ROBERTSON RESEARCH INTERNATIONAL LIMITED

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REPORT ON A GEOCHEMICAL EVALUATION OF THE INTERVAL 2005m TO 2961m IN THE SAGA 34/4 - 1 WELL, NORWEGIAN NORTH SEA.

by

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SUMMARY

The Cretaceous and Triassic sediments from the interval 2005 to 2961 metres in the Saga 34/4-1 well are mature for the generation of oil but contain no potential source rock horizons. Migrant oil is present over most of this section .

I

INTRODUCTION

This report presents the results of a geochemical study of the interval 2005 to 2961 metres in the Saga 34/4-1 wildcat well, Norwegian North Sea. 75 wet ditch cuttings samples in sealed cans were provided at 15 metre intervals including 10 samples from side track 1 taken over the interval 2355 to 2488 metres. Maturity was established in the analysed section by spore colouration, airspace gaseous hydrocarbon and gasoline range hydrocarbon analyses; source rock capacity by organic carbon determination and Rock-Eval pyrolysis. Extracts of oil stained samples were examined by gas chromatography.

The following samples were analysed during this study:

1.	Sample preparation	75 samples
2.	Organic carbon content	59 samples
3.	Pyrolysis	15 samples
4.	Airspace gas analysis	74 samples
5.	Gasoline analysis	12 samples
6.	Extraction and gas chromatography	4 samples
7.	Spore Colouration/kerogen description	11 samples

Ages used in this report are taken from the RRI biostratigraphy Report No. 2491. No logs were provided by the client for use in interpretation of data obtained by our analyses.

II

RESULTS AND INTERPRETATION

A. THERMAL MATURITY

Oil-prone organic matter is early mature at the top of the analysed section (2005 metres) and reaches middle maturity (peak oil generation zone) in the Triassic section below 2715 metres.

1. Spore Colouration (Table 1 and Figure 1)

Marine microplankton dominated kerogen residues examined from the Cretaceous interval and although land-plant spores were relatively rare over both the Cretaceous and Triassic sections, sufficient numbers of suitable spores were present to establish the maturity level. Indigenous Late and Middle Triassic spores gave good control between 2535 and 2805 metres. The difference in spore colours across the Cretaceous - Triassic unconformity is not wide, suggesting that any Jurassic sediments deposited and subsequently eroded were of no great thickness. The Cretaceous interval between 2005 and 2455 metres is early mature and the Triassic interval between 2535 and 2805 metres approaches middle maturity with respect to oil - generating kerogen.

2. Airspace Gas Analysis (Table 2 and Figure 2)

Between 2005 and 2745 metres both total amounts of airspace gas and the proportion of wet gases are consistently high. Below 2745 metres, total gas amounts decrease but wet gas content is still relatively high. No maturity conclusions can be drawn from these data but the high concentration of methane to butane gases in the airspaces of the sample cans suggests the presence of migrant hydrocarbons. The marked change in composition and slight increase in amount of gas below about 2500 metres corresponds to the stratigraphic and lithologic boundary between the Cretaceous and Triassic sections. The presence of large quantities of wet gases above the unconformity suggests that there is substantial seepage of hydrocarbons through the Cretaceous claystones up to at least 2000 metres depth. It is also of note that the abundance of gases is markedly lower below about 2600 metres but that the composition of the gases does not change till below about 2800 metres. It may be suggested that this interval 2600 to 2800 metres is water bearing and that water flushing is occurring.

3. Gasoline Hydrocarbon Analysis (Table 3 and Figure 3)

All the samples analysed for gasoline type and abundance in the interval 2005 to 2550 metres show mature profiles, rich in light hydrocarbon species. In view of the lack of oil prone organic matter in the sediments and the likely presence of migrant hydrocarbons suggested by airspace gas analysis, it appears probable that these gasoline hydrocarbons are also migrant in which case no maturity conclusions may be drawn from the data.

4. Pyrolysis (Table 4 and Figure 4)

Temperatures of maximum rates of pyrolysis in the interval 2095 to 2490 metres (420°C to 429°C) are compatible with an early level of organic maturity.

B. SOURCE ROCKS

The Cretaceous interval, 2005 to 2490 metres, contains organic matter of non-oil source type. The organic content of the Triassic interval 2505 to 2961 metres, is low. No source rocks have been identified in either section.

1. Organic Carbon and Pyrolysis (Table 4 and Figure 4)

Organic carbon determinations were made on samples at 15 metre intervals over the section 2005 to 2820 metres. No analyses were made on samples from sidetrack 1, 2355 to 2488 metres since, after washing, these were seen to contain mainly cement. Samples from 2835 to 2961 metres contained mainly sand and sandstone and consequently were not analysed.

Pyrolysis analysis was undertaken on 12 total samples from the Cretaceous interval, 2 picked shales from the Triassic and on one composite of large fragments of grey claystone (possibly cavings) from the interval 2050 to 2335 metres.

2. Kerogen Typing (Table 1)

All the samples examined for spore colouration were also inspected to estimate type and abundance of organic matter. Non-oil generating inertinitic kerogen is dominant in both the Cretaceous and Triassic sections.

3. Gas Chromatography (Figure 5)

Four samples from 2185, 2365, 2550 and 2880 metres were extracted with cold dichloromethane and analysed by capillary gas chromatography. The extracts comprise both straight chain saturate hydrocarbons (alkanes) and rather large concentrations of unresolved or poorly resolved branched and cyclic alkanes and aromatic hydrocarbons. They are probably representative of oils generated from sapropelic source rocks and the lack of odd over even preference indicates that these were probably at relatively high levels of maturity. The sample from 2880 metres is similar in general form to those above but is depleted in the heavier ends. Alteration to the oil composition has evidently occurred and water flushing may be suggested.

4. Cretaceous - Interval 2005 to 2505 metres

Light or medium grey claystones predominate over this interval and although most samples analysed contain in excess of 1% organic carbon, the kerogen is of inertinitic, non-source type. Pyrolysis potential yield values indicate poor source rock quality. No potential source rocks have been identified in this interval.

5. Triassic - Interval 2505 to 2961 metres

Red-brown shales and sandstones are typical of this interval with occasional grey shales or claystones present probably as cavings. Organic carbon contents are consistently low and consequently no pyrolysis was undertaken on the bulk samples. Picked grey shales from 2520 and 2805 metres may be caved. The interval is too organically lean to generate hydrocarbons.

III

CONCLUSIONS

This geochemical study of the 34/4-1 well leads to the following conclusions:

1. Oil-prone organic matter, if present, would be early mature over the Cretaceous interval from 2005 to 2505 metres and early to middle mature over the Triassic interval from 2505 to 2961 metres.

2. Any Jurassic sediments which were deposited and subsequently eroded were of no great thickness.

3. Migrant hydrocarbons have been detected over most of the analysed section. In the Cretaceous claystone section these are considered due to vertical migration from a presumed accumulation between about 2500 and 2700 metres.

4. No potential source rock horizons have been identified in either the Cretaceous or Triassic intervals.

5. Oil extracted from four samples appears to have been generated from sapropelic source rocks at fairly advanced levels of maturity. The composition of the deepest sample is unusual and suggests that alteration processess, possibly water flushing, are occurring.

TABLE 1 MATURITY EVALUATION DATA

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

SAMPLE DEPTH (METRES)	SAMPLE TYPE	GENERALISED LITHOLOGY	SPORE COLOUR INDEX (1 - 10)	VITRINITE REFLECTIVITY IN OIL, R av%	KEROGEN COMPOSITION (%)		
					INERTINITE	VITRINITE	SAPROPEL
2005	Ctgs	CLYST, slty, med gy	3.5		70	30	Df Mnr
2095	"	A/a	3.5		60	30	Df 10
2185	"	A/a	3.5		>90	*	Df Mnr
2275	"	A/a	4.5		>90	*	Df Mnr
2365	"	CLYST, a/a+SND	3.5-4		>90	*	*
2455	"	CLYST, a/a	4		>90	*	*
2535	"	SST, yel-gy+SH, med-gy/red-brn	4.5		Amorphous, indet. (?bitumen)		
2625	"	A/a	4-4.5		>90	Mnr	*
2715	"	SST, yel-gy+SND	5		>90	Mnr	Mnr Cu
2805	"	A/a	5		>90	Mnr	*
2865	"	SND/SST, pk/yel-gy	*		*	*	*

