Milchem®

DRILLING FLUIDS

CASING INTERVAL

COMPANY Saga Petroleum Co. Well No. 9/4-4 Page 1 of 5

Casing Size	Footage	(Bit Size)	Footage
30 "	from - ' to 178 m '	36" " hole	from - ' to 178 m '

Material Consumption for Interval:

Product	Units	Size	Cost/Unit	Total Cost
Barite	16 m/t	Bulk	112.96	1807.36
Caustic	7	25 kg	14.83	103.81
Milben	170	50 kg	7.52	1278.40
Salt Water Gel	225	25 kg	7.79	1752.75
Flosal	70	50 lb	16.44	1150.80
Lime	7	40 kg	6.16	43.12
Milgel	6	50 kg	10.80	64.80

Material Cost for Interval $ 6201.04 Average Cost per Foot $ 12.30

Number of Days 1 Average Cost per Day $ 6201.04

Comments:

Displace hole 3ith 10.0 ppg Hi vis spud mud.

MP-502 1/13

Milchem®
DRILLING FLUIDS

CASING INTERVAL

COMPANY Saga Petroleum Co. Well No. 9/4-4

Casing Size 20" from - ' to 405 ' (Bit Size) 17½ + 26 " hole from 178 ' to 420 '

Material Consumption for Interval:

Product	Units	Size	Cost/Unit	Total Cost
Barite	100	M/T	112.96	11,296.00
Caustic	15	25 kg	14.83	222.45
Milben	130	50 kg	7.52	977.60
Salt Water Gel	375	25 kg	7.79	2,921.25
Flosal	55	50 lb	16.44	904.20
Milgel	60	50 kg	10.80	648.00
Soda Ash	10	50 kg	12.97	129.70
Drispac Reg.	6	50 lb	131.06	786.36

Material Cost for Interval $ 17,885.56 Average Cost per Foot $ 22.53

Number of Days 3 Average Cost per Day $ 5,961.85

Comments:

Drill with 10 ppg mud. Displace hole with 11.0 ppg mud prior to running 20" casing.

Milchem® DRILLING FLUIDS

CASING INTERVAL

COMPANY Saga Petroleum Co. Well No. 9/4-4 Page 3 of 5

Casing Size 13 3/8 " from - ' to 1289 m , (Bit Size) 17½ " hole from 420 ' to 1300 m . Footage 2887'

Material Consumption for Interval:

Product	Units	Size	Cost/Unit	Total Cost
Barite	132	m/t	112.96	14,910.72
Caustic	191	25 kg	14.83	2,832.53
Milben	120	50 kg	7.52	902.40
Milgel	105	50 kg	10.80	1,134.00
Drispac Reg.	9	50 lb	131.06	1,179.54
Gypsum	302	40 kg	5.20	1,570.40
CMC lo vis	72	25 kg	53.94	3,883.68
M.D.	12	55 gal	385.00	4,620.00
Drispac Superlo	19	50 lb	139.57	2,651.83
Unical	194	50 lb	14.37	2,787.78
Defoamer	1	55 gal	1057.10	1,057.10
LD-8	2	5 gal	96.10	192.20

Material Cost for Interval $ 37,722.18 Average Cost per Foot $ 13.07

Number of Days 6 Average Cost per Day $ 6,287.03

Comments:

Build new volume. Gyp mud. Drill 17½" hole increase mud wt to 10.6 prior to interval T.D.

MP-502 1/13

DRILLING FLUIDS

CASING INTERVAL

COMPANY Saga Petroleum Co. Well No. 9/4-4 Page 4 of 5

Casing Size	Footage	(Bit Size)	Footage
" from ' to '		12 1/4 " hole from	1300 m to 2895 m

Material Consumption for Interval:

Product	Units	Size	Cost/Unit	Total Cost
Barite	229	M/T	112.96	25,867.84
Caustic	329	25 kg	14.83	4,879.07
Mil-gel	30	50 kg	10.80	324.00
Soda Ash	11	50 kg	12.97	142.67
Drispac (regular)	90	50 lb	131.06	11,795.40
Drispac (superlo)	99	50 lb	139.57	13,817.43
Unical	175	50 lb	14.37	2,514.75
EML	4	55 gal	325.00	1,300.00
Pipe-Free	3	55 gal	569.73	1,709.19

Material Cost for Interval $ 62,350.35 Average Cost per Foot $ 11.99
" " meters 39.34

Number of Days 18 Average Cost per Day $ 3,463.91

Comments:

MP-502 1/13

U-178 .3

REPORT TITLE

SOURCE ROCK EVALUATION OF WELL 9/4-4

CONTRACTOR

SAGA PETROLEUM A/S

FORTR
i h.t. Beskyttelse
jfr. offentlighets
§ .... nr. ....

CONTRACTORS REF.:

E. Bandlien

JOB. NO.:

0-104/1

IKU

INSTITUTT FOR
KONTINENTALSOKKELUNDERSØKELSER

Continental Shelf Institute

Håkon Magnussons gt. 1 B
Postboks 1883
7001 Trondheim
Telefon: (075) 15 660
Telex 55548
Telegram: "NORSHELF"

ACCESSIBILITY

CONFIDENTIAL

IKU Continental Shelf Institute

Institutt for kontinentalsokkelundersøkelser

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SOURCE ROCK EVALUATION OF WELL 9/4-4

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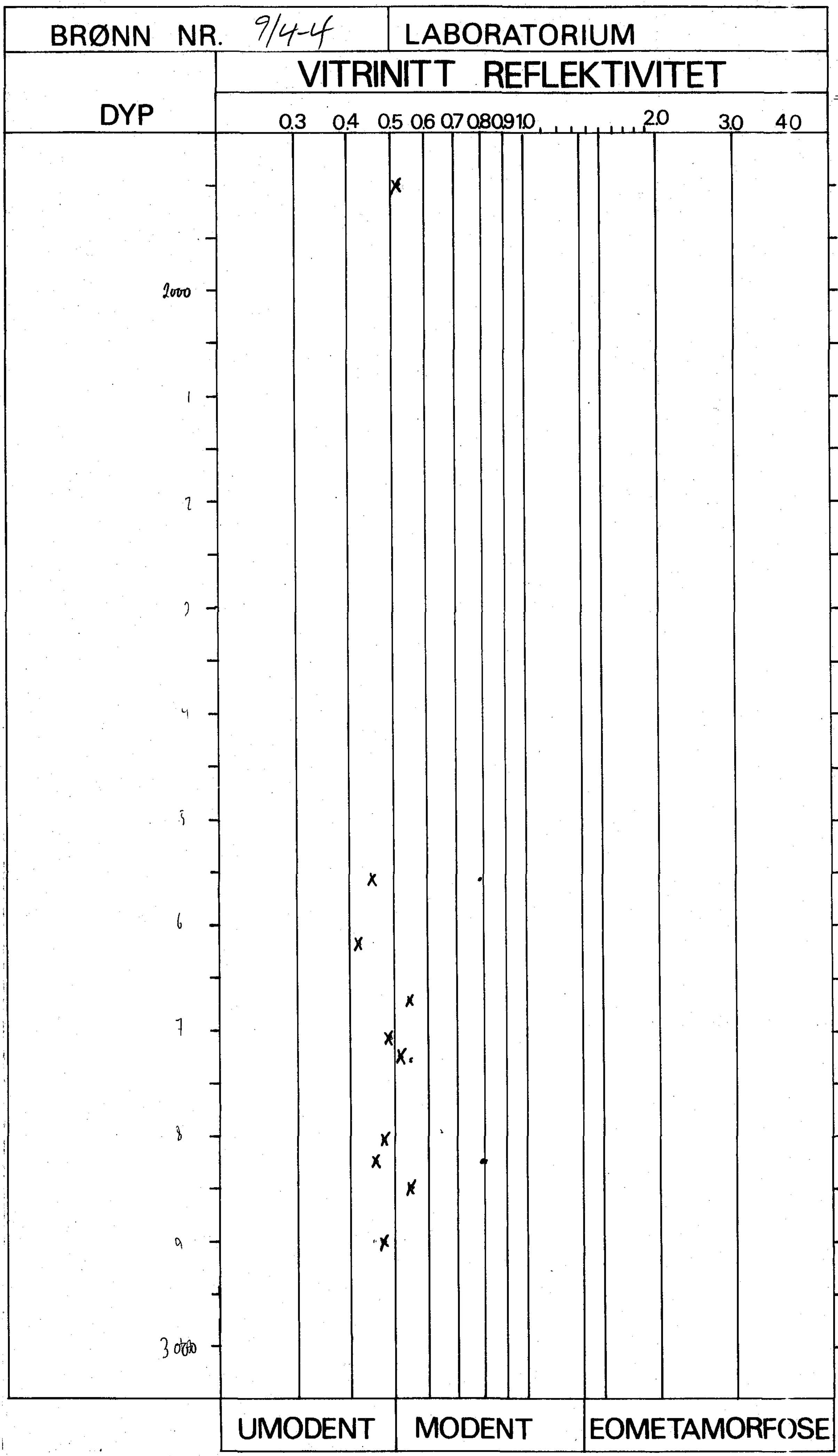
E. Bandlien	0-104/1

SCIENTIST	DATE	PROJECT NO.
M.Bjorøy, P.P.Gyørøsi, T.Rønningsland	24.9.77	
DEPARTMENT	NO. OF PAGES	NO. OF ENCLOSURE
Environmental section	23	7
	RESPONSIBLE SCIENTIST	
	Cand.real. Malvin Bjorøy	

SUMMARY The analysed sequence, 2560-2902 m, can be devided into four zones on the background of the light hydrocarbon data. A: 2560-2720 m, B: 2730-2810 m, C: 2820-2840 m, D: 2850-2902 m. Zone A has a good potential as a source for oil and gas for the first 100 m, and is moderate mature. The rest of the zone has a rich potential and is moderate to mature. Zone B is a sandstone and has no potential as a source for oil and gas. Zone C contains a large proportion of coal, and is immature. Zone D has a rich potential as a source for oil and gas, but is immature to moderate mature.
The vitrinite reflectance shows low values for the whole sequence, with reflectance values of 0.4-0.55. Maximum paleotemperature is calculated to be 45-50°C at the top of the sequence and 40°C at the base of the well.

