), Ro = 1.65 (19). The sample has a low organic content with small gnarled particles of vitrinite and inertinite with high reflectance value. They are all reworked. One minute wisp of low Ro material. U.V light shows no definite organic fluorescence.

As mentioned above, a lot of reworked material was found in these samples, and this together with the mudadditives make it rather difficult to get accurate readings on true vitrinite. However, we are quite certain that the reflectance values of 0.37 and 0.43 for the two uppermost samples are true readings. This, together with the Ro values, of 0.6 - 0.7 towards the lower end and the well will give an indication of the gradient, especially if we also use the assumption of a reflectance value of approximately 0.5 for sample 3370 - 3400 m.

Visual Evaluation of Kerogen

Sixteen samples were treated for visual kerogen analysis. In the analyses of this well, the colour index is given for the dominant organic debris unless otherwise stated. The following interpretation has been used for the qualitative colour index.



In the following, individual samples are discussed separately, and different kerogen components are expressed in terms of percentages of total kerogen. These are based on visual estimates and are not quantitative measurements.

2958 - 61 m: The sample contains mainly amorphous debris with a colour index of 2+, based on algae and pollen. This indicates a moderate mature source rock for oil.

3164 m: Finely dispersed amorphous debris dominates completely. A colour index of 2+/3- is based on algae and pollen and indicates a moderate mature source rock for oil. The slight increase in the colour index compared to the sample above may be due to an increase oxidation and will be dependant of lithology/environment.

3243 - 46 m: This sample is very similar to the samples above with finely dispersed amorphous debris being completely dominant. The colour index is back to 2+,an indication of a moderate mature source rock for oil.

3369 - 72 m: In this sample wood remains dominated slightly over amorphous debris. This change in kerogen compared to the samples above is probably due to a change in lithology/environment. The colour index is again 2+, and is an indication of a moderate mature source rock for oil and gas.

3453 - 56 m: The amount of amorphous debris in this sample is somewhat higher than in the sample above, approximately 60 %. The remainder is made up by wood remains and coal. The colour index is still 2+, which indicates a moderate mature source rock for oil and gas.

3495 - 98 m: This sample contains mainly amorphous and herbaceous debris in approximately equal amounts. A minor amount of wood remains and coal is also recorded. A colour index of 2+ is found for pollen, spores and algae. These results indicate a moderate mature source rock for oil and gas.

3537 - 40 m: Amorphous debris is dominant in this sample, but significant amounts of dispersed herbaceous material and wood remains are also recorded. A colour index of 2+ is recorded for algea and herbaceous material, which together with the type of kerogen indicates a moderate mature source rock for oil and gas.

3590 - 93 m: The sample contains approximately 30 % amorphous and algae debris together with approximately 70 % finely dispersed herbaceous material, cuticles and wood remains. A colour index of 2+ indicates together with the kerogen composition, a moderate mature source rock for oil and gas.

3668 m: The amount of amorphous and algae material in this sample has increased compared to the sample above to approximately 60 %. The remaining kerogen consists mainly of finely dispersed material. A colour index of 3- is found for cuticles and algae. These results indicate a moderate mature/mature source rock for oil and gas.

3708 - 11 m: The amorphous/algal debris has increased and dominates completely with only a small amount of herbaceous material, approximately 10 %. This together with a colour index of 3- to 3 indicates a mature source rock for oil.

3747 - 50 m: This sample has a similar kerogen composition and colour index as the sample above.

3801 - 4 m: The composition of kerogen is similar to the samples above, but the colour index based on algae and and herbaceous material has increased to 3. These results indicate a mature source rock for oil.

3858 - 61 m: This sample has changed completely compared with the samples above. The amorphous/algal remains only make up a minor amount of the kerogen with finely dispersed herbaceous material and wood remains being completely dominant. The colour index has increased to 3+ which indicate the start of the oil window. However the composition of the kerogen indicate the source rock to be mainly gas prone.

3894 - 97 m: This sample is very similar to the sample above both in kerogen composition and colour index.

3915 - 18 m: The kerogen is made up of approximately equal amounts of amorphous material and wood remains. A colour index of 3+ is based on pollen, and dinoflagellates. This indicates the beginning of the oil oil window, with a source rock for oil and gas.

3966 - 69 m: This sample changes in composition of kerogen compared to the three samples above. Amorphous debris is completely dominant with approximately 20 % herbaceous material. A colour index of 3+ is found based on pollen, spores and dinoflagellates. This indicates a source rock for oil at the beginning of the oil window.

The kerogen analyses show most of the analysed section to be moderate mature, going into a mature stage at approximately 3700 m. From this depth down to approximately 3850 m, when the oil window is reached, the analysed samples are found to be mature.

The kerogen of the analysed samples is found to contain mainly amorphous debris down to approximately 3250 m, which indicates this to be a source rock for oil. From 3250 m down to approximately

3670 m a large proportion of finely dispersed herbaceous material and wood remains are found, and this indicates a potential for oil and gas generation. The kerogen from 3700 m to 3800 m is found to be rich in amorphous debris, an indication that this section has a potential for oil generation. The samples from 3850 m to approximately 3920 m are found to be dominated by finely dispersed herbaceous material and woody remains. This section will therefore mainly have a potential for gas generation. However, the composition of kerogen changes again towards the bottom of the well to a more amorphous dominated composition. This indicates that the section from approximately 3900 m has a potential for generation of oil.

CONCLUSION

On the basis of the light hydrocarbon data, the analysed part of the well was divided into nine zones; A: 2830-2860 m, B: 2860-2890 m, C:2890-3070 m, D: 3070-3250 m, E: 3250-3400 m, F: 3400 - 3490 m, G: 3490-3580 m, H: 3580-3760 m and I: 3760-3970 m. However, other analyses have shown very small differences between zone D and zone E.

In our evaluating of the well we have based our richness rating on the light hydrocarbon, total organic carbon (TOC) and extractable organic matter (EOM) data. The maturation rating is mainly based on the vitrinite reflectance and visual kerogen data. However, a lot of reworked material has been found in the samples and this might have affected some of the data.

A: 2830-2860 m: This zone containes only one sample, and is found to be a poor, imature source rock.