Df = Dinoflagellates
Cu = Cuticle

TABLE 2A AIRSPACE GASEOUS HYDROCARBON ANALYSIS DATA

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

DEPTH (METRES)	RELATIVE GASEOUS HYDROCARBON COMPONENT ABUNDANCE (PER CENT)					TOTAL ABUNDANCE (ppm)	TOTAL C_2 - C_4 (%)	RATIO i - Butane / n - Butane
	C_1	C_2	C_3	i - C_4	n - C_4			
2005	48.1	9.8	28.2	3.4	10.6	27500	51.9	0.32
2020	36.5	7.9	34.6	5.4	15.6	6400	63.5	0.35
2035	23.6	9.5	41.8	6.2	18.8	60900	76.4	0.33
2050	25.8	8.8	42.4	7.8	15.2	51300	74.2	0.5
2065	24.6	9.3	41.2	6.1	18.8	71800	75.4	0.32
2080	27.1	9.2	42.6	5.5	15.5	272000	71	0.35
2095	*	*	*	*	*	*	*	*
2110	31.8	11.5	34.8	8.4	13.5	342800	68.2	0.62
2125	41.1	12.3	34.3	3.4	8.9	222760	58.9	0.38
2140	32.5	12.4	38.5	4.3	12.3	279200	67.5	0.35
2155	27.6	11.8	42.5	4.6	13.6	152140	72.4	0.34
2170	18.4	17.1	44.6	5.2	14.7	154700	81.6	0.35
2185	27.6	12.3	42.6	4.3	13.2	216320	72.4	0.33
2200	22.5	9.2	48.1	6.6	13.6	64800	77.5	0.5
2215	32.6	11.9	39.5	3.9	12.1	135590	67.4	0.32
2230	30.0	10.9	39.7	4.6	14.7	193100	70.0	0.30
2245	29.2	12.8	42.1	4.0	11.9	155270	70.8	0.34
2260	33.6	13.6	38.0	3.5	11.2	235700	66.4	0.30
2275	43.4	11.4	32.9	3.2	9.2	118385	56.6	0.35
2290	39.7	12.4	34.8	3.2	9.8	194700	60.3	0.33
2305	41.9	11.5	33.5	3.2	9.9	76500	58.1	0.32
2320	52.9	12.5	25.0	2.2	7.4	86900	47.1	0.30
2335	45.3	10.8	32.0	3.1	8.8	24768	54.7	0.35
2350	56.6	10.1	23.3	2.5	7.6	56400	43.5	0.33
2365	47.7	11.2	30.2	2.8	8.1	21740	52.3	0.35

NOTE: TOTAL GASEOUS HYDROCARBON ABUNDANCE VALUES ARE EXPRESSED AS VOLUME OF HYDROCARBON GASES RELATIVE TO VOLUME OF AIRSPACE

TABLE 2B AIRSPACE GASEOUS HYDROCARBON ANALYSIS DATA

COMPANY: SAGA **WELL:** 34/4-1 **LOCATION:** NORWEGIAN NORTH SEA

DEPTH (METRES)	RELATIVE GASEOUS HYDROCARBON COMPONENT ABUNDANCE (PER CENT)					TOTAL ABUNDANCE (ppm)	TOTAL C_2 - C_4 (%)	RATIO i - Butane / n - Butane
	C_1	C_2	C_3	i - C_4	n - C_4			
2380	48.7	11.5	29.7	2.7	7.4	50630	51.3	0.36
2395	43.8	15.3	23.5	4.5	13.0	30600	56.2	0.35
2410	36.3	11.9	38.1	3.8	9.9	39320	63.7	0.38
2425	73.4	16.4	2.9	2.1	5.2	116000	26.6	0.40
2440	55.9	11.4	25.4	2.0	5.4	39940	44.1	0.37
2455	52.9	15.4	24.4	1.7	5.7	8300	47.1	0.30
2470	42.9	11.3	34.0	3.4	8.4	64450	57.1	0.40
2490	28.7	12.9	41.7	3.4	13.2	37700	71.3	0.26
2505	15.1	9.1	53.1	6.0	16.7	158280	84.9	0.36
2520	4.6	7.2	62.0	7.6	18.6	50700	95.4	0.40
2535	8.2	8.7	56.1	6.8	20.2	135610	91.8	0.34
2550	4.0	4.3	60.0	5.2	26.4	162900	96.0	0.20
2565	9.3	8.4	54.3	6.8	21.1	107765	90.7	0.32
2580	7.1	6.7	52.8	7.7	25.6	117700	92.9	0.30
2595	9.9	6.9	50.6	7.5	25.0	37100	90.1	0.30
2610	7.0	6.0	46.7	5.9	34.1	19200	93.0	0.17
2625	15.2	7.1	37.1	9.3	31.3	8700	84.8	0.30
2640	36.6	5.9	46.2	2.3	8.7	19500	63.4	0.26
2655	31.7	7.3	34.8	6.2	19.9	3900	68.3	0.31
2670	19.3	4.8	28.3	7.3	40.1	1340	80.7	0.18
2685	42.1	10.3	33.1	3.4	11.0	2700	57.9	0.31
2700	13.2	21.8	52.0	3.4	9.6	18700	86.8	0.35
2715	25.9	19.8	44.1	3.0	7.2	14310	74.1	0.42
2730	tr	tr	tr	*	*	tr	*	*
2745	22.2	22.9	45.4	2.9	6.7	11505	77.8	0.43
2760	24.6	17.6	47.4	2.3	8.4	1320	75.4	0.27

NOTE: TOTAL GASEOUS HYDROCARBON ABUNDANCE VALUES ARE EXPRESSED AS VOLUME OF HYDROCARBON GASES RELATIVE TO VOLUME OF AIRSPACE

TABLE 2C AIRSPACE GASEOUS HYDROCARBON ANALYSIS DATA

COMPANY: SAGA **WELL:** 34/4-1 **LOCATION:** NORWEGIAN NORTH SEA

DEPTH (METRES)	RELATIVE GASEOUS HYDROCARBON COMPONENT ABUNDANCE (PER CENT)					TOTAL ABUNDANCE (ppm)	TOTAL C_2 - C_4 (%)	RATIO i - Butane / n - Butane
	C_1	C_2	C_3	i - C_4	n - C_4			
2775	34.9	16.4	39.9	2.5	6.3	1920	65.1	0.40
2795	33.0	23.0	37.8	1.7	4.4	2800	67.0	0.39
2805	46.9	19.9	30.7	2.5	5.9	1260	53.1	0.42
2820	30.9	21.8	44.7	1.5	1.0	2030	69.1	1.5
2835	48.8	19.1	26.3	1.6	4.1	860	51.2	0.39
2850	61.3	15.8	18.7	1.4	2.9	2720	38.7	0.48
2865	91.3	4.7	3.2	0.2	0.5	1900	8.7	0.40
2895	91.2	5.1	3.0	0.2	0.4	2470	8.8	0.50
2910	83.1	12.4	2.8	1.1	0.6	1000	16.9	1.8
2925	87.0	6.3	5.6	0.3	0.8	860	13.0	0.37
2940	84.8	12.0	2.9	tr	0.3	1400	15.2	-
2955	85.7	6.4	6.4	0.4	1.1	560	14.3	0.36
2961	65.5	5.2	21.6	tr	7.8	110	34.5	-
	SIDE TRACK 1							
2355	76.8	8.4	11.7	0.8	2.4	3550	23.2	0.30
2370	78.8	7.0	12.4	tr	1.6	10800	21.2	-
2385	75.3	8.3	13.1	1.0	2.3	7925	24.7	0.43
2400	64.9	8.0	18.2	2.9	5.9	8800	35.1	0.50
2415	66.5	9.6	19.3	1.2	3.3	6260	33.5	0.36
2430	54.3	11.5	27.4	2.1	4.8	4530	45.7	0.44
2445	60.0	12.4	22.3	1.4	3.9	26950	40.0	0.36
2460	33.0	15.8	39.6	2.9	8.5	19300	67.0	0.34
2475	38.0	11.6	36.8	3.3	10.2	17555	62.0	0.32
2488	45.2	10.8	32.7	2.7	8.6	16850	54.8	0.31

NOTE: TOTAL GASEOUS HYDROCARBON ABUNDANCE VALUES ARE EXPRESSED AS VOLUME OF HYDROCARBON GASES RELATIVE TO VOLUME OF AIRSPACE

TABLE 3A

GASOLINE HYDROCARBON ANALYSIS DATA

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

DEPTH: METRES	2005	2065	2125	2185	2245	2305	2365
GASOLINE HYDROCARBON COMPONENTS	RELATIVE GASOLINE HYDROCARBON COMPONENT ABUNDANCES (PER CENT)						
i - BUTANE	*	1.3	2.4	3.3	2.6	tr	2.7
n - BUTANE	*	6.4	12.3	16.5	13.7	14.4	14.1
i - PENTANE	tr	5.4	6.2	6.5	5.8	5.9	5.5
n - PENTANE	7.4	10.0	10.0	11.0	9.1	9.6	8.8
2,2 - DIMETHYL BUTANE	tr	0.3	0.2	0.1	0.2	tr	tr
CYCLOPENTANE	tr	0.4	0.7	0.9	0.9	1.8	1.1
2,3 - DIMETHYL BUTANE	tr	0.6	0.5	0.5	0.5	tr	0.5
2 - METHYL PENTANE	6.2	6.6	5.0	5.3	4.7	5.4	4.5
3 - METHYL PENTANE	5.5	4.3	3.5	3.0	3.2	4.2	2.9
n - HEXANE	15.1	14.5	9.8	9.9	10.4	13.9	8.1
METHYL CYCLOPENTANE / 2,2 - DIMETHYL PENTANE	5.1	4.3	4.8	4.7	5.0	4.8	3.6
2,4 - DIMETHYL PENTANE	tr	0.7	0.5	0.4	0.4	tr	0.6
BENZENE	5.9	0.1	0.4	0.2	0.1	1.0	1.4
CYCLOHEXANE	4.0	3.9	4.7	4.8	5.1	5.2	5.7
3,3 - DIMETHYL PENTANE	*	0.1	0.2	0.1	<0.1	*	tr
2 - METHYL HEXANE	5.9	5.3	4.4	3.6	4.2	3.2	4.9
1,1 - DIMETHYL CYCLOPENTANE	*	0.7	0.8	0.7	0.9	tr	0.5
3 - METHYL HEXANE	6.6	4.5	3.9	3.2	3.8	3.0	4.2
1, CIS - 3 - DIMETHYL CYCLOPENTANE	tr	1.3	1.3	1.1	1.2	1.2	0.9
1, TRANS - 3 - DIMETHYL CYCLOPENTANE	tr	1.5	1.5	1.3	1.4	1.0	1.0
1, TRANS - 2 - DIMETHYL CYCLOPENTANE	tr	3.1	3.2	2.7	3.2	2.8	2.7
3 - ETHYL PENTANE	-	-	-	-	-	-	-
n - HEPTANE	13.2	11.5	9.6	8.3	9.6	6.3	11.4
1, CIS - 2 - DIMETHYL CYCLOPENTANE / METHYL CYCLOHEXANE	11.4	11.0	11.3	9.7	11.7	10.7	9.9
ETHYL CYCLOPENTANE	3.3	0.9	1.1	0.8	0.9	1.5	1.0
TOLUENE	10.3	1.2	1.5	1.5	1.2	3.9	3.9
TOTAL ABUNDANCE (PPB)	270	16200	24100	82600	77300	7780	18800
ORGANIC CARBON (PER CENT)							
GASOLINE ABUNDANCE AT 1 PER CENT ORGANIC CARBON							