KEY WORDS

Source Rock


BRØNN NR. 9/4-4
LABORATORIUM
VITRINITT REFLEKTIVITET
DYP
0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 2.0 3.0 4.0
2000
3000
UMODENT
MODENT
EOMETAMORFOSE

INDEX

EXPERIMENTAL

The canned samples were washed with temperated water on a 0.125 mm sieve to remove drilling mud and thereafter dried at 35^{o}C.

LIGHT HYDROCARBONS

Aliquotes of the samples were dried at room temperature after washing and sieved. The cuttings with 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 EC 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

Some of 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 m glass capillary column, using a Carlo Erba FV 2150 chromatograph. The measurements from the gaschromatograms are shown in Table VII.

VITRINITE REFLECTANCE

Four sidewall cores and six cutting samples were sent for vitrinite reflectance measurements at Geoconsultants, Newcastle upon Tyne.

Upon receipt, the cutting samples were soaked in warm water and sieved through 72 mesh to remove drilling mud. After oven drying at 40^{o}C, the cuttings were mounted in Bakelite resin blocks; care being taken during the setting in the plastic to avoid temperatures in excess of 100^{o}C. The samples were then ground, initially on a diamond 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 nm. 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 kerogen analyses were chosen from those used for biostratigraphic determination at another department at IKU. (Table VIII).

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 Staplin's index (Staplin, F.L. 1969: Sedimentary organic matter, organic metamorphism, and oil and gas occurence. Bull. Canad. Petr. Geol. 17 (1), 46-66).

The thermal alteration index indicates by 1 (fresh yellow) no alteration, 2 (brownish yellow) slight alteration, 3 (brown) moderate alteration, 4 and 5 (black) strong to severe alteration.

RESULTS AND DISCUSSION

Light Hydrocarbons

From the C_1 - C_4 hydrocarbon abundance, the wetness of the gas and the isobutane/n-butane (iC_4/nC_4) ratio, we can devide the analysed section, 2560-2902 m, into four zones, A: 2560-2720 m, B: 2730-2810 m, C: 2820-2840 m and D: 2850-2902 m.

A: 2560-2720 m. This zone has a C_1-C_4 hydrocarbon abundance which varies from 710 μl gas/kg rock at 2600 m to 2880 μl gas/kg rock at 2570 m. The main bulk of the samples have a C_1-C_4 hydrocarbon abundance of approx. 2000 μl gas/kg rock. The gas is quite wet and the wetness increases with increasing depth.

B: 2730-2810 m. This zone has a high degree of variation of both C_1-C_4 hydrocarbon abundance and wetness. There is a mixture of sand and shale in the samples, and this can cause the variation in abundance and wetness.

C: 2820-2840 m. In this zone we find the samples with the highest abundance of C_1-C_4 hydrocarbons and the highest degree of wetness. The samples show a marked drop in C_1-C_4 hydrocarbon abundance with increasing depth and also a drop in wetness, but this is not so sharp. The iC_4/nC_4 ratio shows a small increase over the same area. Particles of coal were detected in the samples.

D: 2850-2902 m. The drop in C_1-C_4 hydrocarbonabundance found in zone C continue into zone D. There is a marked drop in the wetness at 2850 m and we feel that this marked drop indicates a new zone. There is a high grade of variation in the C_1-C_4 abundance in the zone, while the gas wetness is more stable. The iC_4/nC_4 ratio shows a slight increase with increasing depth. The exception is sample 2902 m, which shows a remarkably difference from sample 2900 m. This difference is seen in all three parametres, with higher C_1-C_4 hydrocarbon abundance and lower gas-wetness and iC_4/nC_4 ratio. This might indicate that we are entering into a new zone.

Summary from C_1-C_4 hydrocarbonanalysis

A: Fair potential, with a moderate to wet gas. The whole sequence is a shale sequence.

B: Fair potential, wet gas. The lithological log show this zone to contain shale and sandstone.

Sidewall cores from the same sequence show this to be sandstone. Because of this we expect the shale fragments to be cavings. Casing was stopped at 1278 m. Table I and Fig. 1 show a large variation of C_1-C_4 hydrocarbon abundance in this zone and also variation in the wetness of the gas. We believe this to be due to the variation in lithology of the samples. The samples from this zone show a higher gas wetness than the samples from zone A. This increase in gaswetness in zone B, which is a sandstone, indicates that this might be a reservoir for hydrocarbons. We expect that there would have been a higher gaswetness if the samples had not been contaminated with shale cavings.

C: This zone shows a good potential, with 7400 μl gas/kg rock as the richest sample. The gas in this zone is very wet. The lithological log shows this zone to contain a lot of coal, and this would influence the results. The percentage of coal deminishes with increasing depth from 2820 m to 2840 m, and this is also seen on the C_1-C_4 hydrocarbon results, Table I, Fig. 1.

D: This zone has a poor potential but it contains a wet gas. The lithological log shows the zone to contain mainly shale, but with some sandstone.

Total Organic Carbon (TOC)

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

A: 2560-2720 m. This zone contains only shale, and it shows a good to fair potential. It has the poorest potential at the top (1,30% at 2560 m) and the TOC increases with increasing depth down to 2640 m where it has a maximum of 4.75%. From 2640 m the ROC value decreases towards the bottom of the zone.

B: 2730-2810 m. This zone has a mixed lithology of shale and sandstone. The shale might be cavings from zone A or higher up in the well. The shale shows a good potential with the exceptance of 2780 and 2790 where there is a rich potential. The sandstone samples in this zone have a high TOC value and this might indicate that hydrocarbons which have migrated into the sandstone act as a reservoir. Samples 2780 and 2790 show a remarcable high TOC content. This might come from small coal particles in the sandstone or from hydrocarbons. We find the first alternative the most likely. Sidewall cores from this zone show sandstone with small lenzes of bituminous material. This material is nearly coalified and would give a high TOC value if the sample contained some of it.

C: 2820-2840 m. The samples from this zone contained a large proportion of coal. Care was taken to remove this from the shales, but the TOC values show that this has not been successful.

D: 2850-2902 m. This zone contained a mixed lithology of shale and sandstone. The shale samples show a rich potential and a decreasing TOC value with increasing depth. The sandstone samples show again a remarkable high TOC value. We expect some of this to be because of coal cavings from the coalzone C. These coalparticles would be that small that it would be impossible to remove them by mecanical means.

Extractable Organic Matter (EOM) and Chromatographic Fractions

From the light hydrocarbon data and the TOC measurements, eleven samples were picked for extraction. Ten shale samples and sample 2820 m, which contained a large amount of coal were extracted, and the EOM fractionated on silica/alumina columns. The saturated hydrocarbon fractions were analysed gaschromatographicly.

A: Five samples from zone A were analysed, 2560, 2640, 2660, 2690 and 2720 m. Sample 2560 m has a good potential while 2640, 2660, 2690 and 2720 m must be classified as rich. The samples from the top of the zone are moderate mature and the maturity increases towards the bottom of the zone (Table VII, Fig. 3). Sample 2690, however, shows a high Carbon Preference Index (CPI) value, a low Pristane/ nC_{17} ratio and a high Pristane/Phytane ratio. The gc chromatogram looks very similar to those from higher up in the well, so the sample might contain a large proportion of cavings.

B: One sample of the shale cuttings is analysed. Since later data have shown that zone B is a sandstone (sidewall cores for biostratigraphic analyses) we assume now that the shale samples in zone B are cavings, and they will not be discussed further.

C: This zone is a coal bearing strata, and one sample was analysed from this sequence. Care was taken to avoid coal particles, but as the TOC results shows, this was not successful. This sample, 2820 m, shows extremely high pristane/nC_{17} and pristane/phytane ratios together with a high CPI value, which indicate an immature sample.

D: Four samples from this zone were analysed, 2850, 2860, 2880 and 2900. All the samples will be rated to have a rich source rock potential, and there are only small variations in the different chromatographic fractions.

The CPI values of the four samples are fairly equal, while we find some variations in the pristane/nC_{17} and pristane/phytane ratios (Table VII). These variations might be caused by coal particles from higher up in the well.

As mentioned above, the coal sample has high pristane/nC_{17} and pristane/phytane ratios, and this would influence the pristane/nC_{17} and pristane/phytane ratios more than the CPI values if there are contaminations from coal. On the whole, the chemical investigations show this zone to be immature to moderate mature.