B: 2860 - 2890 m: Again a zone with only one sample. The light hydrocarbon measurements show this zone to contain large amounts of gas, and it probably contains accumulated hydrocarbons. There was not enought material for a detailed C_{15}^{+} study. However, the TOC analysis does not show a particularly high value, and we assume therefore the accumulation to be mainly gas/condensate.

C: 2890 - 3070 m: The extracted sample, from this zone, 2950 - 2980 m, was found to contain diesel from the drilling mud. On the basis of the light hydrocarbons and the TOC measurements we estimate the richness to be fair. Sample 2958 m, analysed for visual kerogen, is found to contain manily amorphous debris, with a colour index of approximately 2+. This together with the vitrinite reflectance of 0,43 shows the zone to be moderate mature and with a fair potential as a source rock for oil.

D: 3070 - 3250 m: On the basis of the light hydrocarbons, TOC and EOM data this zone is rated as fair to good in richness. The maturity measurements are poor for this zone with no reliable vitrinite reflectance measurements. However, on the basis of the visual kerogen it could be rated as moderate mature with a fair/good potential for oil.

E: 3250 - 3400 m: The richness and maturity rating for this zone is the same as for zone D. However, the visual kerogen has shown it to contain large amounts of herbaceous material. The sone would therefore be rated as moderate mature, with a fair/good potential for oil and gas.

F: 3400 - 3490 m: This zone is richer than the zones above, and is rated as good on the basis on the EOM, TOC and light hydrocarbon datas. The vitrinite reflectance data are very poor in this interval. However, the visual kerogen analysis indicates it to be moderate mature and with a composition of kerogen of amorphous and herbaceous material. The zone is therefore rated as moderate mature with a good potential as a source for oil and gas.

G: 3490 - 3580 m: This zone is rated as good in richness. No vitrinite reflectance data are available, but the visual kerogen shows the zone to be moderate mature with a composition similar to zone F. The zone is therefore rated as moderate mature, with a good potential for oil and gas.

H: 3580 - 3760: The extracted samples from this zone show a marked drop in hydrocarbons while the TOC and light hydrocarbon values vary grately. The vitrinite reflectance data are poor at the top of the zone, but at the lower end of the zone there is a reliable reading of 0.62. The visual kerogen analyses show a distinct increase in colour estimation with increasing depth together with a change in the composition of kerogen from amorphous/herbaceous to mainly amorphous. The zone is moderate mature at the top, but increases in maturity to mature towards the lower end and has a fair/good potential as a source for oil and gas.

I: 3760 - 3970 m: Three samples were extracted from this zone and they show a large variation in richness with a distinct drop for the middle sample. The visual kerogen shows a large variation in the composition. The top part of the zone consists mainly of amorphous debris. The middle part, approximately 3850 - 3900 m has large proportion of herbaceous material while the lower end again is mainly amorphous debris. The top part of the zone is found to be mature, while we enter the oilwindow at approximately 3850 m. On the basis of these data we give the following ratings.

The top part of the zone, down to 3850 m, is mature with a good potential as a source rock for oil. The middle part is in the oilwindow, but with a fair/good potential as a source rock for oil and gas. The lower end of the zone is in the oilwindow, with a good potential as a source rock for oil.

T A B L E I

Concentration (µl gas / kg rock) of C_1 - C_4 hydrocarbons in cuttings.

Depth (m)	C_1	C_2	C_3	iC_4	nC_4	Tot. C_1-C_4	Tot. C_2-C_4	% Gas wetness	iC_4/nC_4
3610 - 40	4118	219	50	5	14	4405	287	6.51	0.34
3640 - 70	1971	92	16	0	1	2081	110	5.28	
3670 -700	4373	234	33	2	5	4647	274	5.90	0.46
3700 - 30	4488	232	33	4	6	4764	275	5.78	0.73
3730 - 60	4207	255	49	35	70	4557	350	7.67	0.50
3760 - 90	1558	78	12	1	1	1651	93	5.63	0.74
3790 -820	2261	224	85	15	30	2614	353	13.52	0.50
3820 - 50	865	137	59	10	20	1091	226	20.69	0.48
3850 - 80	2041	265	112	23	41	2481	440	17.74	0.56
3880 -910	2303	298	135	20	49	2805	503	17.91	0.41
3910 - 40	1257	135	55	8	19	1475	218	14.79	0.42
3940 - 70	1020	131	65	8	24	1250	229	18.32	0.35

T A B L E I

Concentration (µl gas / kg rock of C_1 - C_4 hydrocarbons i cuttings.

Depth (m)	C_1	C_2	C_3	iC_4	nC_4	Tot. C_1-C_4	Tot. C_2-C_4	% Gas wetness	iC_4/nC_4
3250 - 80	2098	168	33	4	6	2309	212	9.16	0.78
3280 -310	456	37	5	1	1	499	43	8.62	0.77
3310 - 40	1664	134	29	9	7	1842	178	9.67	1.28
3340 - 70	1418	135	39	12	11	1615	197	12.21	1.03
3370 -400	1714	117	28	5	8	1872	158	8.46	0.66
3400 - 30	613	41	10	1	3	668	55	8.21	0.32
3430 - 60	3068	386	171	17	57	3700	632	17.07	0.30
3460 - 90	3069	435	241	22	91	3858	789	20.45	0.24
3490 -520	1859	148	54	8	18	2086	228	10.91	0.42
3520 - 50	1441	96	23	7	6	1573	131	8.36	1.13
3550 - 80	3212	251	89	9	28	3590	378	10.52	0.33
3580 -610	1693	100	24	1	6	1824	131	7.16	0.22

T A B L E I

Concentration (µl gas / kg rock) of C_1 - C_4 hydrocarbons in cuttings

Depth (m)	C_1	C_2	C_3	iC_4	nC_4	Tot. C_1-C_4	Tot. C_2-C_4	% Gas wetness	iC_4/nC_4
2830 - 60	1786	319	116	34	40	2295	509	22.16	0,84
2860 - 90	23323	5217	2863	194	1019	32616	9293	28.49	0.19
2890 -920	2941	541	251	49	93	3875	934	24.09	0.52
2920 - 50	4128	371	89	14	23	4625	497	10.75	0.64
2950 - 80	3857	402	97	17	22	4395	538	12.24	0.77
2980-3010	4233	350	74	11	14	4682	449	9.59	0.78
3010 - 40	5092	421	88	13	16	5630	538	9.55	0.77
3040 - 70	3713	302	72	7	17	4111	398	9.68	0.44
3070 -100	2174	165	34	4	5	2382	208	8.74	0.72
3100 - 30	2323	226	66	6	10	2631	309	11.73	0.63
3130 - 60	1854	161	35	7	6	2062	209	10.13	1.04
3160 - 90	1732	178	55	9	16	1989	257	12.93	0.56
3190 -220	2814	330	135	15	43	3348	524	15.70	0.35
3220 - 50	1208	125	53	7	17	1410	202	14.32	0.38

T A B L E II

Lithology and Total Organic (TOC) Measurements.