NOTE: TOTAL GASOLINE ABUNDANCE VALUES ARE EXPRESSED AS WEIGHT OF GAS RELATIVE TO WEIGHT OF WET ROCK.

TABLE 3B

GASOLINE HYDROCARBON ANALYSIS DATA

COMPANY: SAGA **WELL:** 34/4-1 **LOCATION:** NORWEGIAN NORTH SEA

DEPTH: METRES	2395	2455	2490	2550	2795		
GASOLINE HYDROCARBON COMPONENTS	RELATIVE GASOLINE HYDROCARBON COMPONENT ABUNDANCES (PER CENT)						
i - BUTANE	4.5	5.9	3.5	5.3	*		
n - BUTANE	22.2	24.3	14.6	22.8	*		
i - PENTANE	6.4	8.7	6.4	7.6	*		
n - PENTANE	10.6	9.6	9.7	12.6	*		
2,2 - DIMETHYL BUTANE	*	tr	0.4	0.1	*		
CYCLOPENTANE	1.5	1.9	1.1	0.9	*		
2,3 - DIMETHYL BUTANE	tr	0.5	0.6	0.5	*		
2 - METHYL PENTANE	4.5	4.3	5.5	5.5	*		
3 - METHYL PENTANE	2.9	3.2	3.4	3.0	*		
n - HEXANE	7.5	7.1	9.9	9.9	*		
METHYL CYCLOPENTANE	3.0	3.1	3.6	4.0	*		
2,2 - DIMETHYL PENTANE					*		
2,4 - DIMETHYL PENTANE	tr	tr	0.7	0.4	*		
BENZENE	1.1	2.2	1.1	>0.1	*		
CYCLOHEXANE	4.4	4.9	4.1	3.8	*		
3,3 - DIMETHYL PENTANE	*	*	0.3	>0.1	*		
2 - METHYL HEXANE	3.5	2.9	4.6	3.1	*		
1,1 - DIMETHYL CYCLOPENTANE	tr	tr	0.9	0.6	*		
3 - METHYL HEXANE	3.3	2.5	3.9	2.6	*		
1, CIS - 3 - DIMETHYL CYCLOPENTANE	tr	tr	1.1	0.8	*		
1, TRANS - 3 - DIMETHYL CYCLOPENTANE	tr	tr	1.2	1.0	*		
1, TRANS - 2 - DIMETHYL CYCLOPENTANE	1.9	1.5	2.8	2.1	*		
3 - ETHYL PENTANE	–	–	–	–	–		
n - HEPTANE	8.0	5.3	9.1	6.4	*		
1, CIS - 2 - DIMETHYL CYCLOPENTANE	7.7	6.4	8.7	6.1	*		
METHYL CYCLOHEXANE					*		
ETHYL CYCLOPENTANE	0.8	0.5	0.8	0.4	*		
TOLUENE	6.2	5.0	2.1	0.6	*		
TOTAL ABUNDANCE (PPB)	9450	6600	21200	329000	*		
ORGANIC CARBON (PER CENT)							
GASOLINE ABUNDANCE AT 1 PER CENT ORGANIC CARBON							

NOTE: TOTAL GASOLINE ABUNDANCE VALUES ARE EXPRESSED AS WEIGHT OF GAS RELATIVE TO WEIGHT OF WET ROCK.

Table 4A **CHEMICAL ANALYSIS DATA**

COMPANY: SAGA **WELL:** 34/4-1 **LOCATION:** NORWEGIAN NORTH SEA

GENERAL DATA			CHEMICAL ANALYSIS DATA											
				PYROLYSIS					SOLVENT EXTRACTION					
												HYDROCARBONS		
SAMPLE DEPTH (METRES)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TEMP-ERATURE °C	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD	TOTAL EXTRACT (ppm)	HYDRO-CARBONS (ppm)	EXTRACT % OF ORGANIC CARBON	ppm OF ORGANIC CARBON	% OF EXTRACT	ALKANES % OF HYDRO-CARBONS
2005	CTGS	CLYST slty, med gy	1.11	*	*	114	*	*						
2020	"	A/a	0.97											
2035	"	A/a	1.89											
2050	"	A/a	2.03	*	*	50	*	*						
2065	"	A/a	1.49											
2080	"	A/a	1.28											
2095	"	A/a	1.61	420	17	84	0.1	300						
2110	"	A/a	1.23											
2125	"	A/a	1.12											
2140	"	A/a	0.98											
2155	"	A/a	1.14											
2170	"	A/a	1.30	420	39	148	0.3	500						
2185	"	A/a	1.16											
2200	"	A/a	0.89											
2215	"	A/a	0.92											
2230	"	A/a	1.11	429	27	110	0.3	300						
2245	"	A/a	0.86											
2260	"	A/a	0.93											
2275	"	A/a	0.87											
2290	"	CLYST a/a 90%+10% SND	1.19	420	21	112	0.3	200						
2305	"	A/a	1.10											
2320	"	A/a	1.00											
2335	"	A/a	1.04											
2350	"	A/a	0.94											
2365	"	A/a	1.34	*	*	148	*	*						
2380	"	CLYST, slty, med gy+MD	1.22											
2395	"	A/a	1.65	424	22	120	0.2	400						
2410	"	A/a	1.61	421	31	173	0.2	500						
2425	"	A/a	1.39											
2440	"	A/a	1.11											
2455	"	A/a	1.86	420	18	112	0.2	300						
2470	"	A/a	1.42											
2490	"	CLYSH slty, red-brn 30%,med gy 40% +SND+SST 30%	1.33	423	28	137	0.3	400						
2490	" P	CLYSH, med gy a/a	0.47	*	*	98	*	*						
2505	"	CLYSH slty, red-brn 60%, med gy 20%+SST 20%+CHK mnr	0.39											

Table 4B CHEMICAL ANALYSIS DATA

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

GENERAL DATA			CHEMICAL ANALYSIS DATA											
				PYROLYSIS					SOLVENT EXTRACTION					
												HYDROCARBONS		
SAMPLE DEPTH (METRES)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TEMP-ERATURE °C	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD	TOTAL EXTRACT (ppm)	HYDRO-CARBONS (ppm)	EXTRACT % OF ORGANIC CARBON	ppm OF ORGANIC CARBON	% OF EXTRACT	ALKANES % OF HYDRO-CARBONS
2520	CTGS	CLYSH slty, red-brn20%, med gy 40% + SST 30%+CHK 10%	0.63											
2520	" P	CLYSH, med gy a/a	0.73	*	*	24	*	*						
2535	"	SST yel-gy 60% + CLYSH, med gy, 30%, red-brn, 10%	0.30											
2550	"	SST yel-gy 70% + CLYSH med gy 20%, red-brn, 10%	0.42											
2565	"	SST yel-gy 70%+CLYSH med gy 30%	0.36											
2580	"	SST yel-gy 90%+CLYSH med gy 10%+mic	0.30											
2595	"	SST a/a+mnr CLYSH A/a	0.11											
2610	"	SST a/a 40%+SND crs, 50% + CLYSH multi 10%	0.07											
2625	"	SST a/a 30%+SND a/a 60%+CLYSH a/a 10%	0.03											
2640	"	A/a	0.00											
2655	"	SST a/a 40%+SND a/a 50%+CLYSH a/a 10%	0.03											
2670	"	SST a/a 20%+SND a/a 80%+mnr CLYSH a/a	0.01											
2685	"	A/a	0.00											
2700	"	SST a/a 30% + SND a/a 60%+mnr CLYSH a/a+mnr coal	0.29											
2715	"	A/a	0.12											
2730	"	SST a/a 20% + SND a/a 70%+ CLYSH a/a, mnr+mnr coal	0.24											
2745	"	SST a/a 40% + SND a/a 50%+ CLYSH a/a, mnr,+mnr coal	0.53											
2760	"	SND 60% + SST yel gy 30%+CLYSH, med gy, mnr+coal mnr	0.18											
2775	"	SND 60%+SST a/a 40%+CLYSH mnr	0.21											
2795	"	SND 50%+SST a/a 40%+CLYSH 10%	0.23											
2805	"	SND 45%+SST a/a 45%+CLYSH 10%	0.10											
2805	" P	CLYSH a/a	1.74	429	28	16	0.2	500						
2820	"	SND, pnk, 60% + SST a/a 40%+ CLYSH 10%	0.41											
2835	"	SND yel, 70% + SST a/a 30%+ CLYSH mnr	-											
2850	"	SND pnk 70%+SST a/a 30%+CLYSH mnr	-											
2865	"	SND a/a 50%+SST a/a 50%+CLYSH, mnr	-											
2880	"	SND, red-brn	-											
2895	"	A/a	-											

