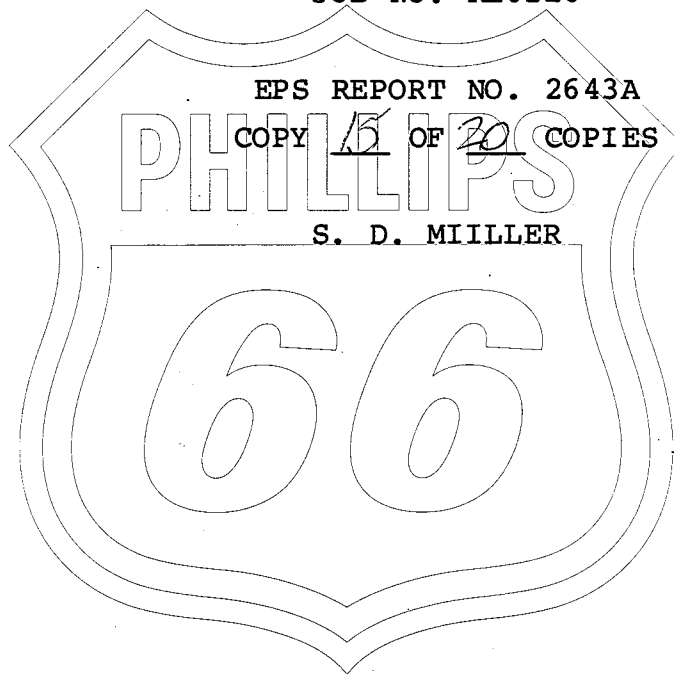


SOURCE ROCK POTENTIAL OF SELECTED SAMPLES
FROM THE FLYNDRE 1/5-2X, ELDFISK 2/7-15X,
2/7-19X AND 8/11-1 WELLS,
GROUP LICENSE AREA
NORWEGIAN SECTOR, NORTH SEA
JOB NO. RE0210

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PHILLIPS PETROLEUM COMPANY
EXPLORATION PROJECTS SECTION
BARTLESVILLE, OKLAHOMA
JULY, 1984

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Source Rock Potential of Selected Samples
 from the Flyndre 1/5-2X, Eldfisk 2/7-15X, 2/7-19X,
 and the 8/11-1 Wells, Group License Area,
 Norwegian North Sea
 EPS Report No. 2643A

SUMMARY AND CONCLUSIONS

Based on visual, TOC, and pyrolysis measurements of nineteen selected cuttings samples from four wells in the Norwegian sector of the North Sea, the following source rock types and their hydrocarbon potentials are established:

<u>WELL:</u>	<u>DEPTH (FT.)</u>	<u>HYDROCARBON POTENTIAL</u>	<u>HYDROCARBON TYPE</u>
<u>2/7-15X:</u>	13200-13500	Excellent	Oil/Wet Gas/Gas
	13420-13430	"	"
	13430-13440	"	"
	13440-13450	"	"
<u>2/7-15X:</u>	12700-13200	Very Good	Oil/Wet Gas/Gas
	13500-13700	"	"
	13770-14180	"	"
	14180-14300	"	"
	14300-14510	"	"
<u>1/5-2X:</u>	13790-13870	Good	Oil/Wet Gas/Gas
<u>2/7-15X:</u>	11900-12200	"	"
	12360-12460	"	"
<u>8/11-1:</u>	9220- 9300	"	"
<u>8/11-1:</u>	10120-10130	Fair	Oil/Wet Gas/Gas
	10140-10190	"	"
	10500-10600	"	"

<u>WELL:</u>	<u>DEPTH (FT.)</u>	<u>HYDROCARBON POTENTIAL</u>	<u>HYDROCARBON TYPE</u>
<u>2/7-19X:</u>	15300-15400	Fair	Dry Gas
	15710-15800	"	"
	15900-16000	"	"

The sediments studied in the 1/5-2X, 2/7-15X and 8/11-1 wells have reached the advanced stage of the main oil generation phase, whereas those of the 2/7-19X well have reached the dry gas stage. The deposits of the latter mentioned well probably already have generated and expelled much of their liquid hydrocarbons and the remaining potential is for dry gas only. The hydrocarbon potential for the other wells is good for both the present and future generation of oil, wet gas and gas from most of the intervals examined.

DISCUSSION

Nineteen selected cuttings samples from four wells in the Norwegian sector of the North Sea were examined. The samples have been chosen by the EPS geochemists as part of a larger source rock study of the Group License Area (GLA) in the North Sea.

Vitrinite reflectance, thermal alteration index, fluorescence microscopy, kerogen typing, total organic carbon and pyrolysis measurements were made (Figs. 1-6). The following is a well-by-well discussion of source rock type and hydrocarbon generation potential for each of the studied intervals.

Flyndre 1/5-2X Well (13790-13870 ft.)

The examined interval, 13790-13870 ft. possesses good potential to produce oil, wet gas and gas. The sample has reached the high end of the main oil generation phase according to vitrinite reflectance measurements ($R_o = 1.17$). It contains abundant amorphous sapropel (95%) that exhibits a dull brown fluorescence.

This dull fluorescence may be related to the high maturity of the interval indicating that perhaps the kerogen is either of low quality or that it is a humic precipitate.

This interval has a high TOC value (2.7) but low HI (46.7) and H/C ratio (.559) values. The low HI and H/C values may be a function of its high thermal maturity or they may indicate that the kerogen inherently has a low HI value. These sediments may have generated and possibly expelled most of their liquid hydrocarbons, thus lowering both the HI and H/C values. The production index value (.400) is still fairly high and this factor suggests that either some generation still is occurring, or that expulsion is not complete.

Eldfisk 2/7-15X Well (11900-14510 ft.)