VITRINITE REFLECTANCE

The samples for vitrinite reflectance from this well were quite good, and all the results are reliable. Over the sequence measured, the reflectance vary from 0.42 - 0.55. No definite gradient is found. Some of the samples contain quite a bit of bitumen. Together with the actual reflectance value (Table VIII), we also get other information, and in the following we will discuss each sample. Samples marked * are sidewall core samples.

1900 m: Shale and limestone. Ro = 0.52. The sample has a moderate organic content. Nearly all the particles are reworked, but there are some cuttings which are rich in good stringers of bitumen and vitrinite. UV light shows a very variable exinite content from cutting to cutting, and an orange fluorescence from spores. These samples were taken from cuttings for biostratigraphic measurements to try to find the gradient in the well. However, with a Ro of 0.52 for this sample, no distinct vitrinite reflectance gradient was found.

2560 m: Shale and siltstone. Ro = 0.45 and Ro = 0.79. The sample has a low to moderate organic content. The high Ro value is on rounded, gnarled particles of reworked material. Some inertinite is found together with wisps of bitumen. Little, if any, true vitrinite. UV light shows a yellow to orange fluorescence from spore fragments and a moderate to rich exinite content.

2620 m: Shale and carbonate. Ro = 0.42. The sample has a moderate to rich organic content with abundant, tenuous bitumen stringers and wisps. A lot of reworked particles and only a few vitrinite particles are found. UV litht shows a yellow and orange fluorescence from spores and a moderate to rich exinite content.

2673 m*: Shale. Ro = 0.54. The sample is rich in organic material, but it is mostly reworked particles of vitrinite and inertinite, and these are not measured. Very occasional particles with low Ro value, are found. No wisps or stringers are found in this sample. The sample also contains large bodies of pyrite. UV light show an orange fluorescence from spores and a moderate to rich exinite content.

2710 m: Siltstone and sandstone. Ro = 0.49. The sample has a rich organic content with large angular, interstitial areas of bitumen. A few particles of reworked material is also found. UV light shows an orange fluorescence from spores and a low exinite content.

2730 m: Shale. Ro = 0.51. The sample is rich in reworked particles of vitrinite and inertinite with some bitumen wisps and stringers. A few true vitrinite wisps are found. UV light shows a yellow to orange fluorescence from spores and a moderate exinite content.

2812 m*: Sandstone. Ro = 0.48. The sample has a moderate organic content, with a good content of interstitual bitumen with large, perfect areas. No other organic materials are recorded. UV light shows an orange fluorescence from spores in interstitial areas and a low exinite content.

2831.5 m*: Shale. Ro = 0.46 and Ro = 0.80. The sample has a moderate organic content with small reworked particles of vitrinite and inertinite. A little bitumen and some exinite is found, but only a trace of vitrinite. UV light shows a strong rather deep orange fluorescence from spores and resin and a moderate exinite content.

2850 m: Shale and siltstone. Ro = 0.54 and Ro = 0.70. The sample has a moderate organic content but it vary a lot from cutting to cutting. A lot of good wisps and stringers of vitrinite. Most of the material is reworked particles (the high Ro value). There are a few lignite cuttings in the sample. UV light shows an orange fluorescence from spores and resin and a moderate to rich exinite content.

2902 m: Mixed lithologies of shale, silt and sandstone. Ro = 0.47. The sample has a moderate organic content with good vitrinite stringers in carbargillite. A single coal cutting is recorded and there are a lot of reworked particles in shale with bitumen. UV light shows a yellow and orange fluorescence from spores which vary both in colour and content from cutting to cutting. There is a low to moderate exinite content.

By using the vitrinite reflectance data and the biostratigraphic dating of the well (IKU report 0100/1/77), the maximum paleotemperature of the samples can be calculated by the method developed by Karweil (J. Karweil, Z. Deut. Geol. Ges. 1956, 107, 132).

With using an age of approx. 150 x 10^6 years at 2560 m and 200 x 10^6 years at 2900 m we find that the top of the sequence (2560 m) has had a max. paleotemperature of 45-50^oC while the bottom of the sequence (2902 m) has had a max. paleotemperature of 40^oC (Fig. 7 and 8).

KEROGEN ANALYSIS

A detailed study of the kerogen content (acid-insoluble residue) from different samples has been undertaken by Cand.real. J. Os Vigran as a part of the palynological investigation/stratigraphic analyses of this well (IKU report 0-100/1/77), and the section from 2560 m to base of the well will be discussed here.

The kerogen in the analysed samples show them to be slight to moderate mature with a Staplin index of 2.2-2.3 (Table VIII). The small variation found in the index correspond with changes in lithology. The lowest values (lightest colours) are found in fine grained clastics, while the higher values (darker colours) are found in zones with carbonaceous rocks or sandy deposits.

In shale samples, where palynofacies/kerogen indicate a high content of marine organic remains, we would expect a possible source for oil and gas. Samples with a high content of marine organic remains are found in zone A and D (Fig. 5).

CONCLUSION

From the light hydrocarbon data, the sequence from 2560 to 2902 m can be devided into four different zones, A: 2560-2720 m, B: 2730-2810 m, C: 2820-2840 m, D: 2850-2902 m.

A: 2560-2720 m. This zone consists of shales, and the interval 2560-2650 m has a good potential as a source rock for oil and gas but both microscopical and chemical analyses show it to be moderate mature. The interval from 2660-2720 m has a rich potential as a source for oil and gas. The different analyses, vitrinite reflectance, visual kerogen, CPI measurements, pristane/phytane ratio etc., show this interval to be more mature than the interval above, but the difference is not very much. The chemical analyses show a bigger difference than the microscopical ones. This might be due to contamination from diesel which had been added to the drilling mud higher up in the well. But because of the increase in maturity shown both by vitrinite reflectance and by visual kerogen, we believe this to be a real increase of maturity.

B: 2730-2810 m. This zone is shown by both the electrical log and sidewall cores, to be a sandstone, but there might be small lenses of bitumen or shales. These lenses will have no interest in a source rock analysis. The shale cuttings found in the canned samples from this zone are believed to be mainly cavings. The TOC results show rather high values for the sandstone samples. This might be caused by coal fragments or migrated hydrocarbons. The visual kerogen shows the samples from this zone to contain quite a lot of coal fragments, which indicates the first alternative to be the correct. The sandsamples were not analysed for migrated hydrocarbons.

C: 2820-2840 m. This zone contains a lot of coal, and it is immature.

D: 2850-2902 m. This zone has a rich potential for oil and gas, but it is immature to moderate mature.

The vitrinite reflectance for the sequence 2560-2902 m shows no definite gradient and a rather low reflectance value for all the samples. Calculations of the maximum paleotemperature show that this sequence has only been subjected to low to moderate heat, with a max. paleotemperature of 45-50^{o}C at the top of the sequence and 40^{o}C at the base of the well.

TABLE I

Concentration (l gas/kg rock) of C_1 - C_5 hydrocarbons in cuttings.

Depth (m)	C_1	C_2	C_3	iC_4	nC_4	iC_5	nC_5	Tot. C_1-C_4	Tot. C_2-C_4	% Gas wetness	iC_4/nC_4
2560	1205	151	74	41	44	55	19	1515	310	20.5	0.93
2570	2304	334	151	32	60	36	19	2881	577	20.0	0.53
2580	1002	130	66	36	45	50	23	1279	277	21.7	0.80
2590	1145	131	64	31	40	40	15	1411	266	18.9	0.78
2600	579	74	31	10	15	15	6	709	130	18.3	0.67
2610	1035	136	75	37	60	68	28	1343	308	23.0	0.62
2620	970	136	105	77	98	151	59	1386	416	30.0	0.79
2630	1234	167	110	73	103	161	75	1687	453	26.9	0.71
2640	989	156	128	93	115	255	112	1481	492	33.2	0.81
2650	1264	197	148	87	107	172	75	1803	539	29.9	0.81
2660	1397	215	154	86	110	166	71	1962	565	28.8	0.78
2670	1747	286	193	107	140	207	100	2473	726	29.4	0.76
2680	1258	218	200	132	292	350	242	2100	842	40.1	0.45
2690	1340	244	190	117	209	245	160	2100	760	36.2	0.56
2700	1246	199	138	92	153	227	146	1828	582	31.8	0.60
2710	1345	246	192	120	213	251	164	2116	771	36.4	0.56
2720	1340	203	179	122	220	321	223	2064	724	35.1	0.55
2730	1362	223	244	149	414	380	313	2392	1030	43.1	0.36

T A B L E I - cont.