Table 4C CHEMICAL ANALYSIS DATA

COMPANY: SAGA **WELL:** 34/4-1 **LOCATION:** NORWEGIAN NORTH SEA

GENERAL DATA			CHEMICAL ANALYSIS DATA												
				PYROLYSIS					SOLVENT EXTRACTION						
												HYDROCARBONS		
SAMPLE DEPTH (METRES)	SAMPLE TYPE	ANALYSED LITHOLOGY	ORGANIC CARBON % OF ROCK	TEMP-ERATURE °C	HYDROGEN INDEX	OXYGEN INDEX	PRODUCTION INDEX	POTENTIAL YIELD	TOTAL EXTRACT (ppm)	HYDRO-CARBONS (ppm)	EXTRACT % OF ORGANIC CARBON	ppm OF ORGANIC CARBON	% OF EXTRACT	ALKANES % OF HYDRO-CARBONS
2910	CTGS	SND a/a, 70%+SST red-brn, 30% +CLYSH, med gy, mnr	-											
2925	"	A/a	-											
2940	"	SND a/a 80%+SST a/a 20%+CLYSH a/a, mnr	-											
2955	"	A/a	-											
2961	"	SND a/a 70%+SST a/a 20%+CLYSH a/a 10%	-											
		SIDE TRACK 1												
2355	"	CLYST, slty, med-dk gy+CMT	-											
2370	"	A/a	-											
2385	"	A/a	-											
2400	"	A/a	-											
2415	"	A/a	-											
2430	"	A/a	-											
2445	"	A/a	-											
2460	"	A/a	-											
2475	"	A/a	-											
2488	"	CLYST slty, med brn 40%, med gy 30%+SND 30%	-											
		MISCELLANEOUS												
2050-2335	"	CLYST, med-gy, probable cavings	0.86	429	30	186	0.2	300						