Sample Depth (m)	TOC %	Lithology
2830 - 60	0.22 0.74	80 % Limestone, white to light grey. 20 % Claystone to Marl, grey, sometimes brownish greenish. Obs. Quartz; Pyrite.
2860 - 90	0.43 0.85	90 % Limestone, white to grey and brownish. 10 % Claystone to Marl, grey to greenish grey. % Lignosulphonate Obs. Quartz; Pyrite.
2890 -920	0.27 0.42	80 % Limestone, light grey to brown grey 19 % Marl to Claystone, grey. 1 % Lignosulphonate
2920 - 50	0.43 0.24	80 % Marl to Claystone, sometimes sulty, grey. 20 % Limestone, light grey to brown grey. Obs. Pyrite.
2950 - 80	0.31 0.71	60 % Limestone, light grey to brown grey. 40 % Marl to Claystone, sometimes silty, light grey to grey.
2980-3010	0.51	98 % Marl to Claystone, light grey to grey. 2 % Limestone, light grey to brown grey.
3010 - 40	0.56	100 % Marl to Claystone, light grey to grey. Sm.am.Limestone, light grey to white and brownish.
3040 - 70	0.21	100 % Marl to Claystone, light grey to grey.
3070 -100	0.52 0.21	50 % Marl to Claystone, light grey to grey. 50 % Limestone, light grey to brownish.
3100 -130	0.44	95 % Marl, brownish grey to red brown (48 %), light grey and partly grey (47 %). 5 % Limestone, light grey.
3130 - 60	0.59	100 % Marl, grey brown (55%), light grey and some grey (45 %). Obs. Lignosulphonate
3160 - 90	0.45	100 % Marl, brownish grey to red brown (55%), light grey and grey (45 %). Sm.am.Limestone, white to light grey.
3190 -220	0.35	100 % Marl, grey brown to red brown (50%), light grey to grey (50 %).

T A B L E II

Lithology and Total Organic (TOC) Measurements.

Sample Depth (m)	TOC %	Lithology
3220 - 50	0.32	100 % Marl, red brown (70 %), light grey and some grey (30 %).
3250 - 80	0.40	100 % Marl, light grey, partly grey
3280-3310	0.30	70 % Limestone, light grey to white and brownish.
	0.48	30 % Marl, light grey to grey.
3310 - 40	0.29	60 % Limestone, light grey to white and some brownish.
	0.55	40 % Marl, light grey to grey.
3340 - 70	0.24	75 % Limestone, light grey to white and some brownish.
	0.78	25 % Marl, light grey to grey.
3370 -400	0.32	75 % Limestone, light grey to white, partly brownish.
	0.85	25 % Marl, light grey to grey.
		Sm.am.Lignosulphonate
3400 - 30	0.66	55 % Marl to Claystone, light grey to grey
	0.24	45 % Limestone, light grey to grey.
3430 - 60	0.23	50 % Limestone, light grey to white.
	0.72	50 % Marl to Claystone, light grey to grey.
3460 - 90	0.19	80 % Limestone, light grey to white and brownish.
	0.92	20 % Marl to Claystone, light grey to grey.
		Sm.am.Lignosulphonate
3490-3520	0.22	50 % Limestone, light grey to white and brownish.
	1.98	50 % Marl to Claystone, grey to light grey.
		Sm.am.Lignosulphonate.
3520 - 50	1.23	55 % Marl to Claystone, light grey to grey.
	0.27	45 % Limestone, light grey to white and brownish.
		Sm.am.Lignosulphonate.
3350 - 80	0.76	55 % Marl to Claystone, light grey to gry
	0.21	45 % Limestone, light brownish, grey to white.
		Obs. Lignosulphonate
3580-3610	1.01	100 % Marl to Claystone, light grey to grey.
		Sm.am.Limestone, white to light grey; Lignosulphonate
		Obs. Glauconite.

TABLE II

Lithology and Total Organic (TOC) Measurements.

Sample Depth (m)	TOC %	Lithology
3610 - 40	0.89	100 % Marl to Claystone, light grey to grey. Sm.am.Limestone, white to light grey, Lignosulphonate.
3640 - 70	1.60	100 % Marl to Claystone, light grey to grey. Sm.am.Limestone, white to light grey; Lignosulphonate.
3670 -700	1.33	98 % Marl to Claystone, light grey to grey. 2 % Limestone, white to light grey. Sm.am.Lignosulphonate.
3700 - 30	0.97	100 % Marl to Claystone, light grey to grey. Sm.am.Limestone, white to light grey and brownish. Obs. Lignosulphonate
3730 - 60	1.31	99 % Marl to Claystone, light grey to grey. 1 % Limestone, white to light grey and brownish. Sm.am.Lignosulphonate
3760 - 90	0.58	98 % Marl to Claystone, light grey to grey. 2 % Limestone, white to light grey and brownish. Sm.am.Lignosulphonate.
3790 -820	5.08	98 % Marl to Claystone, ligt grey to grey. 2 % Siltstone, redbrown (from mud). Sm.am.Lignosulphonate. Obs.Glauconite.
820 - 50	1.19	100 % Claystone, light grey to grey. 2 % Limestone, light grey to white. Sm.am.Lignosulphonate; Glauconite; Siltstone with glauconite, light. Obs. Pyrite.
3850 - 80	1.95	99 % Claystone, light grey to grey. 1 % Limestone, white to light grey and brownish. Obs. Lignosulphonate; Siltstone, redbrown (from mud); Glauconite; Quartz.
3880-3910	0.88	100 % Claystone, light grey to grey, some redbrown fragments. Sm.am.Limestone.