Depth(m)	C_1	C_2	C_3	iC_4	nC_4	iC_5	nC_5	Tot. C_1-C_4	Tot. C_2-C_4	% Gas wetness	iC_4/nC_4
2740	3118	549	271	106	307	316	298	4351	1233	28.3	0.35
2750	1272	208	200	113	304	273	224	2097	825	39.3	0.37
2760	1146	158	127	76	126	151	97	1633	487	29.8	0.60
2770	1225	237	152	41	77	76	49	1732	507	29.3	0.53
2780	2120	351	446	240	607	467	389	3764	1644	43.7	0.40
2790	677	106	183	120	280	273	216	1366	689	50.4	0.43
2800	1540	267	277	153	396	349	273	2633	1093	41.5	0.39
2810	786	113	90	45	97	111	80	1131	345	30.5	0.46
2820	978	1435	3522	514	953	343	178	7402	6424	86.8	0.54
2830	710	466	1830	411	620	403	224	4037	3327	82.4	0.66
2840	568	162	835	299	379	311	145	2243	1675	74.7	0.79
2850	699	173	238	78	147	128	93	1335	636	47.6	0.53
2860	453	94	176	60	92	83	50	875	422	48.2	0.65
2870	444	98	219	76	137	121	84	974	530	54.4	0.55
2880	589	125	240	81	126	110	67	1161	572	49.3	0.64
2890	296	55	176	51	69	55	28	647	351	54.3	0.74
2900	192	41	97	40	42	50	19	412	220	53.4	0.95
2902	450	80	152	53	109	91	65	844	394	46.7	0.49

TABLE II

Lithology and Total Organic Carbon(TOC) measurements.

Sample depth(m)	TOC	Lithology
256o	1.3o	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite. Quartz, Carbonate, Coal, observed.
257o	1.42	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
258o	1.7o	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
259o	2.o5	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
26oo	2.o7	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
261o	2.55	1oo% Siltstone, grey to dark grey; with muscovite.
262o	3.99	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
263o	3.oo	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
264o	4.75	1oo% Siltstone, grey to dark grey; with muscovite. Glauconite, observed.
265o	4.26	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite.
266o	4.12	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite. 1% Chalk. Pyrite, observed.
267o	3.3o	1oo% Siltstone to silty Claystone, grey to dark grey; with muscovite. Chalk, sporadic.
268o	3.6o	1oo% Siltstone to silty Claystone, grey to dark grey, some brownish fragments; with muscovite. Chalk, sporadic. Pyrite, observed.
269o	2.9o	1oo% Siltstone to silty Claystone, grey to dark grey, some brownish fragments; with muscovite. Quartz, Chalk, sporadic. Pyrite, observed.

TABLE II - p.2

Sample depth(m)	TOC	Lithology
27oo	2.92	97% Siltstone, partly silty Claystone, light grey to dark grey, partly brownish; with muscovite. 2-3% Limestone, light brown; Chalk. Pyrite, observed.
271o	2.35	98% Siltstone, partly silty Claystone, light grey to dark grey, some brownish fragments; with muscovite. Pyrite, observed. 2% Limestone,light brown.
272o	2.9o	96% Siltstone, partly silty Claystone, light grey to dark grey, some brownish fragments; with muscovite. 3% Quartz sand. 1-2% Limestone, light brown; Chalk.
273o	1.7o 1.25	6o% Siltstone, partly silty Claystone, light grey to dark grey; with muscovite. 4o% Quartz sand. Limestone, light brown; Chalk, sporadic. Pyrite, observed.
274o	1.35	6o% Siltstone to silty Claystone, light grey to dark grey, some brownish fragments; with muscovite. 4o% Quartz sand. Limestone, light brown, sporadic. Glauconite, Pyrite, observed.
275o	o.99 o.73	45% Siltstone, light grey to dark grey; with muscovite. 55% Quartz sand. Pyrite, observed.
276o	1.85 o.74	6o% Siltstone to silty Claystone, light grey to dark grey; with muscovite. 4o% Quartz sand. Chalk; Limestone, light brown, sporadic. Glauconite, Pyrite, observed.
277o	1.63 1.6o	6o% Siltstone, light grey to dark grey; with muscovite. 4o% Quartz sand. Chalk, sporadic. Coal, observed.
278o	5.o5 2.o5	5o% Siltstone to silty Claystone, light grey to dark grey, partly brown; with muscovite. 5o% Quartz sand. Pyrite, Coal, observed.
279o	4.25 1.89	4o% Siltstone to silty Claystone, light grey to dark grey; with muscovite. 6o% Quartz sand. Chalk, small amounts. Coal, observed.

T A B L E II - p.3

Sample depth(m)	TOC	Lithology
28oo	1.75	35% Siltstone to silty Claystone, light grey to dark grey; with muscovite.
	o.51	65% Quartz sand.
		Chalk, small amounts.
		Pyrite, observed.
281o	1.45	75% Siltstone, partly silty Claystone, light grey to dark grey; with muscovite.
	1.15	25% Quartz sand.
		Chalk, very sporadic.
		Pyrite, observed.
282o		6o% Coal, partly shiny, concoidal, homogenous; leaf and wood tissues.
	17.8o	2o% Siltstone, partly Claystone, light grey to dark grey; with muscovite.
	16.o5	2o% Quartz sand.
		Pyrite, observed.
283o		44% Coal, partly shiny, concoidal, leaf and wood tissues.
	17.oo	44% Siltstone to Claystone, light grey to dark grey, some brownish fragments, with muscovite.
	15.84	1o-15% Quartz sand.
		Chalk, sporadic.
		Pyrite, observed.
284o		3o% Coal, partly shiny, concoidal, homogenous; leaf and wood tissues.
	8.81	63% Siltstone to Claystone, light grey to dark grey and brown; with muscovite.
		6% Quartz sand.
		1% Chalk.
		Pyrite, observed.
285o	4.25	93% Siltstone to Claystone, light grey to dark grey and brown.
		3% Coal.
		3-4% Quartz sand.
		Limestone, light brown; Chalk, sporadic.
		Pyrite,observed.
286o	4.53	82% Siltstone to Claystone, light grey to dark grey and brown; with muscovite.
		2% Coal.
	2.96	15% Quartz sand.
		1% Chalk.
		Pyrite, observed.
287o	3.15	86% Siltstone and some Claystone, grey to dark grey and brown; with muscovite.
		2% Coal.
	1.9o	12% Quartz sand.
		Chalk, sporadic.
		Pyrite, observed.

TABLE II - p.4

Sample depth(m)	TOC	Lithology
288o	3.95	85% Siltstone to Claystone, grey to dark grey and light brown; with muscovite.
	2.34	15% Quartz sand.
		Chalk, Coal, sporadic.
		Pyrite, observed.
289o	4.o5	75% Claystone to Siltstone, grey to dark grey and light brown; with muscovite.
		25% Quartz sand.
		Chalk, Coal, sporadic.
		Pyrite, observed.
29oo	2.4o	45% Claystone to Siltstone, grey to dark grey and light brown; with muscovite.
	o.72	55% Quartz sand.
		Pyrite, Coal, observed.
29o2	2.1o	4o% Claystone to Siltstone, grey to dark grey and light brown.
	o.63	6o% Quartz sand.
		Chalk, sporadic.
		Pyrite, observed.

The percentages are approximate.

T A B L E III

Weight (mg) of EOM and chromatographic fractions.

Depth(mg)	Rock extracted(g)	EOM	Sat	Aro	Hydrocarbons HC	Non Hydrocarb.
256o	41.5	24.o	3.9	4.2	8.1	14.1
264o	1oo.3	3o7.4	51.2	76.4	127.6	178.1
266o	1oo.1	227.6	47.9	59.8	1o7.7	114.2
269o	1oo.2	135.4	21.o	35.3	56.3	77.4
272o	69.6	251.6	1o.2	3o.2	4o.4	2o8.6
278o	1oo.6	469.5	6.4	98.5	1o4.9	349.3
282o	1oo.3	185o.2	55.1	446.2	5o1.3	1339.3
285o	1oo.o	16o.1	9.o	53.1	62.1	94.8
286o	1oo.o	193.9	11.2	52.2	63.4	129.1
288o	82.5	152.o	4.o	38.4	42.4	1o8.3
29oo	28.4	41.7	2.6	8.2	1o.8	16.8

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.
256o	58o	94	1o1	195	34o
264o	3o6o	51o	762	1272	1776
266o	227o	479	597	1o76	1141
269o	135o	21o	352	562	772
272o	361o	147	434	581	2997
278o	467o	64	979	1o43	3472
282o	1845o	549	4449	4998	13353
285o	16oo	9o	531	621	948
286o	194o	112	522	634	1291
288o	1842	48	465	541	1313
29oo	1468	92	289	38o	592

TABLE V

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

Depth(m)	EOM	SAT	Aro	Total hydrocarb.	Non hydrocarb.
256o	44.5	7.2	7.8	15.o	26.1
264o	64.5	1o.8	16.o	26.8	37.4
266o	55.2	11.6	14.5	26.1	27.7
269o	46.8	7.3	12.2	19.4	26.7
272o	124.7	5.1	15.o	2o.1	1o3.4
278o	92.4	1.3	19.4	2o.7	68.8
282o	1o3.6	3.1	25.o	28.1	74.7
285o	37.6	2.1	12.5	14.6	22.3
286o	42.8	2.5	11.5	14.o	28.5
288o	45.1	1.2	11.4	12.6	32.1
29oo	63.o	3.9	12.4	16.3	25.4

T A B L E VI

Composition in % of the material extracted from the rock.