P = Picked lithology

FIGURE I SPORE COLOURATION INDICES AGAINST DEPTH

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

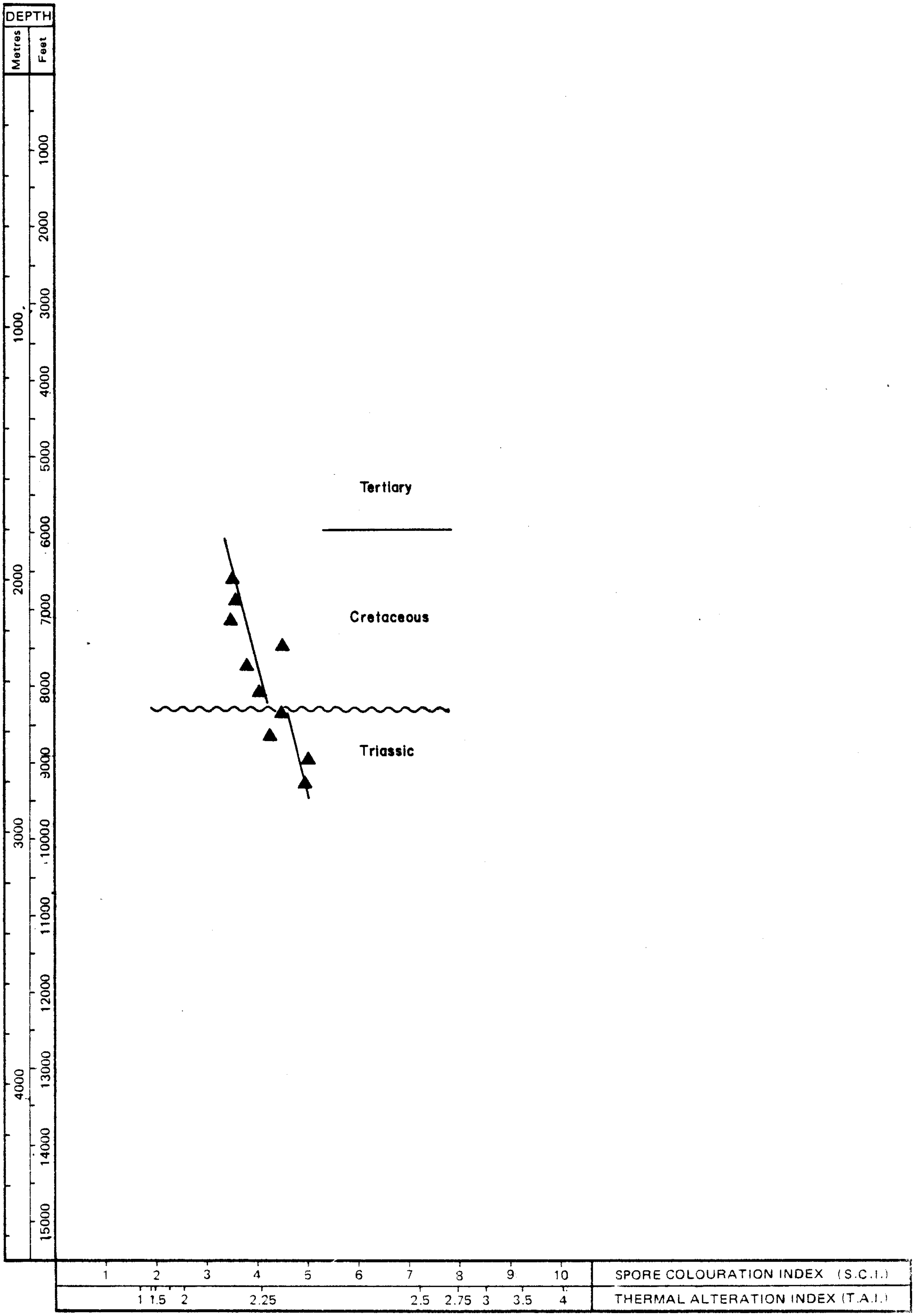


FIGURE 2 GASEOUS (C_1 - C_4) HYDROCARBONS

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

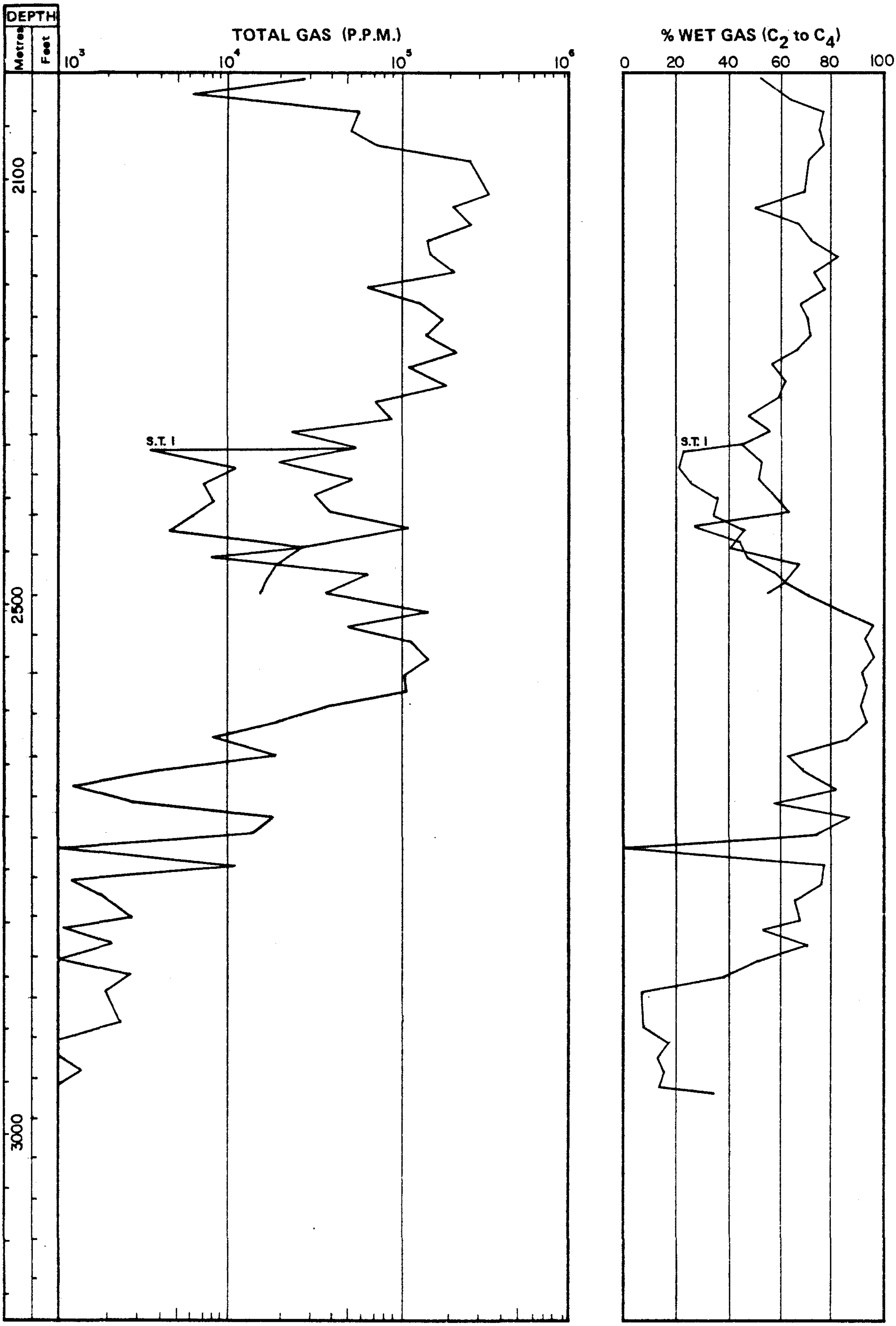
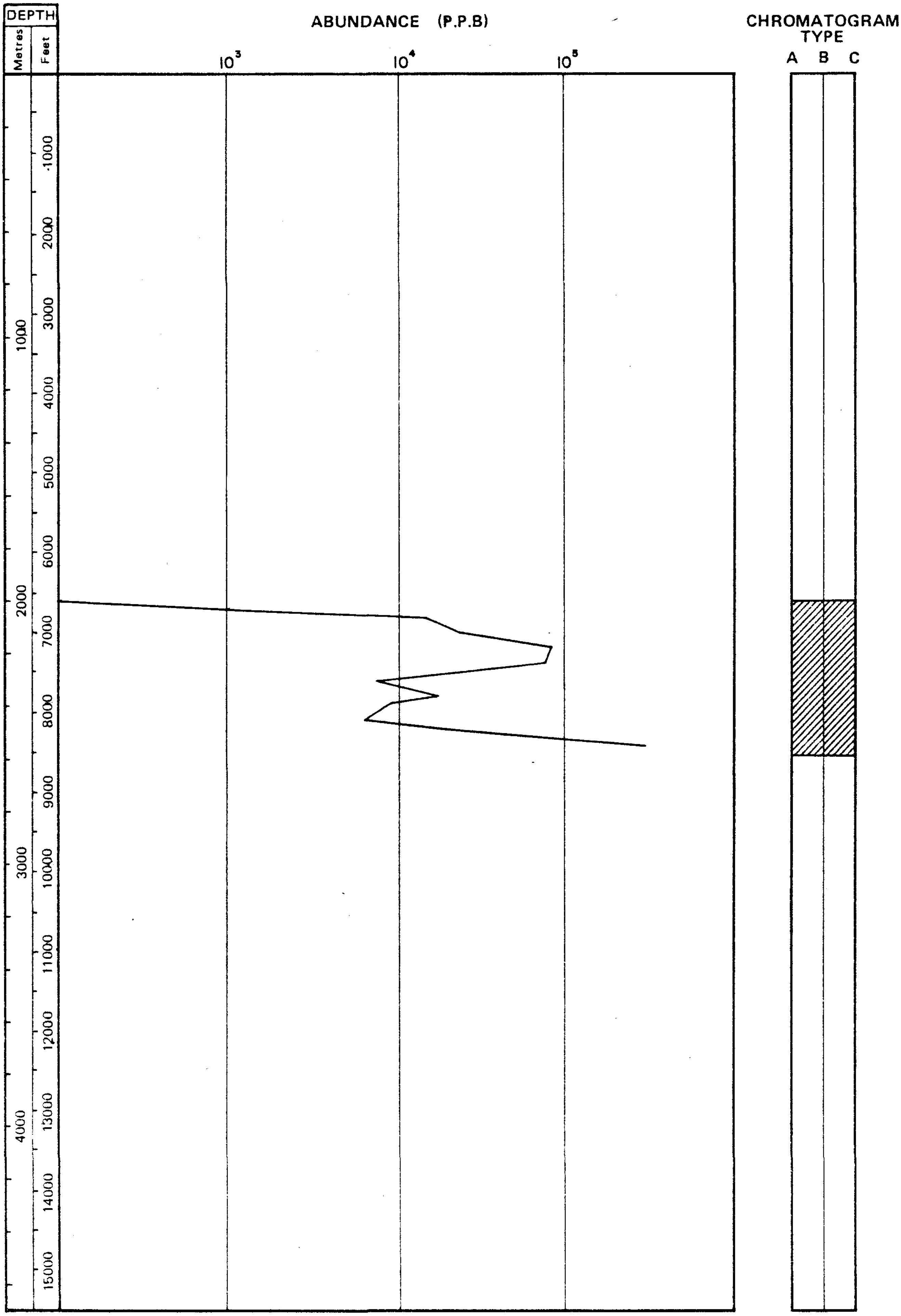