T A B L E II

Lithology and Total Organic (TOC) Measurements.

Sample Depth (m)	TOC %	Lithology
3910 - 40	0.70	100 % Claystone, light grey to grey, some redbrown fragments. Sm.am. Limestone Obs. Pyrite.
3940 - 70	0.74	100 % Claystone, light grey to grey, some redbrown fragments. Obs. Pyrite.

T A B L E III

Weight (mg) of EOM and chromatographic fractions.

Depth (m)	Rock extracted (g)	EOM	Sat	Aro	Hydrocarbons HC	Non Hydrocarbons
2950 - 2980	40.000	30.8	9.0	9.0	18.0	9.5
3130 - 3160	100.000	50.7	10.1	18.1	28.2	22.4
3370 - 3400	100.000	53.8	12.3	16.9	29.2	22.6
3490 - 3520	100.000	65.1	10.6	21.6	32.2	32.0
3520 - 3550	100.000	68.1	11.7	24.2	35.9	30.9
3640 - 3670	100.000	50.6	9.2	14.2	23.4	25.2
3730 - 3760	100.000	29.9	5.6	8.6	14.2	13.2
3790 - 3820	100.000	59.3	7.3	14.0	21.3	35.6
3850 - 3880	45.000	16.5	1.3	3.1	4.4	9.9
3940 - 3970	85.000	92.1	10.3	32.1	42.4	45.0

T A B L E IV

Concentration of EOM and chromatographic fractions
(Weight ppm of rock).

Depth (m)	EOM	Sat	Aro	Total hydrocarb.	Non hydrocarb.
2950 - 2980	770	225	225	450	237
3130 - 3160	530	101	181	282	224
3370 - 3400	540	123	169	292	226
3490 - 3520	650	106	216	322	320
3520 - 3550	680	117	242	359	303
3640 - 3670	510	92	142	234	252
3730 - 3760	300	56	86	142	132
3790 - 3820	590	70	140	213	356
3850 - 3880	370	29	69	98	220
3940 - 3970	1080	121	378	499	529

T A B L E V

Concentration of EOM and chromatograpic fractions (mg/gTOC).

Depth (m)	EOM	Sat	Aro	Total hydrocarb.	Non hydrocarb.
2950 - 2980	110.0	32.1	32.1	64.2	33.9
3130 - 3160	89.3	17.1	30.7	47.8	38.0
3370 - 3400	63.3	14.5	19.9	34.4	26.6
3490 - 3520	32.9	5.4	10.9	16.3	16.2
3520 - 3550	53.4	9.5	16.7	29.2	24.6
3640 - 3670	31.6	5.8	8.9	14.7	15.8
3730 - 3760	22.8	4.3	6.6	10.9	10.1
3790 - 3820	11.7	1.4	2.8	4.2	7.0
3850 - 3880	18.8	1.5	3.5	5.0	11.3
3940 - 3970	146.4	16.4	51.0	67.4	71.5

TABLE VI

Composition in % of the organic material extracted from the rock.

Depth (m)	Sat / EOM	Aro / EOM	HC / EOM	Sat / Aro	Non HC / EOM	HC / Non HC
2950 - 2980	29.2	29.2	58.4	100.0	30.8	189.5
3130 - 3160	19.2	34.4	53.5	55.8	42.5	125.9
3370 - 3400	22.9	31.4	54.3	72.8	42.0	129.2
3490 - 3520	16.3	33.2	49.5	49.1	49.2	100.6
3520 - 3550	17.2	35.5	52.7	48.4	44.5	118.5
3640 - 3670	18.2	28.1	46.3	64.8	49.8	92.9
3730 - 3760	18.7	28.8	47.5	65.1	44.2	107.6
3790 - 3820	12.3	23.6	35.9	52.1	60.0	59.8
3850 - 3880	7.9	18.8	26.7	41.9	60.0	44.4
3940 - 3970	11.2	34.9	46.0	32.1	48.9	94.2

T A B L E VII

Tabulation of datas from the gaschromatograms.

Depth (m)	Pristane/nC_{17}	Pristane/Phytane	CPI
2950 - 2980			
3130 - 3160			
3370 - 3400			
3490 - 3520	0.37	1.23	1.6
3520 - 3550	0.39	1.14	1.4
2640 - 3670	0.34	1.15	1.4
3730 - 3760	0.43	1.13	1.3
3790 - 3820	0.41	1.10	1.1
3850 - 3880	0.50	1.14	1.4
3940 - 3970	0.46	1.28	1.1

T A B L E VIII

Vitrinite Reflectance and Visual Kerogen Estimation

Depth (m)	Vitrinite reflectance			Colour index	Type of organic matter
2830 - 2860	0.37(3)	0.73(11)	1.58(5)		
2950 - 2980	0.43(5)				
2958 - 2961				2+	Am.
3164		0.67(1)	1.69(19)	2+/3-	Am.
3243 - 3246				2+	Am.
3250 - 3280		1.11(5)			
3369 - 3372				2+	He/Am
3370 - 3400	0.39(23)	0.79(1)			
3453 - 3456				2+	Am/He
3490 - 3520	0.35(23)				
3495 - 3498				2+	He/Am
3537 - 3540				2+	Am/He
3590 - 3593				2+	He/Am
3668		1.00(20)		3-	Am/He
3708 - 3711				3-	Am
3730 - 3760	0.33(18)	0.62(7)			
3747 - 3750				3-/3	Am