Depth(m)	Sat/EOM	Aro/EOM	HC/EOM	Sat/Aro	Non HC/EOM	HC/Non HC
256o	16.3	17.5	33.8	92.9	58.8	57.5
264o	16.7	24.9	41.5	67.o	57.9	71.7
266o	21.1	26.3	47.3	8o.1	5o.2	94.3
269o	15.5	26.1	41.6	59.5	57.2	72.7
272o	4.1	12.o	16.1	33.8	82.9	19.4
278o	1.4	21.o	22.3	6.5	74.4	3o.o
282o	3.o	24.1	27.1	12.4	72.4	37.4
285o	5.6	33.2	38.8	17.o	59.2	65.5
286o	5.8	26.9	32.7	21.5	66.6	49.1
288o	2.6	25.3	27.9	1o.4	71.3	39.2
29oo	6.2	19.7	25.9	31.7	4o.3	64.3

T A B L E VII

Tabulation of datas from the gaschromatograms.

Depth(m)	Pristane/nC_{17}	Pristane/Phytane	CPI
256o	1.46	1.48	1.22
264o	1.26	1.18	1.23
266o	1.31	1.33	1.o9
269o	1.24	1.45	1.21
272o	1.64	1.22	1.o9
278o	1.84	2.25	1.o6
282o	8.7o	13.39	1.62
285o	2.o3	3.31	1.33
286o	1.62	2.94	1.33
288o	2.31	5.21	1.28
29oo	1.15	1.76	1.22

T A B L E VIII

Vitrinite reflectance and visual kerogen.(Number of particles measured for vitrinite reflectance in brachets).

Depth(m)	Visual kerogen	Vitrinite reflectance
19oo	2.2 - 2.3	o.27(1) o.52(2o)
256o	2.2 - 2.3	o.45(6) o.79(1)
262o	2.2 -	o.25(1) o.42(7)
2673*	2.2 - 2.3	o.55(4)
271o*	- 2.3	o.49(2o)
273o	- 2.3	o.28(2) o.51(8)
2812	2.2 - 2.3	o.48(2o)
2831.5*	2.2 - 2.3	o.46(16) o.8o(6
285o	2.2 - 2.3	o.54(15) o.7o(7)
29o2	- 2.3	o.24(2) o.47(18)

* Side wall cores.

PRESENTATION OF ANALYTICAL DATA

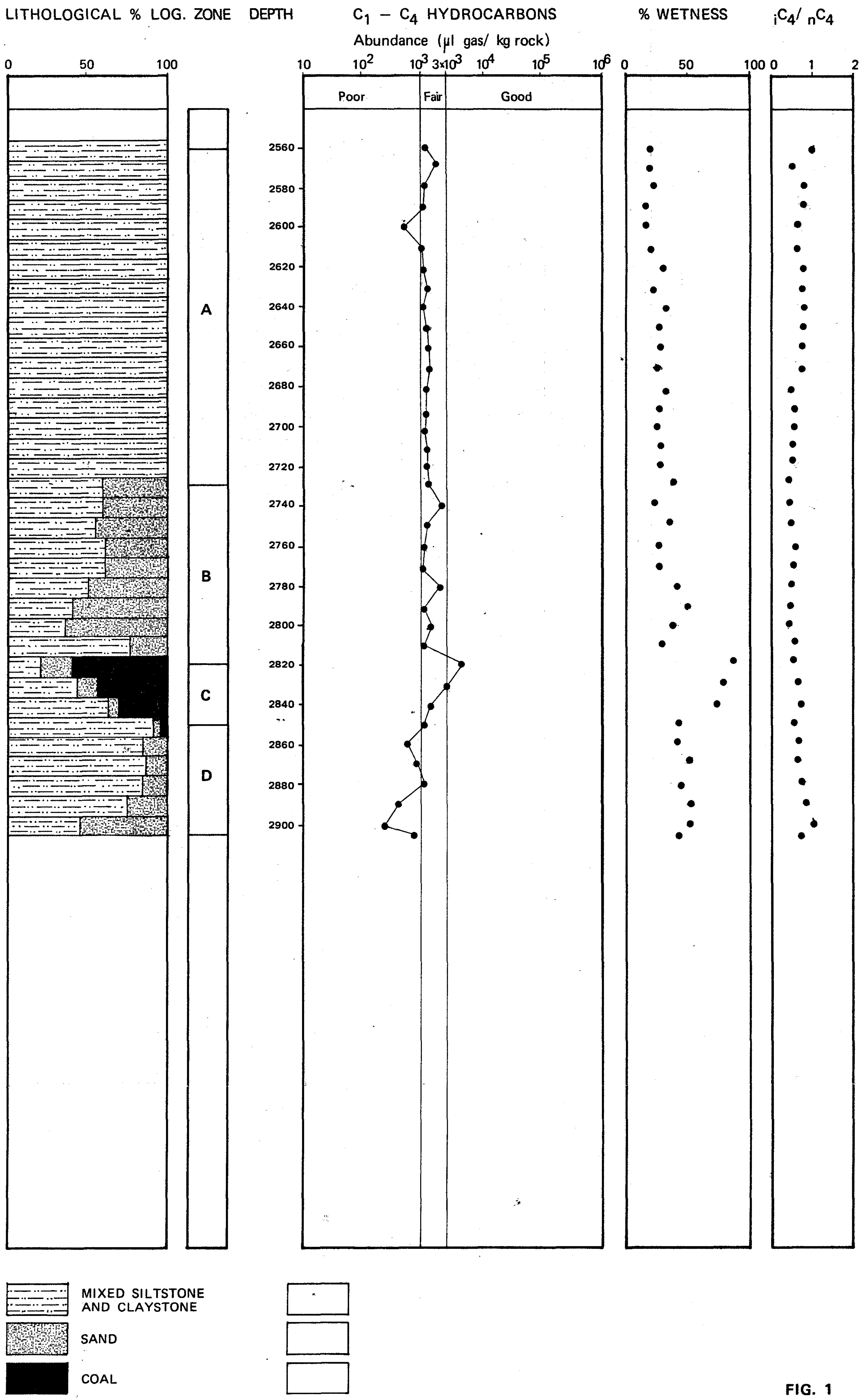
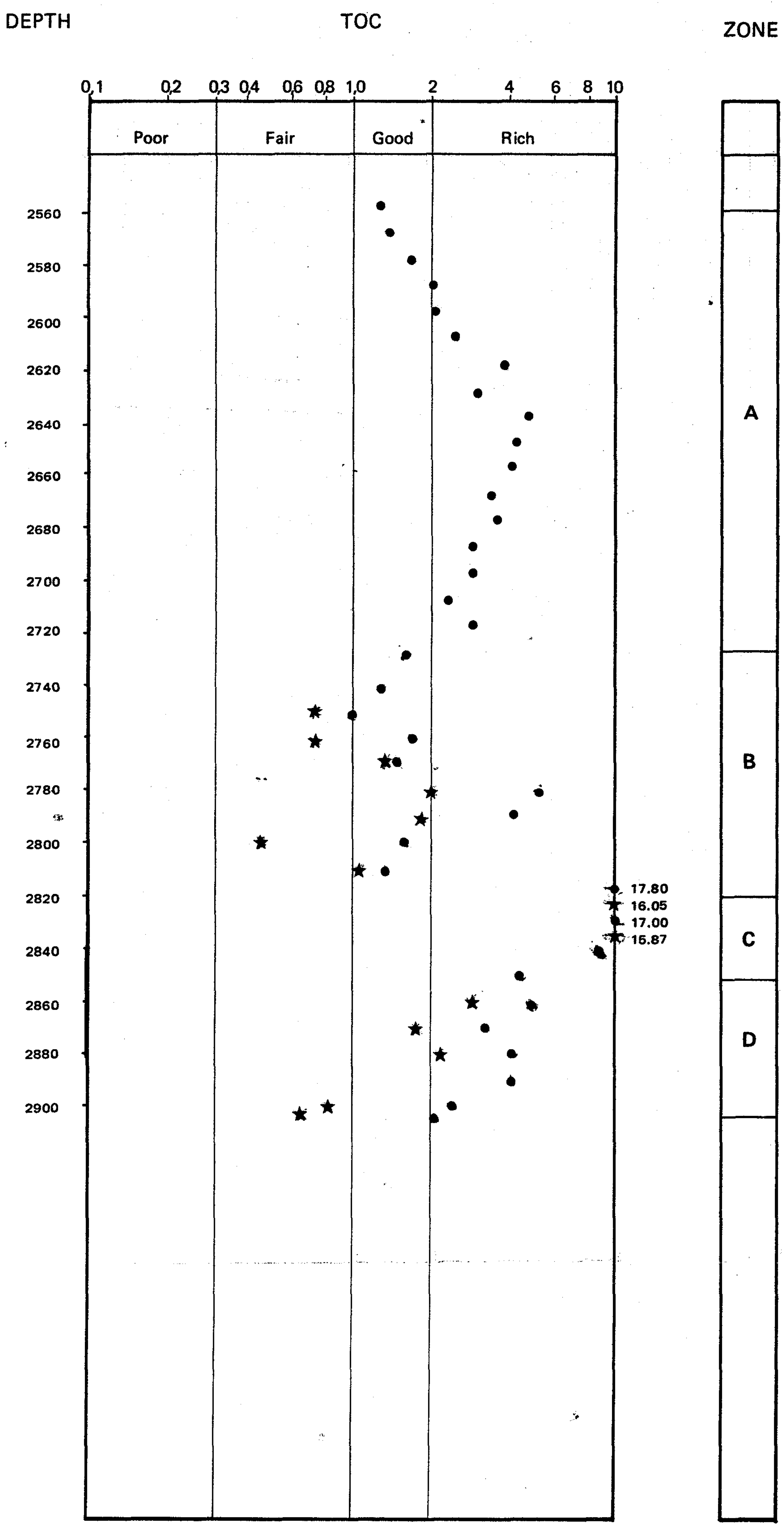