FIGURE 3 GASOLINE (C_4–C_7) HYDROCARBONS AGAINST DEPTH

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA



A - IMMATURE B - TRANSITIONAL C - OIL LIKE

---- ABUNDANCE (PPB) CALCULATED AT 1% ORGANIC CARBON CONTENT

FIGURE 4 PYROLYSIS DATA SUMMARY CHART

COMPANY: SAGA WELL: 34/4-1 LOCATION: NORWEGIAN NORTH SEA

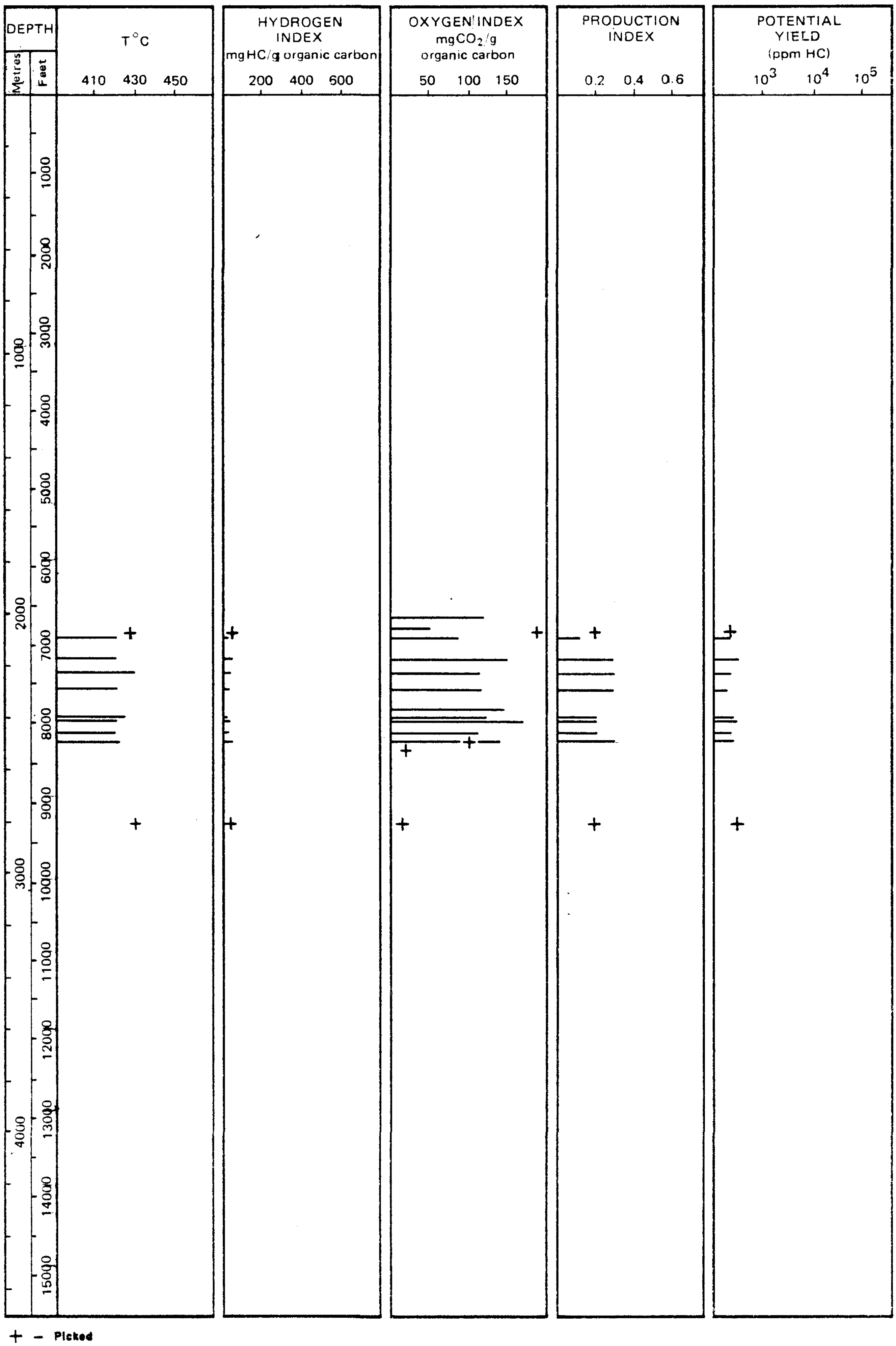


FIGURE 5A 2185m

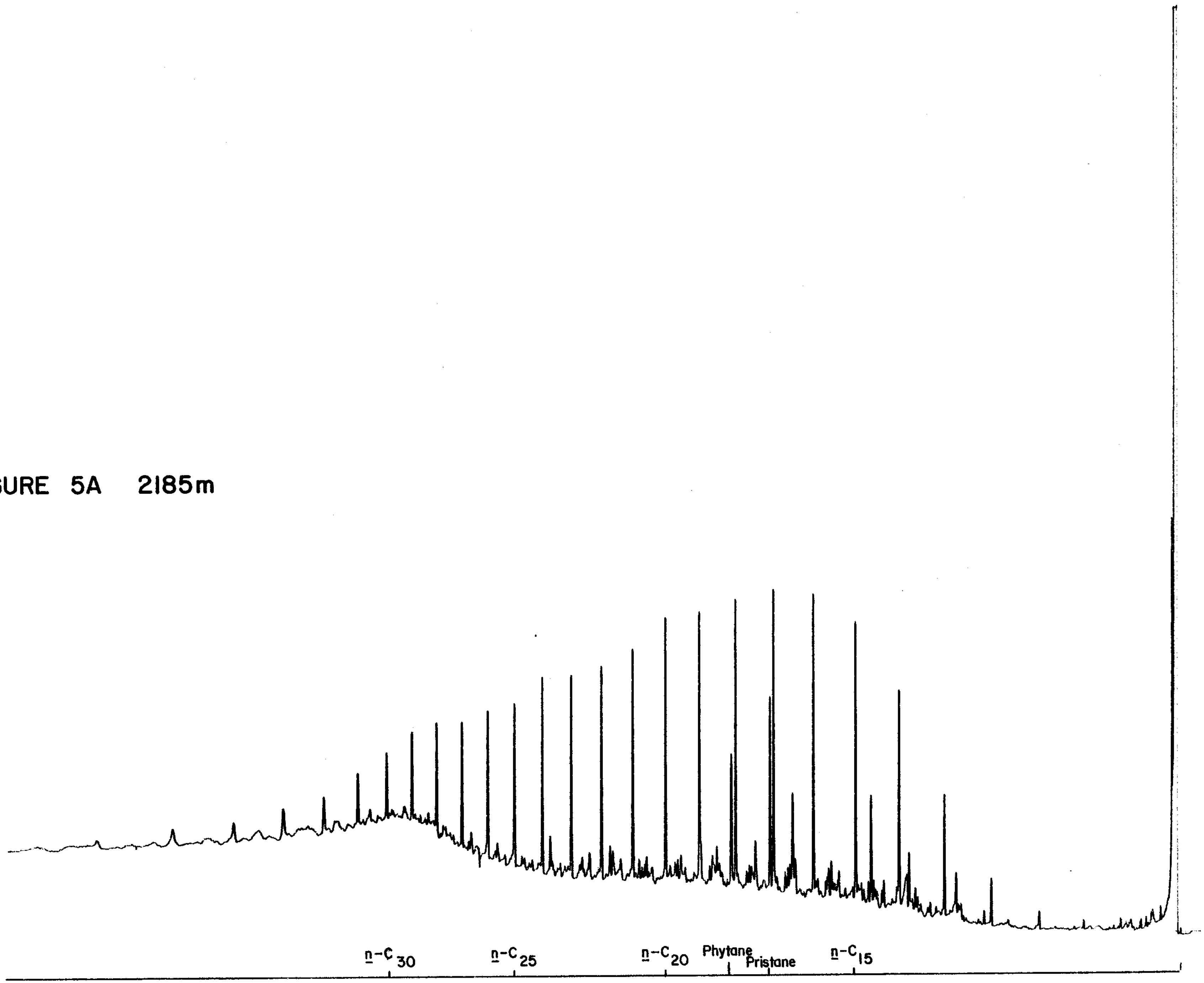


FIGURE 5B 2365m

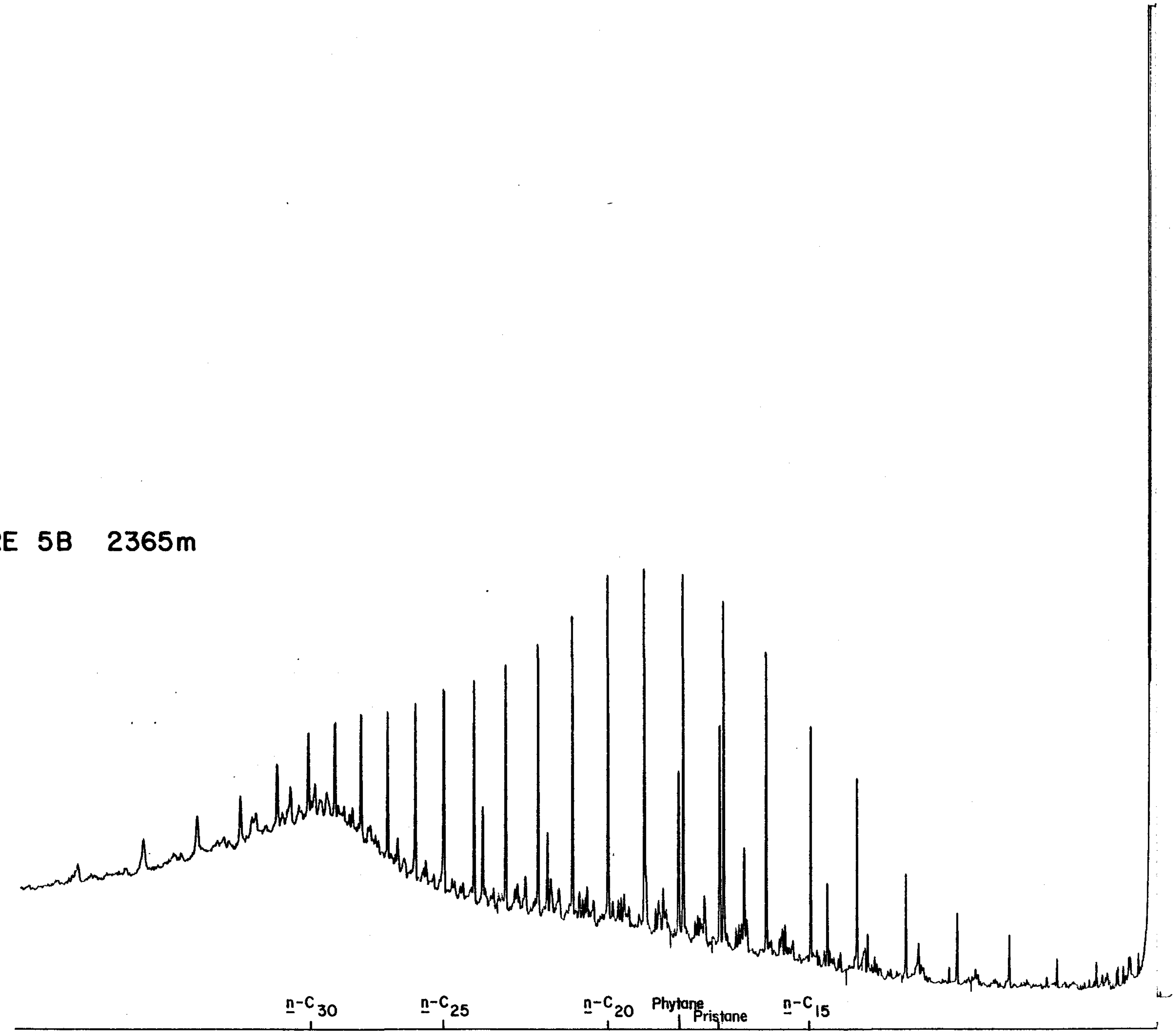


FIGURE 5C 2550m

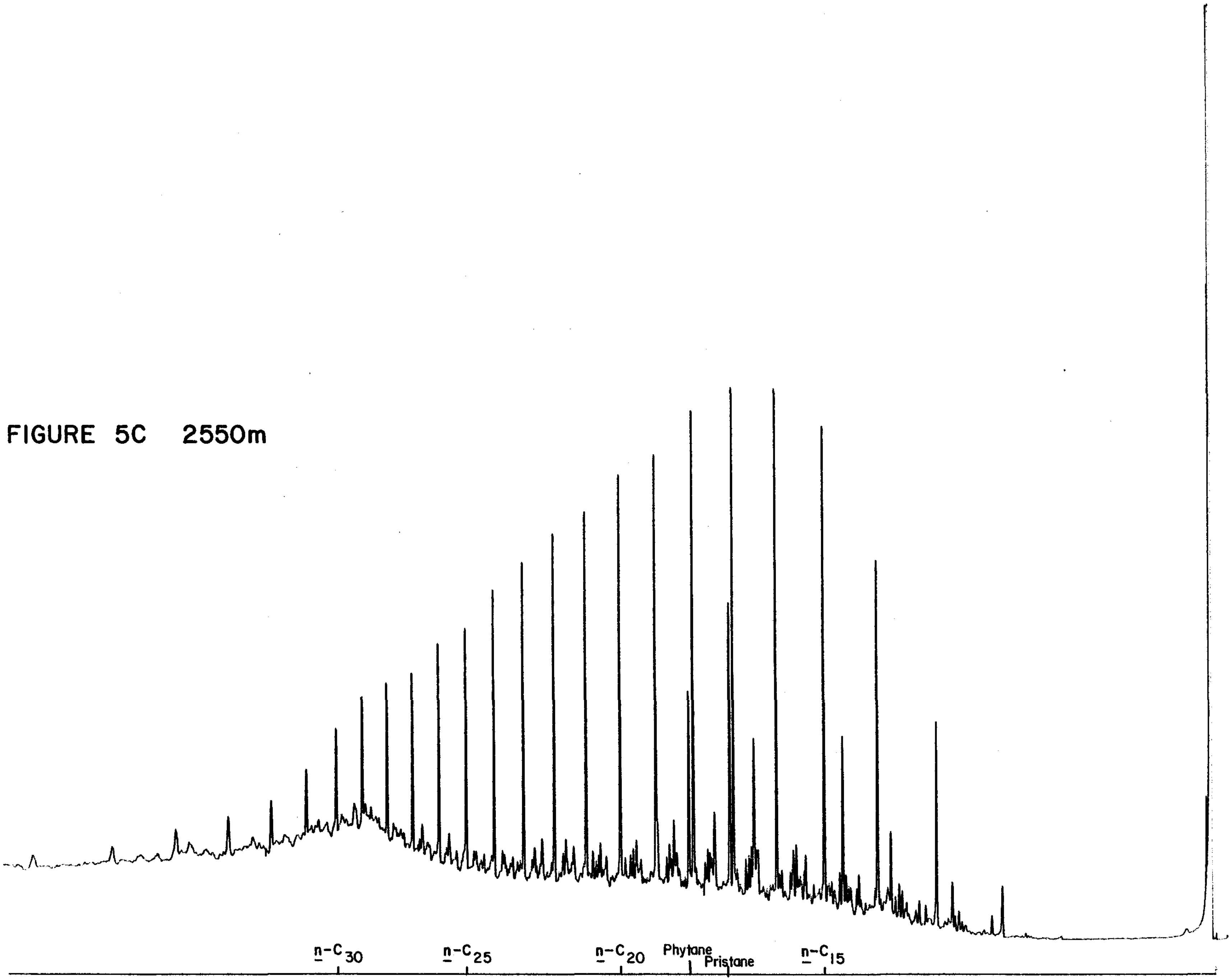
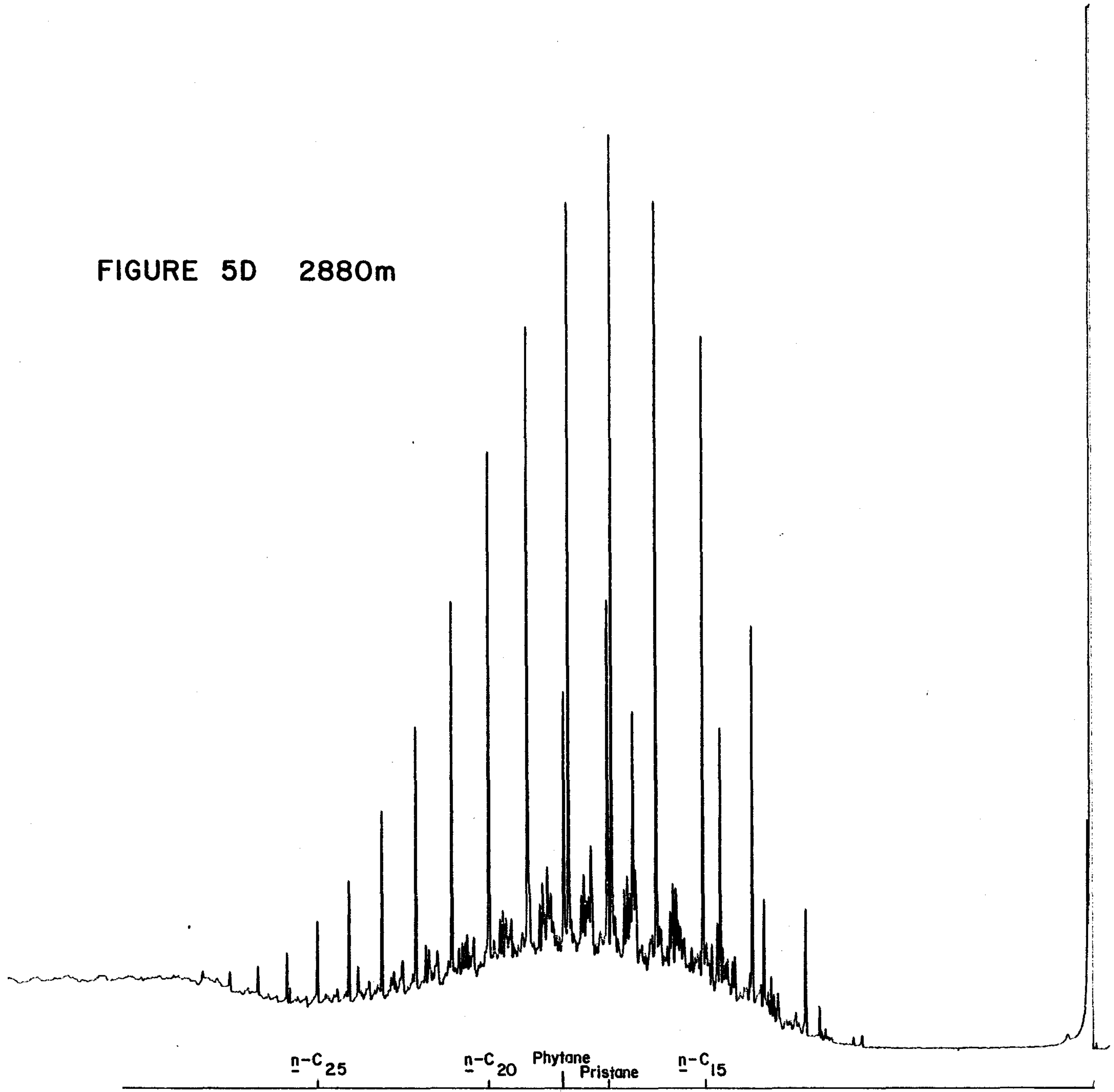


FIGURE 5D 2880m



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	HP	Hand picked lithology
Med	Medium	i/b	Interbedded
Mic	Micaceous		
Mnl	Mineral		
Mnr	Minor		

TYPE OF KEROGEN / DOMINANT HYDROCARBON PRODUCT		OIL	GAS	NONE
SAPROPELIC	EXINITES	SPOROPOLLENIN (Spores and pollen)		
		CUTINITE (Land plant cuticle)		
	LIPTINITES	ALGINITE (Algal fragments and masses in oil shales)		
		RESINITE (Land plant exudates, e.g. Amber)		
		AMORPHOUS SAPROPEL		
HUMIC	VITRINITES Most abundant coal maceral		TELINITE (Cellular tissue)	
			COLLINITE (Amorphous)	
	INERTINITES Mainly oxidised woody organic matter			FUSINITE (Opaque, often as broken cell walls)
			SEMI-FUSINITE (Intermediate between fusinite and vitrinite)	
			MICRINITE (Granular inertinite)	

APPENDIX II KEROGEN COMPONENTS OF ORGANIC MATTER AND THEIR DOMINANT HYDROCARBON PRODUCTS.

For further information see STACH'S textbook of COAL PETROLOGY, Gebruder Borntraeger, Berlin - Stuttgart, 1975

APPENDIX III. ANALYTICAL PROCEDURES AND TECHNIQUES