TABLE VIII

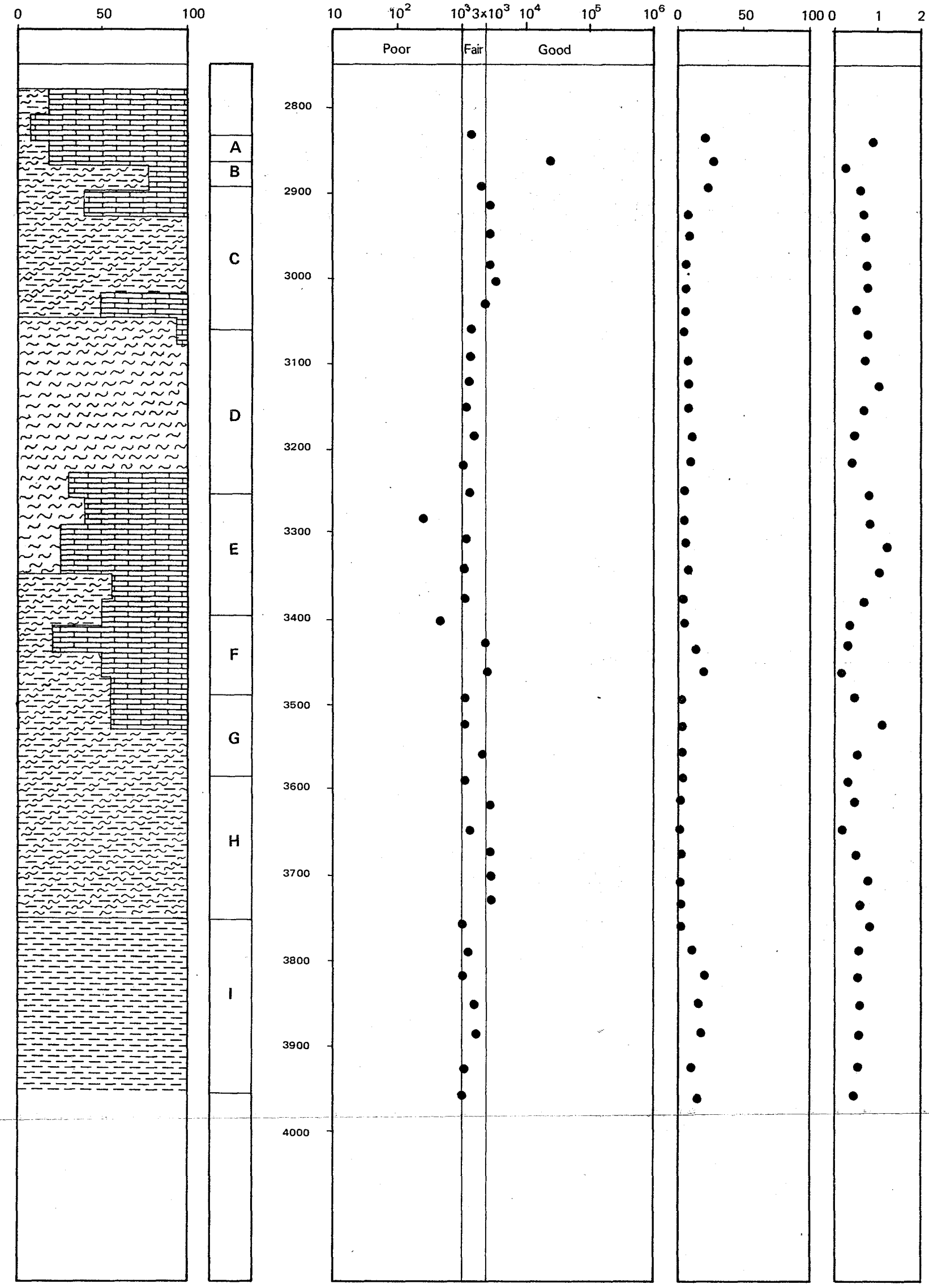
Depth (m)	Vitrinite Reflectance		Colour index	Type of organic matter
3795	0.67(5)	1.64(15)		
3801 - 3804			3	Am
3850		1.58(20)		
3858 - 3861			3+	He/Am
3894 - 3897			3+	He/Am
3915 - 3918			3+	Am/He
3966 - 3969			3+	Am
3973	0.52(1)	1.65(19)		