FIG. 1

TOTAL ORGANIC CARBON (TOC) AND C_R / C_T

Presentation of analytical Data



TOC : Total Organic Carbon

C_R/C_T : Organic Carbon Residue/ Total Organic Carbon

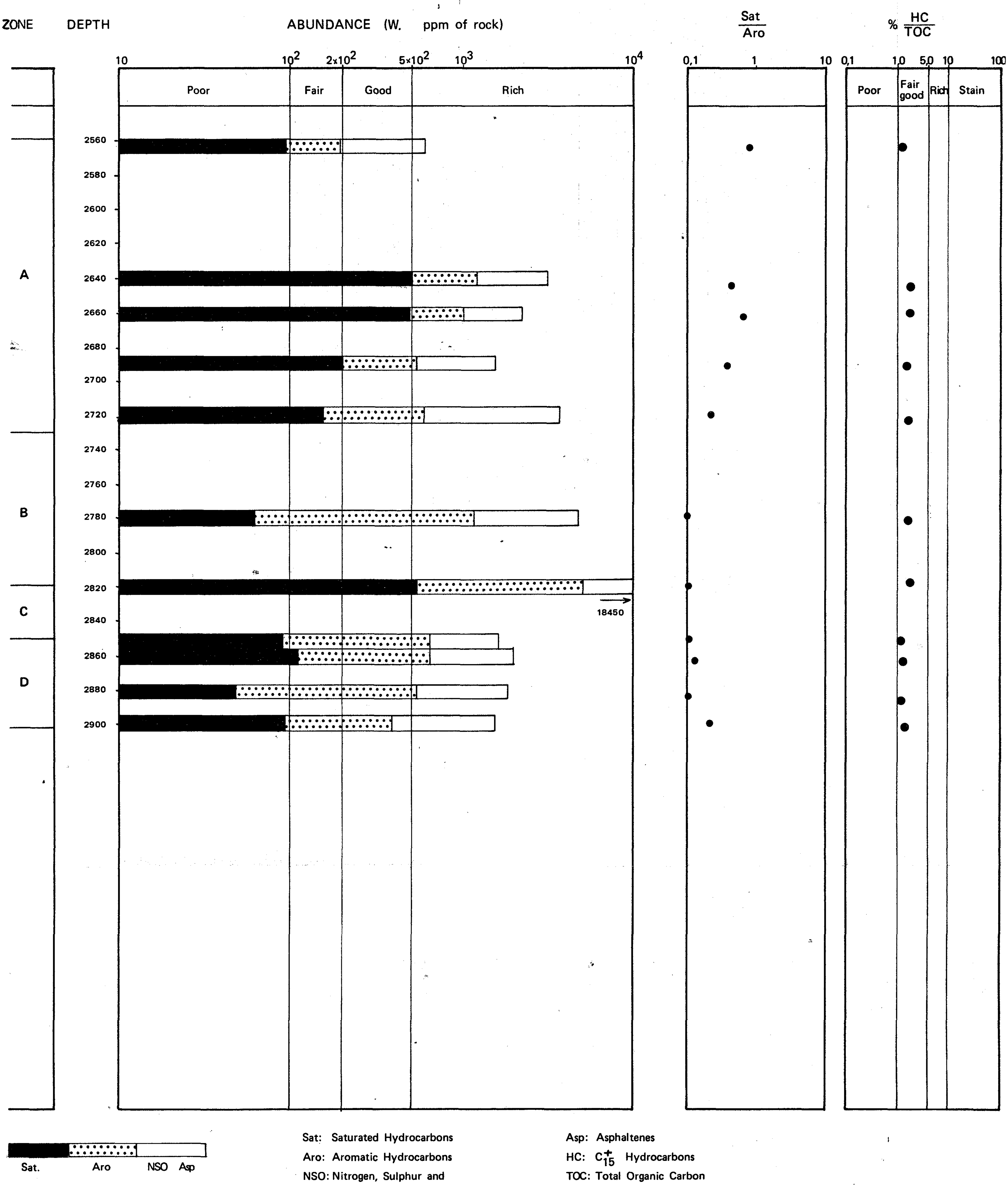
● : Shale

★ : Sandstone

FIG. 2

C_{15}^{+} HYDROCARBONS

Presentation of Analytical Data



Sat: Saturated Hydrocarbons

Aro: Aromatic Hydrocarbons

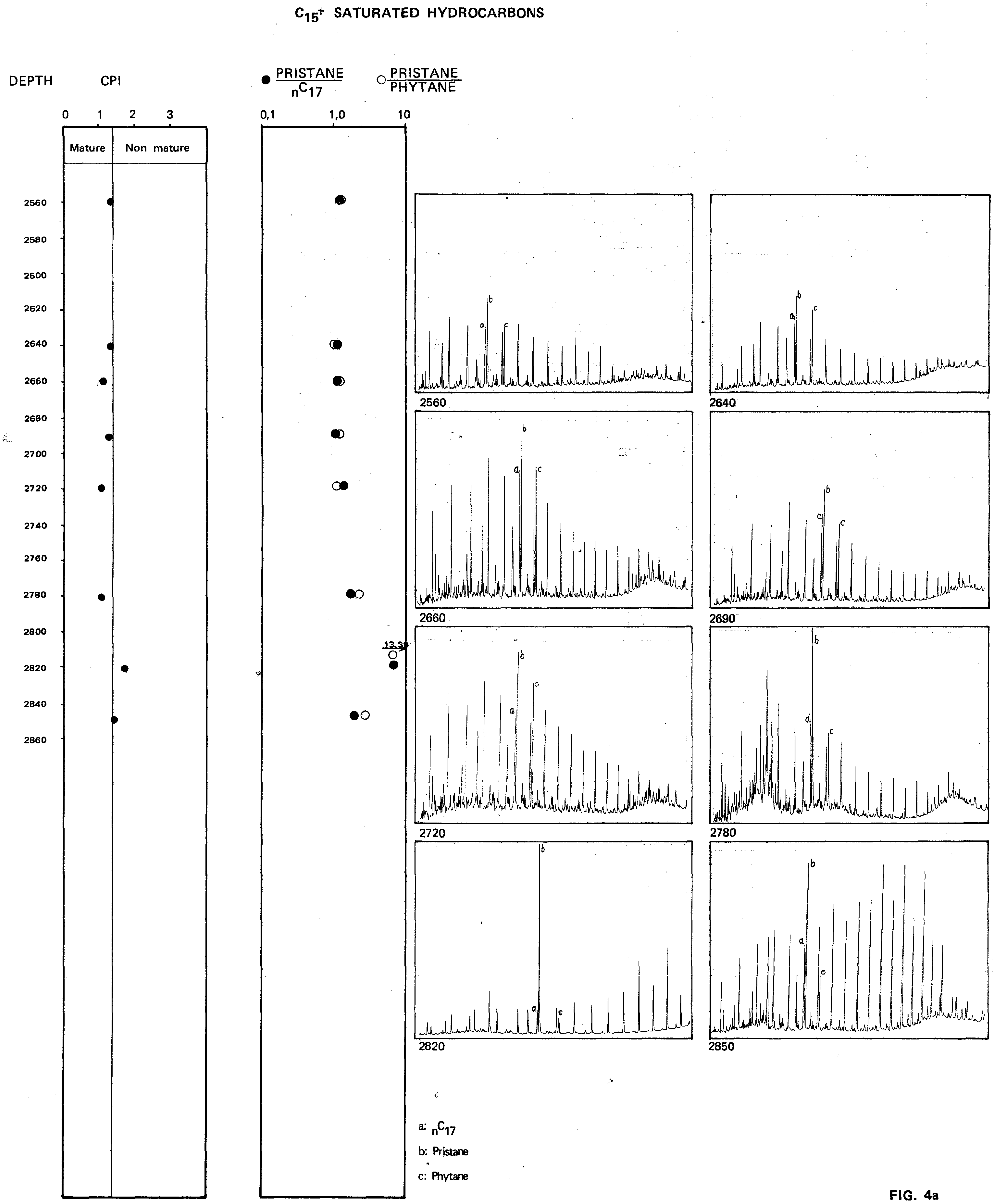
NSO: Nitrogen, Sulphur and Oxygen containing compounds

Asp: Asphaltenes

HC: C_{15}^{+} Hydrocarbons

TOC: Total Organic Carbon

FIG. 3



C_{15}^+ SATURATED HYDROCARBONS
DEPTH
CPI
0 1 2 3
Mature
Non mature
● PRISTANE / nC_{17}
○ PRISTANE / PHYTANE
0,1 1,0 10
2560
2580
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
2820
2840
2860
13,39
2560
2640
2660
2690
2720
2780
2820
2850
a: nC_{17}
b: Pristane
c: Phytane