This appendix summarises the main steps in the analyses carried out in the Robertson Research geochemistry laboratories. Conditions for chemical analyses are given and interpretation guidelines are defined. Techniques may in certain circumstances be adapted to suit particular samples or conditions.

1. Sample Preparation

Following airspace gas analysis of the canned samples, the cuttings are washed. After setting aside a wet sub-sample for gasoline analysis, the remainder is oven-dried at 50°C and described. Obvious cavings and particulate contaminants are removed and the significant lithologies hand-picked for organic carbon screening analysis. Coals if present are picked for vitrinite reflectivity measurement and splits of the total cuttings are made for the preparation of kerogen concentrates. Subsequently the bulk samples except those containing much loose sand or coal are crushed to pass through a 250 micron (60 - mesh) sieve and submitted for organic carbon screening analysis.

2. Maturity Evaluation

Maturation is assessed by measurement of spore colour and vitrinite reflectivity and the analysis of airspace gas and gasolines. Kerogen concentrates for microscopic analysis are prepared using standard palynological procedures (i.e. acid maceration) but without oxidation and acetolysis. Mineral residues, particularly pyrite, are separated from the kerogen by a combination of ultrasonic vibration and zinc bromide flotation. For spore colour measurement and kerogen typing, mounts are prepared of both the total kerogen and the coarser-than-20-micron size fraction. Sample blocks for measurement of vitrinite reflectivity are prepared by mounting the coarser-than-20-micron kerogen fraction in an epoxy resin, followed by polishing with carborundum and alumina.