Am: Amorphous

He: Herbaceous

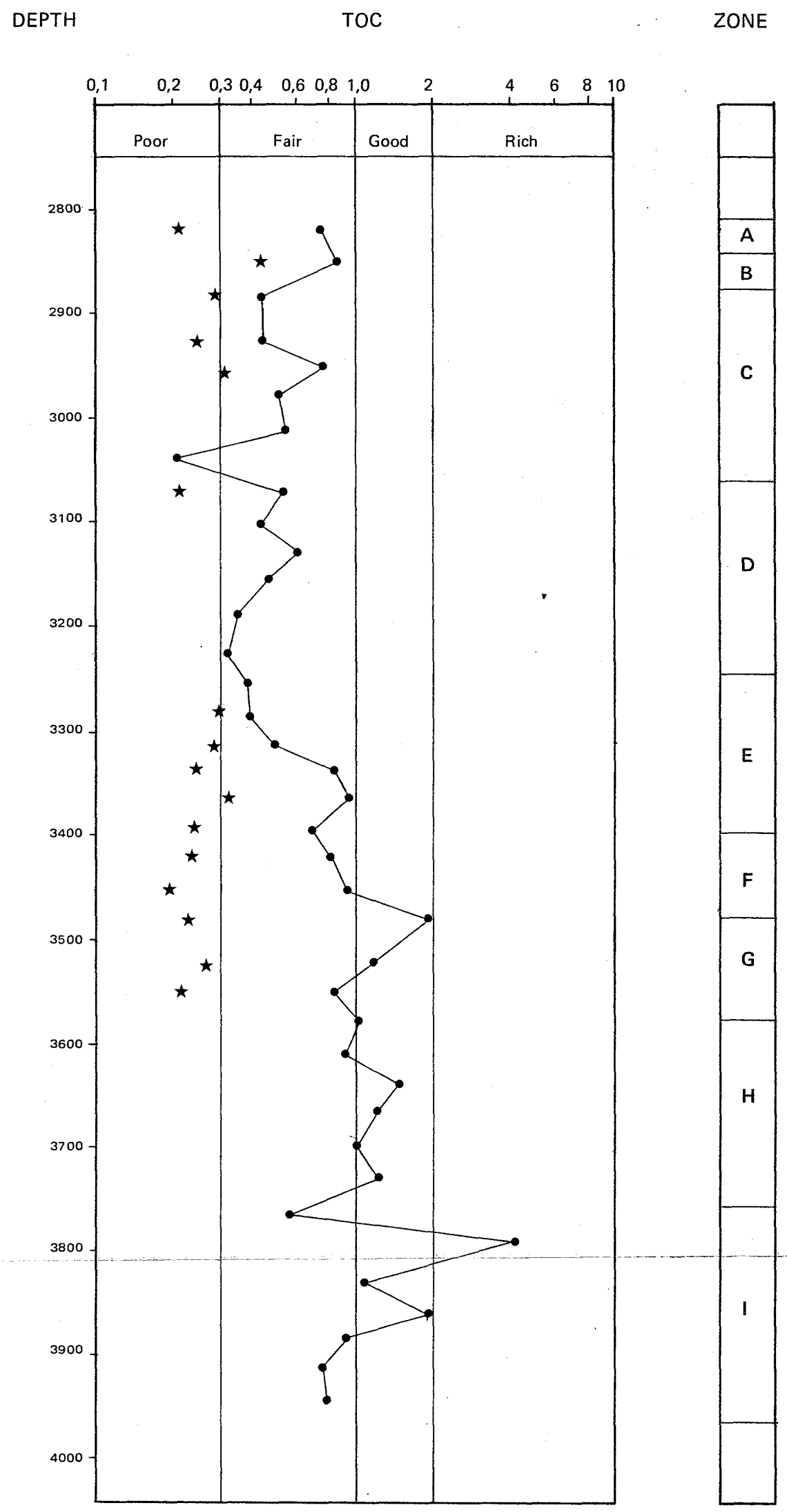
$C_1 - C_4$ HYDROCARBONS

Presentation of Analytical Data



TOTAL ORGANIC CARBON (TOC)