FIG. 4a

C_{15}^{+} SATURATED HYDROCARBONS

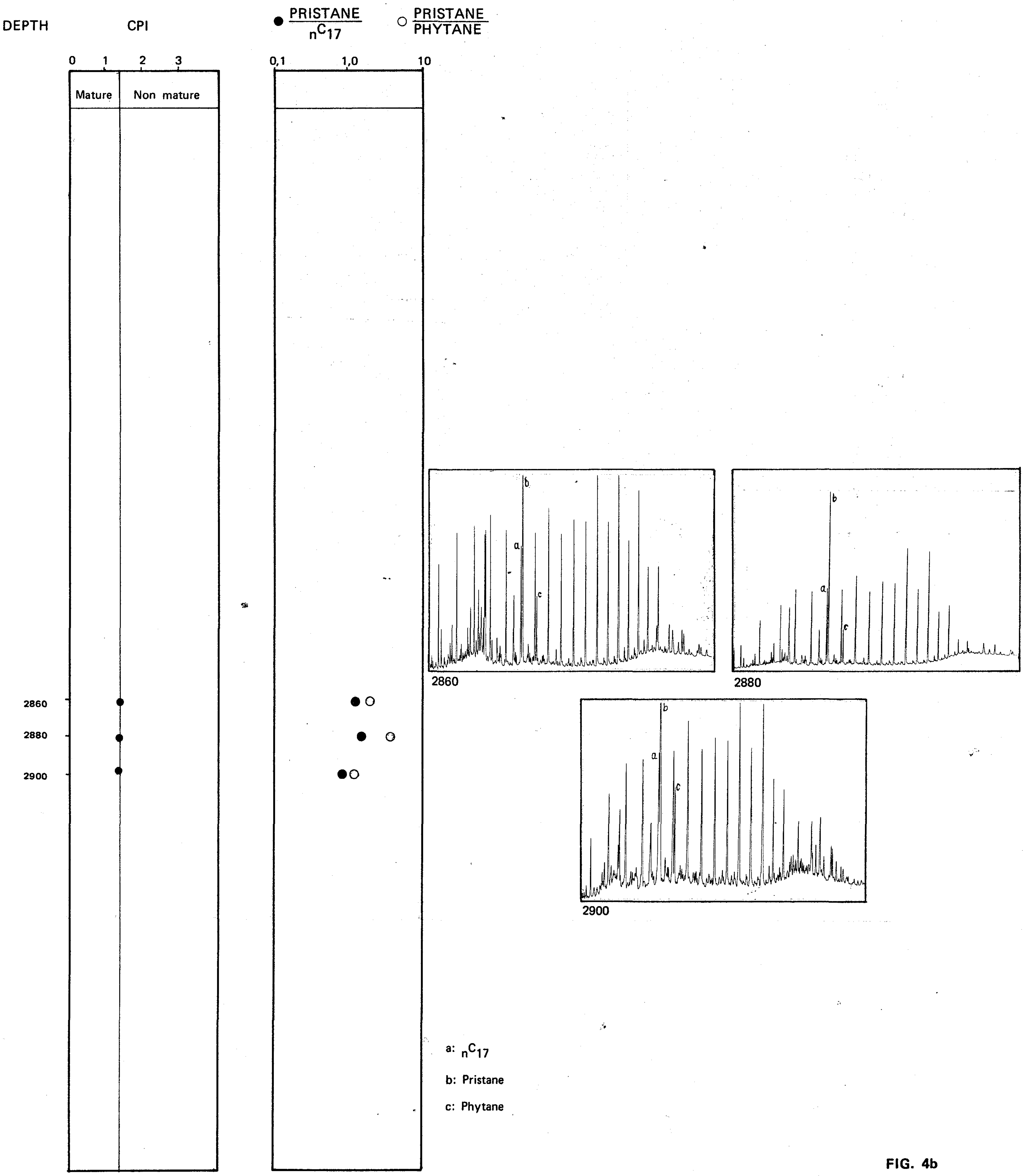
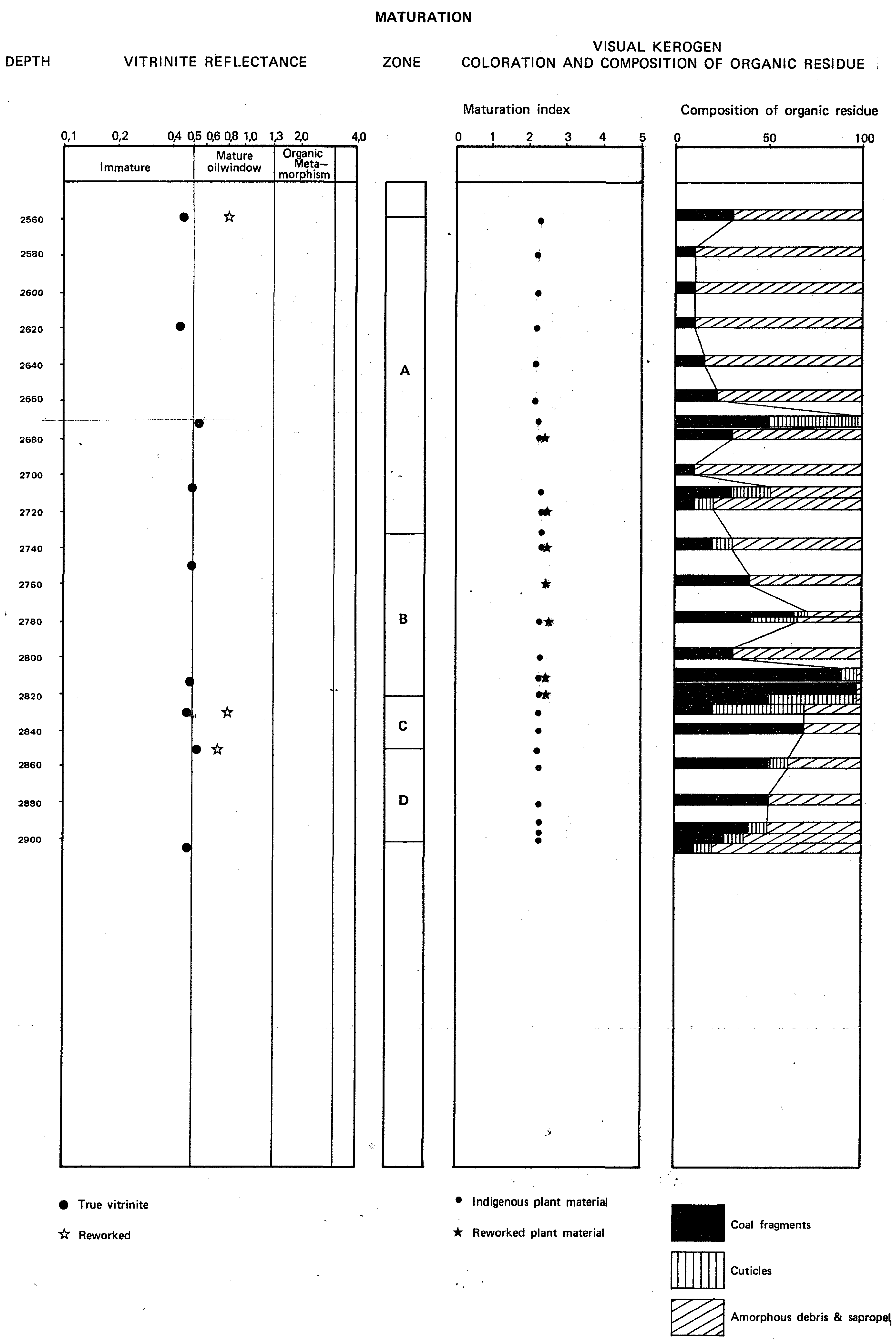