Airspace Gas Analysis

If samples of wet cuttings are collected at the well-site and sealed in an airtight can, the headspace gases can be analysed in the laboratory to provide a rapid assessment of maturity. The gas is extracted from the sealed can using a can piercer fitted with a septum and analysed by gas liquid chromatography. The proportions of methane, ethane, propane and butane are calculated by comparison with a standard mixture of these gases. Methane is usually the dominant gas and comprises 90-100% from immature sediments and 30-70% from mature sediments. Abrupt departures from composition/depth trends may indicate faults with migrant gases or reservoir rocks.

Gasoline Analysis

Cuttings samples received wet, preferably in sealed containers, are suitable for gasoline analysis. A portion of the washed cuttings sample is retained wet, pulverised in a sealed shaker and warmed to expel the gasoline components into the shaker airspace. A sample of this airspace gas is then removed and analysed by gas chromatography. 28 hydrocarbon species are identified in the C_4 to C_7 range and their relative proportions calculated with reference to standard mixtures. Immature source rocks yield mixtures dominated by a small number of components but mature source rocks usually contain a full range of identified hydrocarbons in similar orders of concentration. The onset of maturity may also be indicated by an increase in total gasolines relative to the organic carbon content of the host rock (+200 ppm hydrocarbons per 1% organic carbon). Occasionally, oil stain will be recognised by the presence of anomalous amounts and it may be possible to identify its source rock by a similarity in distribution of components.

Spore Colouration

The maturity of oil-prone organic matter present in kerogen concentrates is assessed by visual examination of the indigenous sporomorphs. With increasing thermal maturity, spore colours change from pale yellow, through orange and brown, to black. Measurement is made using a standard reference set of sporomorphs. Spore colouration indices measured are on the Robertson Research scale of 1 to 10. Our experience shows that values of 3.0 to 3.5 are representative of the transition zone between immaturity and maturity. The range 3.5 to 8.0 is arbitrarily divided into zones of organic maturity: 3.5 to 5.0, early maturity; 5.0 to 7.0, middle maturity; 7.0 to 8.0 late maturity. Direct comparison with source rock data indicates that, given the presence of oil-prone organic matter, low gravity oils are likely to be generated in the zone of early maturity, medium gravity oils in the zone of middle maturity and high gravity oils in the zone of late maturity. The onset of generation of condensate, wet gas and, ultimately, dry gas is characterised by spore colour indices above 8.0.

Vitrinite Reflectivity

Vitrinite, a humic degradation product largely derived from the anaerobic decomposition of the lignin, cellulose and nitrogen-containing compounds of woody tissues, is the chief component of coals and is also common in fine-grained clastic rocks. The reflectivity of an optically flat surface is defined as the percentage of normally incident light reflected from the surface. Reflectivity can be used to define the level of thermal maturity of sedimentary organic matter since it increases from approximately 0.2% to 5.0% at a relatively uniform rate through the coal rank series. Zones of oil and gas generation can be related to the coal rank series and therefore defined in terms of vitrinite reflectivity, even though vitrinite is not an oil source but generates gas. The onset of oil generation has been placed at between 0.35% and 0.6% reflectivity, depending on the type of sedimentary basin; 0.5% is a widely accepted threshold value. The floor for oil generation is characterised by a vitrinite reflectivity of approximately 1.2%. Wet gas generation peaks at a reflectivity of about 1.0% and ceases at the 2.0% level. Dry gas generation peaks at a reflectivity of about 1.5% and ceases at the 3% level. However, to define the appropriate limits for a particular basin, vitrinite reflectivity must be correlated with other thermal maturation parameters.

3. Source Rock Evaluation

Organic Carbon Content

On average, between 1% and 2% of argillaceous sediments consist of organic carbon. Since major hydrocarbon accumulations are the exception rather than the rule it is likely that their sources are of above average organic carbon content. Sediments containing less than 0.3% organic carbon are regarded as having no source potential, and those containing between 0.3% and 1.0% are marginal sources. Obviously the kerogen type is also of fundamental importance in determining the source potential of a rock.

Organic carbon values are obtained as follows. A 0.1 or 0.5 g sample, depending on lithotype,of crushed rock is treated with concentrated hydrochloric acid to remove carbonates and the residue filtered onto a glass fibre paper prior to ignition in a 'Leco' carbon analyser.

Extract Analysis

The soluble organic materials present in rocks can be extracted with organic solvents, fractionated and analysed. The type and amount of material extracted depends largely upon the nature of the contained organic matter and its maturity.

A maximum of 40 g of crushed sample is extracted for a minimum of 12 hours in a 'Soxhlet' apparatus by a 2 : 1 mixture of laboratory redistilled dichloromethane and methanol. The weight of the 'total extract' after final evaporation is expressed as ppm of the total rock. The more volatile components (up to C-15) are lost during extraction. The total extract is dissolved in hexane and a known volume separated by high pressure liquid chromatography into saturate hydrocarbon (alkanes), aromatic hydrocarbon and resene-asphaltene fractions.

Extract analysis provides a measure of source-rock richness in the oil-generation maturity zone. In addition to organic carbon contents, five parameters are calculated; total extract, extract/organic carbon x 100 i.e. extractability or EPOC, hydrocarbons as ppm of rock, hydrocarbons as percent of extract and alkanes as percent of hydrocarbons.

The extractability of oil-prone sapropelic organic matter increases rapidly in the oil generation zone and diminishes to very low values in post-mature sediments. Overall the extractability of sapropelic organic matter is greater than that of gas-prone humic organic matter for similar levels of maturity. Samples with extractabilities of greater than 20% generally contain migrated oil or are contaminated with mud additives.

The hydrocarbon content of a rock is the sum of the alkane and aromatic fractions of the total extract. As maturation proceeds in the oil generation zone the proportion of hydrocarbons in the total extract increases from less than 20% to a maximum in the most productive horizons of around 60%. This trend is reversed as the oil-condensate zone is entered. The relative proportions of alkanes to aromatics can be used as a check for low levels of contamination.

Pyrolysis

Pyrolysis data are obtained using the IFP-Fina "ROCK-EVAL" apparatus. The method involves the heating of samples from 250° to 550°C at 25°C/minute in a stream of inert gas. During this time, three pulses of gases are released and recorded as weights of gas. The first of these pulses relates to hydrocarbons present in the sediment which could normally be extracted by organic solvents; these are either the adsorbed hydrocarbons indicating present source potential, or reservoired hydrocarbons. The second gas pulse is of hydrocarbons released by the thermal breakdown of kerogen (optimum source potential), and simultaneously the temperature of maximum rate of evolution is measured. The third pulse comprises carbon dioxide.

The parameters used in interpretation are the hydrogen index (ratio of released hydrocarbons to organic carbon content), the oxygen index (ratio of released carbon dioxide to organic carbon content), the temperature of maximum rate of pyrolysis, and the production index (ratio of the amount of hydrocarbons released in the first stage of heating to the total amount of released hydrocarbons). Kerogens rich in sapropelic matter exhibit a high hydrogen index and a low oxygen index while those in which humic debris predominates will display a low hydrogen index and a high oxygen index. Hydrogen and oxygen indices for a particular type of kerogen are also susceptible to a reduction in their values during the course of thermal maturation.

The hydrogen index is a measure of the hydrocarbon generating potential of the kerogen. Immature, organically rich source rocks and oil shales give values above 500, mature oil source rocks give values between 200 and 550.

The temperature of maximum rate of pyrolysis depends on the nature of the organic matter, but the transition from immature to mature organic matter is marked by temperatures between 415° and 435°C. The maturity transition from oil and wet gas generation to dry gas generation is marked by temperatures between 455° and 460°C. In practice, greater variation than these ideal temperature ranges may be seen, but they are nevertheless useful as general guides to the level of maturity attained by the sediment.

The production index increases with maturity from values near zero for immature organic matter to maximum values of 0.15 during the late stages of oil generation. Anomalously high values indicate the presence of free oil. The hydrocarbon yield is an indication of the potential yield of hydrocarbons from the source rock at optimum maturity and is a measure of the quality of the source rock. A value of 0 to 2000 of hydrocarbon in ppm of rock characterises a poor source rock, 2000 to 6000 ppm fair, 6000 to 20,000 ppm good and above 20,000 ppm very good.

Visual Examination of Kerogen Concentrates

All palynological preparations are examined in transmitted white and ultraviolet light and the relative abundances of vitrinite, inertinite and sapropel (essentially a fine-grained, apparently amorphous mixture of liptinite and exinite) estimated. The coarser-than-20-micron fractions are also examined in reflected white and ultraviolet light.

Gas Chromatography of C-15+ Alkanes

A portion of the "total extract" obtained from Soxhlet extraction is eluted with pentane through a short silica column to yield the saturate hydrocarbon fraction. This fraction is evaporated to dryness in a stream of dry nitrogen at room temperature. A small portion of the fraction is then taken up in methylene dichloride and injected on to a 25 metre, wall-coated, open-tubular, glass capillary column coated with OV-1 mounted in a Perkin Elmer F-17 gas chromatograph and programmed from 80°C to 260°C at 4°C/minute.

Distributions of _n_-alkanes and the relative abundances of steranes and triterpanes are noted and the ratios pristane/_n_-C_{17} and phytane/_n_-C_{18} are measured. The CPI may also be measured. Inspection of the chromatograms may reveal information about the kerogen type of the source rock, its maturity and conditions of deposition and, if migrant oil is present, whether this has been water-flushed or biodegraded. Drilling mud additives may be identified.