Presentation of analytical Data



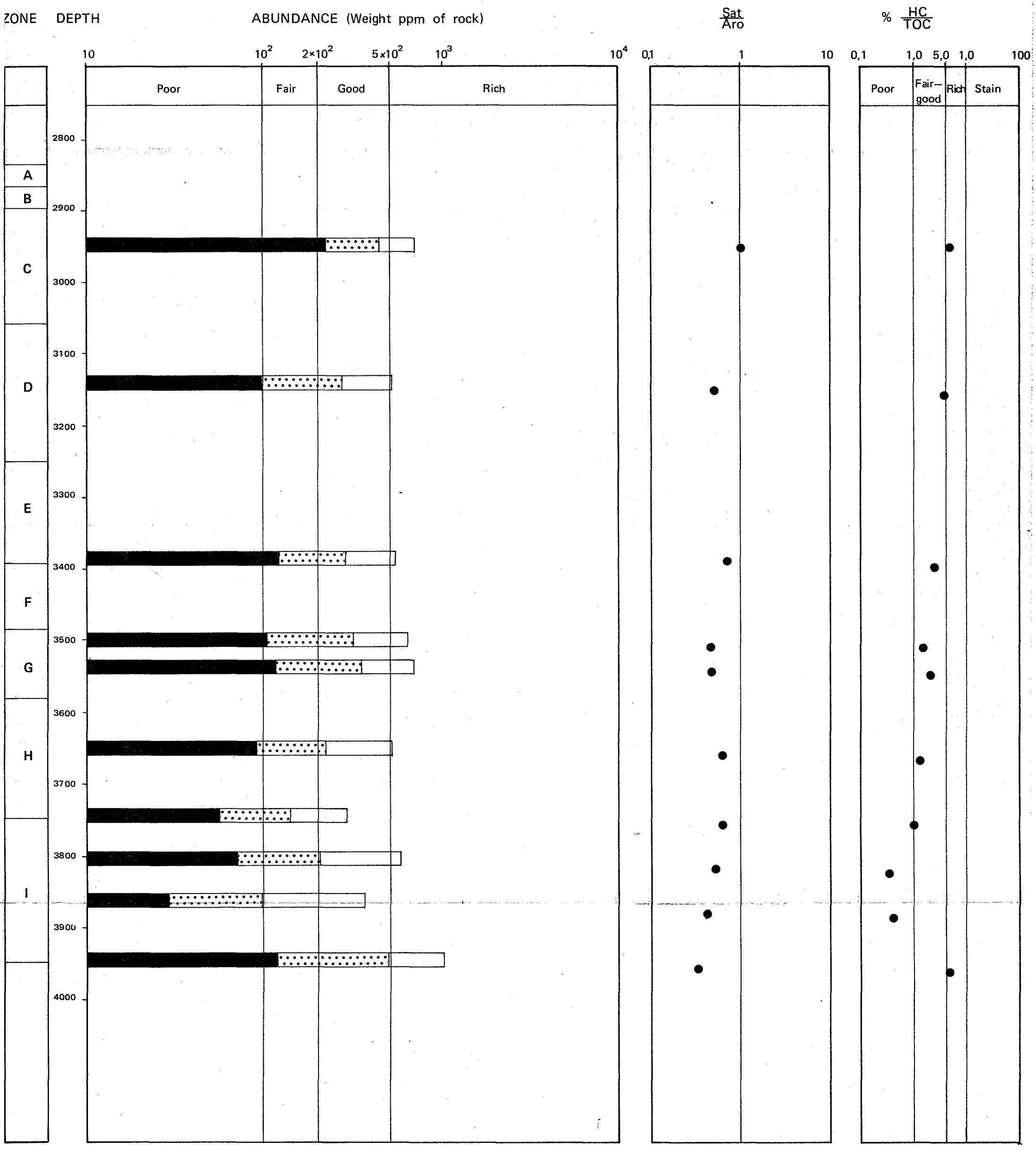
TOC: Total Organic Carbon

★ Limestone

● Marl/ Claystone

C_{15}^{+} HYDROCARBONS

Presentation of Analytical Data

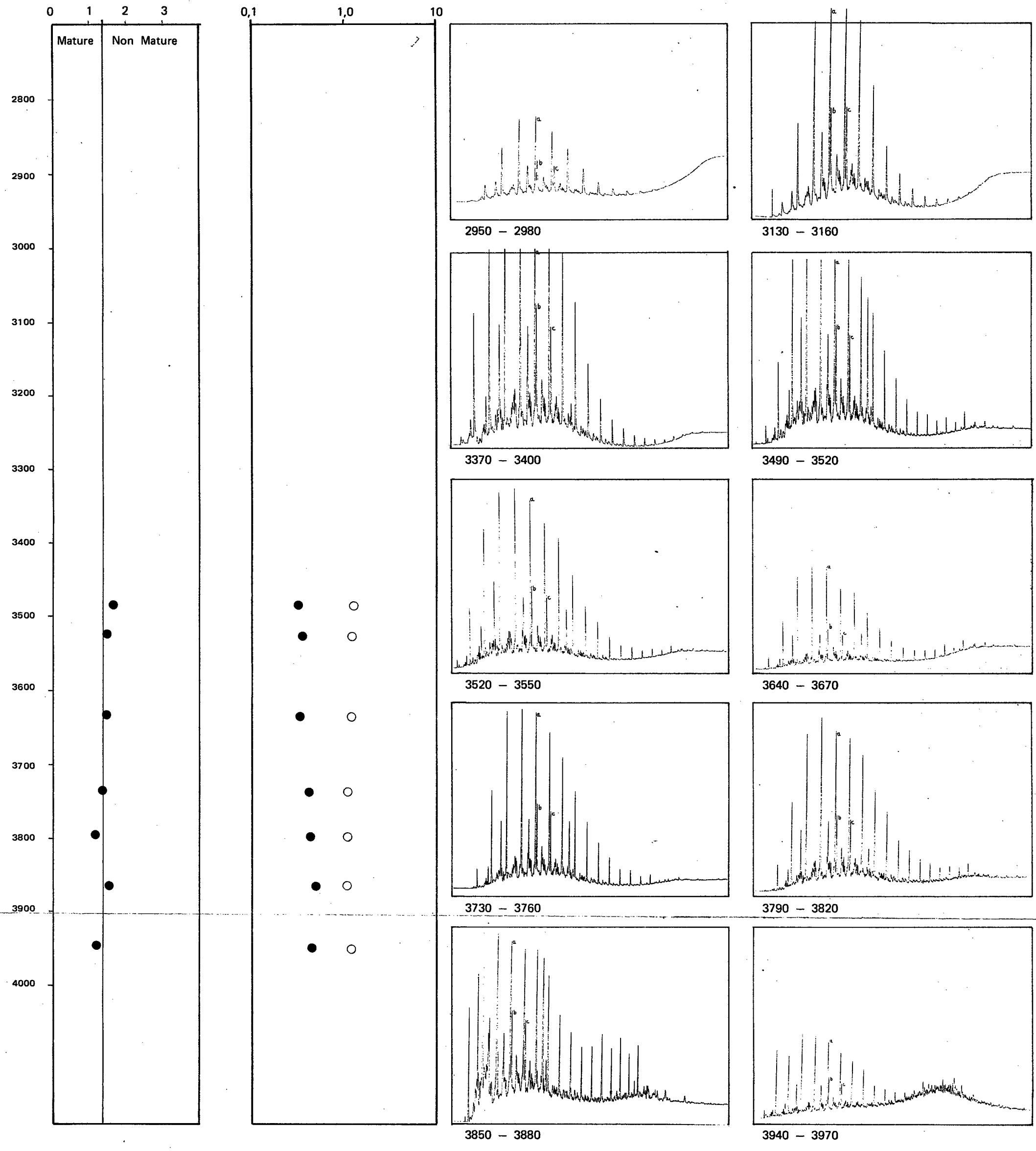


Sat: Saturated Hydrocarbons
Aro: Aromatic Hydrocarbons
NSO: Nitrogen, Sulphur and Oxygen containing compounds

Asp: Asphaltenes
HC: C_{15}^{+} Hydrocarbons
TOC: Total Organic Carbon

C_{15}^{+} SATURATED HYDROCARBONS

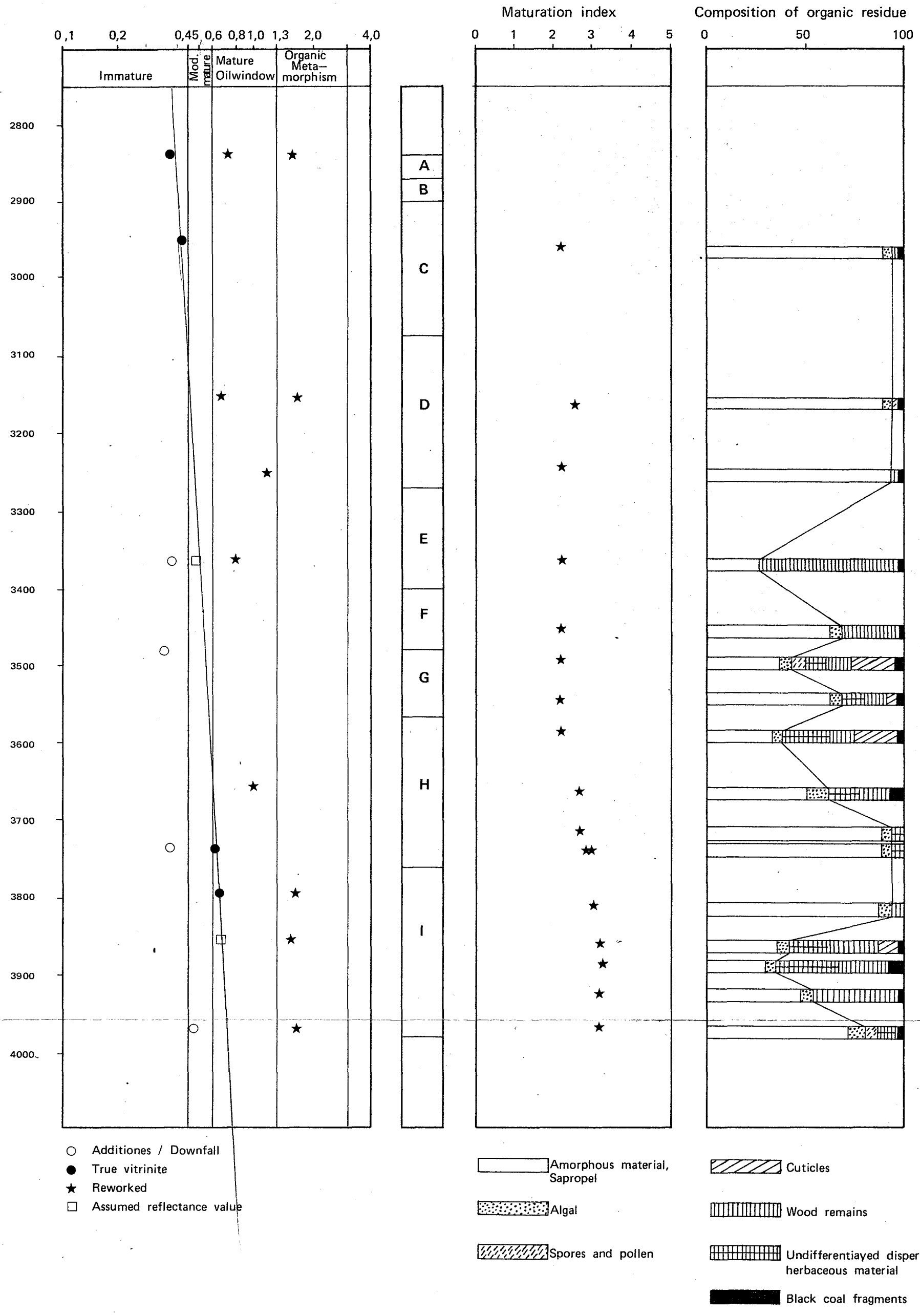
DEPTH CPI ● $\frac{\text{PRISTANE}}{n C_{17}}$ ○ $\frac{\text{PRISTANE}}{\text{PHYTANE}}$