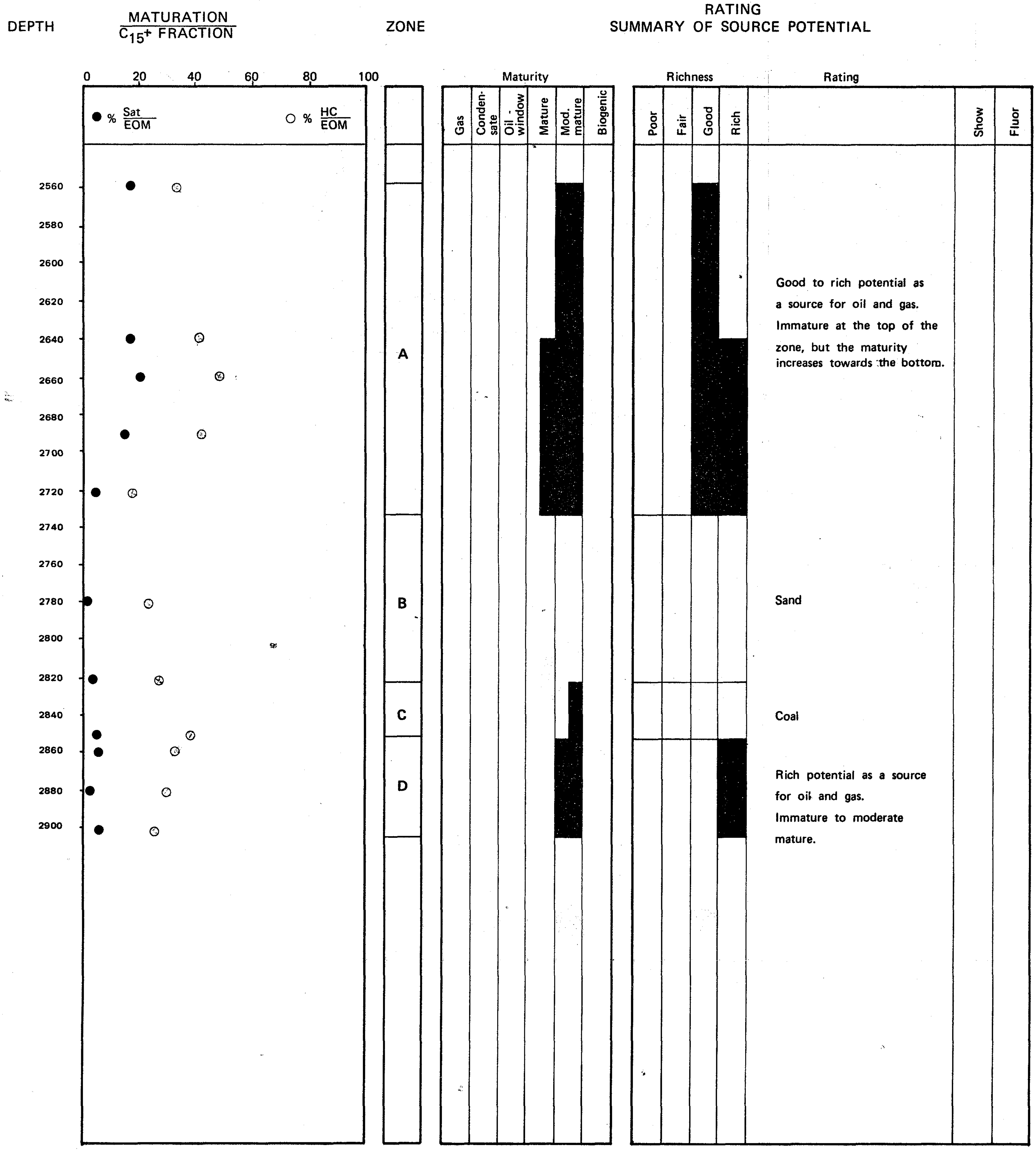
FIG. 4b



MATURATION
DEPTH
VITRINITE REFLECTANCE
ZONE
VISUAL KEROGEN
COLORATION AND COMPOSITION OF ORGANIC RESIDUE
Maturation index
Composition of organic residue
0,1 0,2 0,4 0,5 0,6 0,8 1,0 1,3 2,0 4,0
Immature
Mature oilwindow
Organic Meta– morphism
0 1 2 3 4 5
0 50 100
2560
2580
2600
2620
2640
2660
2680
2700
2720
2740
2760
2780
2800
2820
2840
2860
2880
2900
A
B
C
D
True vitrinite
Reworked
Indigenous plant material
Reworked plant material
Coal fragments
Cuticles
Amorphous debris & sapropel

FIG. 5

INTERPRETATION DIAGRAM



Sat: Saturated Hydrocarbons

HC: Hydrocarbons

EOM: Extractable Organic Matter

FIG. 6

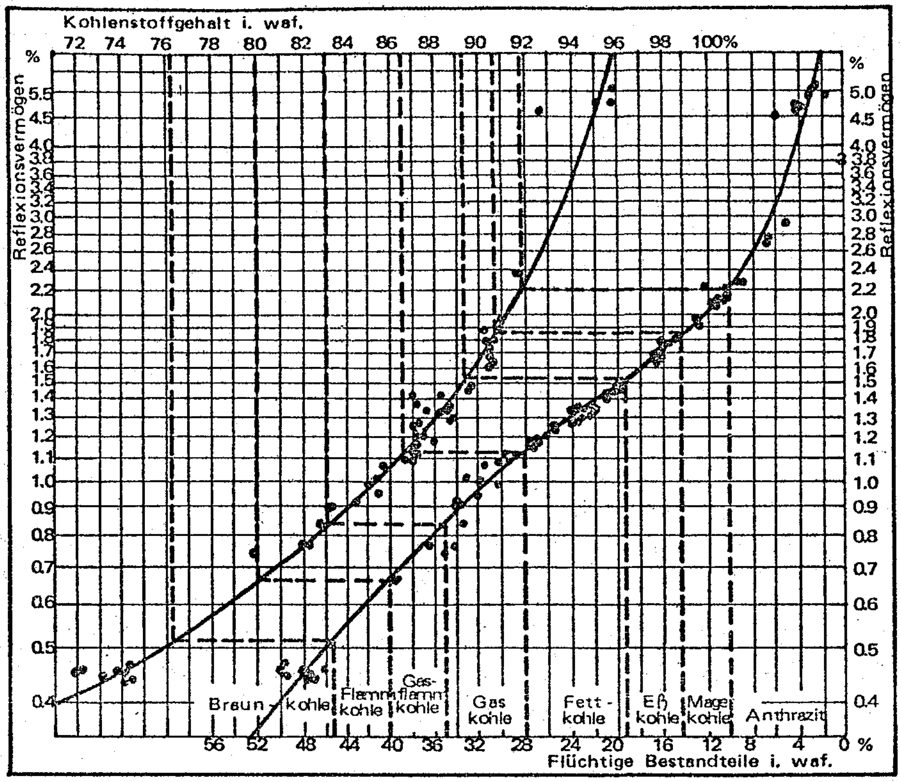


Fig. 7. Reflectance / volatile matter / carbon content / correlation curves

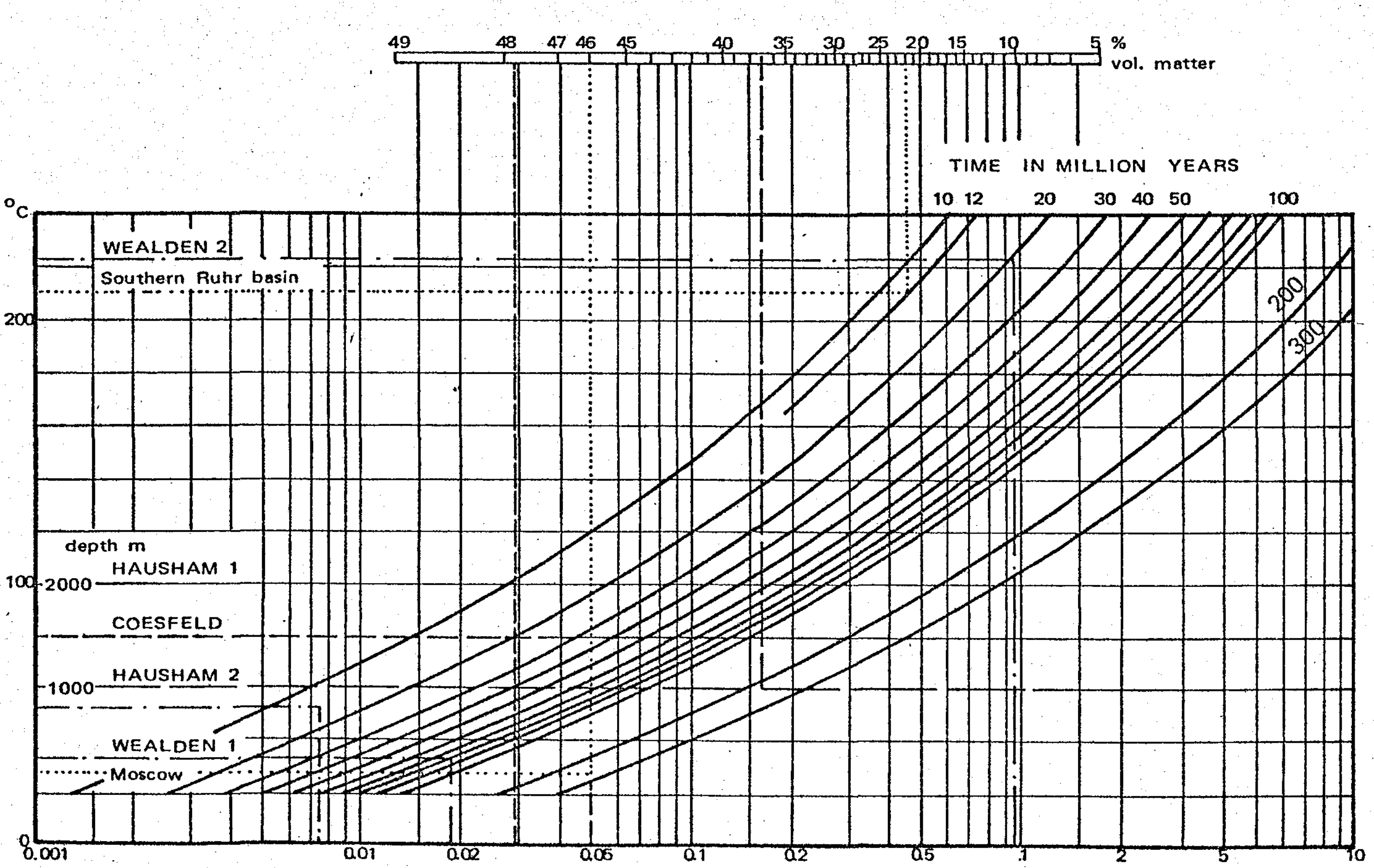


Fig. 8. Relationship between coal rank (volatile matter), temperature and coalification time (from Karweil 1956).