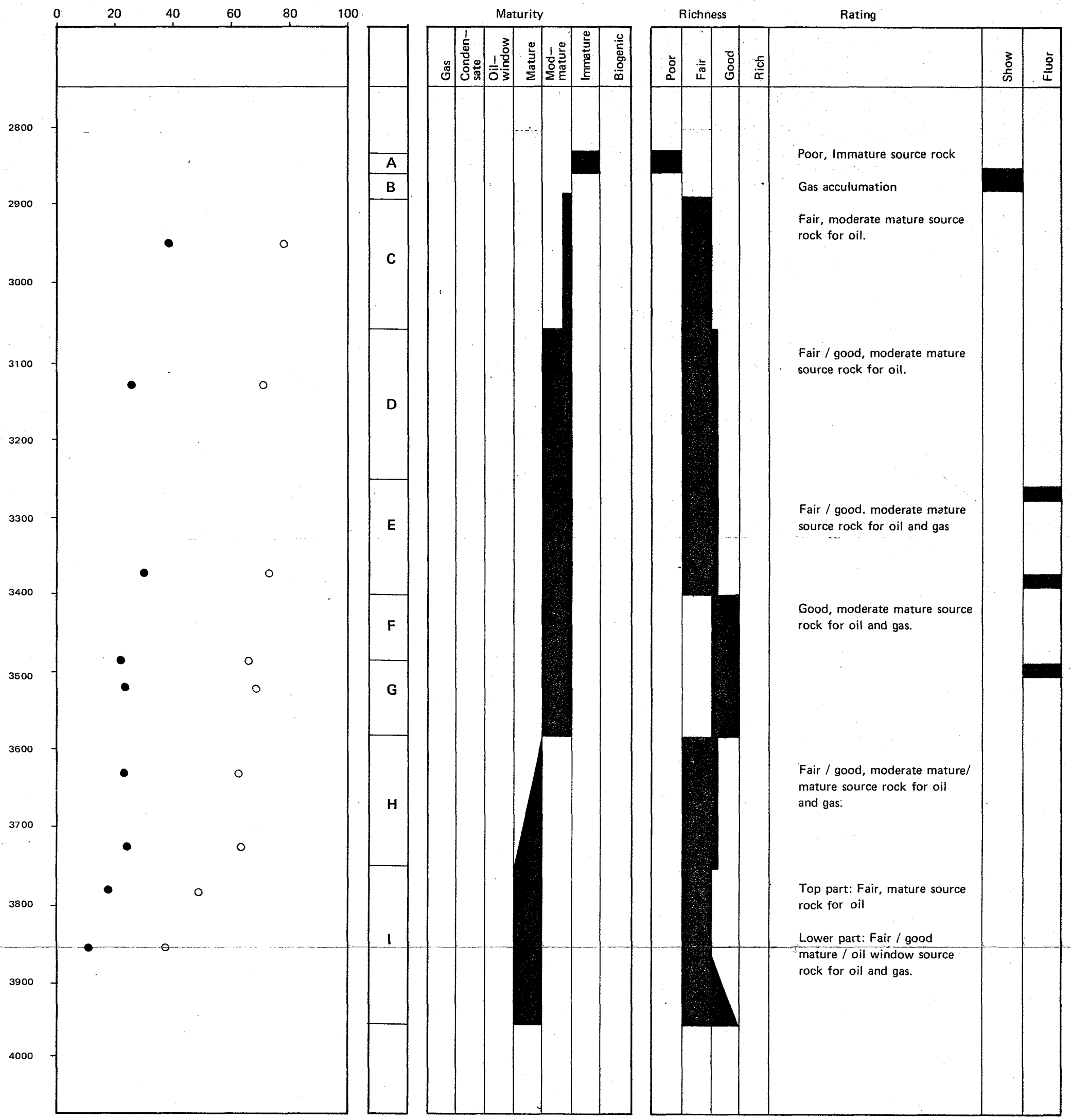
a: nC_{17}
b: Pristane
c: Phytane

MATURATION

DEPTH | VITRINITE REFLECTANCE | ZONE | VISUAL KEROGEN COLORATION AND COMPOSITION OF ORGANIC RESIDUE



INTERPRETATION DIAGRAM



Sat : Saturated Hydrocarbons
HC : Hydrocarbons
EOM: Extractable Organic Matter