Interval 12700-14510 ft.:

Within the examined 11900-14510 ft. interval, the best source rock potential occurs between 12700 and 14510 ft. The sediments here possess a very good to excellent potential to produce significant quantities of oil, condensate and gas. The highest stage of the main oil generation phase has been reached, as determined by vitrinite reflectance measurements ($R_o = 1.0-1.25$). Abundant, good quality oil-prone kerogen (75-90%) also is present. High TOC values (2.5-15.6%) coupled with good HI values (214-399) suggest that a very good to excellent source potential for oil and condensate exists.

Three, 10 ft. composited cuttings samples analyzed between 13420 and 13450 ft. exhibit excellent source rock potential. This conclusion is based on very high TOC values (5.8-15.6%) coupled with high HI values (332-399). These samples contain the most abundant oil-prone kerogen observed in this well (90%).

Interval 11900-12460 ft.:

This interval possesses good source rock potential and it should generate both oil and condensate at its present thermal regime. These sediments have reached an advanced stage of the main oil generation phase ($R_o = 0.94$) and they contain adequate amounts of oil-prone kerogen (80%). Good TOC values (1.7-2.0) together with good to very good HI values (219 and 264) indicate the presence of a favorable source rock, but its potential is slightly lower than that observed for the deeper samples examined from this well.

In comparing the present study of the 2/7-15X well to that prepared by E. B. Robertson (EPS Report #1989A), differences are noted in R_o values for the same examined interval. R_o values reported in the earlier investigation average 0.10% higher than those measured in the present study. It is possible that the large standard deviations of the measured vitrinite values in the present study are a function of the large sample composites. These large variations make the in situ vitrinite populations more difficult to interpret than if smaller composites were used. On the other hand, it also is possible that the rapid increase in the R_o values reported for the shallower portion of the well in the earlier study could have inflated the R_o trend too rapidly. Furthermore, the interval between 11600 and 13000 ft. was not examined in the previous study. However, both studies reach the same conclusion; namely, the section is highly mature, contains oil-prone kerogen and should yield liquid hydrocarbons and gas.

2/7-19X Well (15300-16000 ft.)

The examined interval between 15300-16000 ft. possesses a fair to good potential to generate gas based on the presence of adequate gas-prone kerogen (50-55%) and a very high thermal regime. The sediments have reached the dry gas phase of thermal maturity as determined from their vitrinite reflectance

measurements ($R_o = 1.45$ to 1.75).

The samples exhibit fair to good TOC values (1.09 to 1.83), although HI values (57.8 to 80.9) and H/C ratio values (0.57 to 0.60) are low. The low HI and H/C values can be attributed to either the advanced stages of maturity or the inherently low hydrogen content of the kerogen.

An increase in the TEI values to 37.16 between 15710 - 15800 ft., and 27.40 at 15900 - 16000 ft. may signal the presence of bitumen, either indigenous or non-indigenous in origin. Some bitumen was observed during the visual examination of the prepared slides. Increased TEI values may reflect the affect of the elevated TOC values of these samples (1.46 - 1.83%).

8/11-1 Well (9220-10600 ft.)

The interval 9220 - 10600 ft. exhibits fair to good potential to generate oil, wet gas and gas at its present thermal regime. It has reached the advanced stage of the main oil generation phase based on vitrinite reflectance measurements ($R_o = 0.97$ to 1.05) and TAI values ($3-$). The presence of good quality, abundant amorphous kerogen (70 - 85%) in this interval indicates a good liquid hydrocarbon generating potential. A fair to good potential is indicated by the range of TOC values (0.76 to 2.58) and HI values (102 to 195).

The best source rock potential for the sediments studied from this well is found in the sample 9220 - 9300 ft. It has the best TOC value measured (2.58%), together with a fair hydrogen index (192) and abundant oil-prone kerogen; good liquid hydrocarbon source potential is indicated.

Approved: _____

E. A. Stanley

S. D. Miller

S. D. Miller

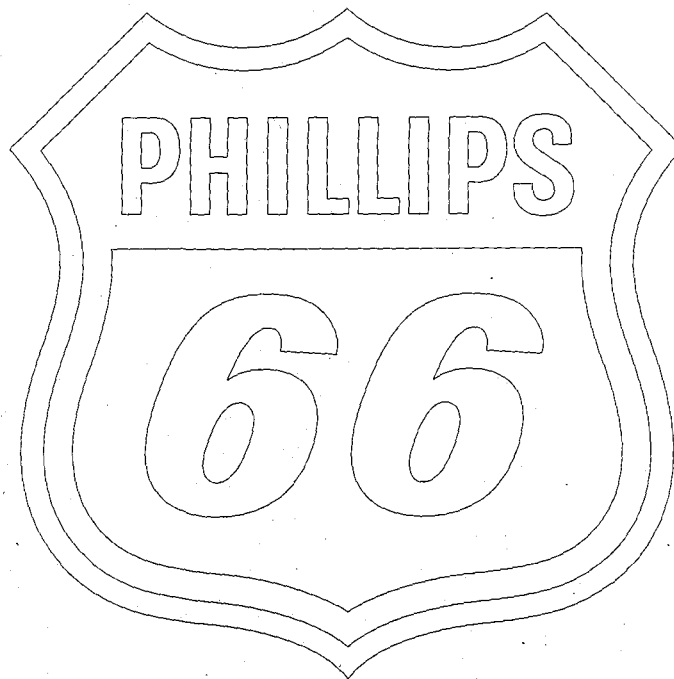
Figures and Tables in this Report:

Figures 1-4. Source Rock Potential, Thermal Alteration and Pyrolysis Results Plot.

Figure 5. Fluorescence and Oxidation vs. Reduction Plot.

Figure 6. Vitrinite Reflectance Histogram Plot, Unedited Data.

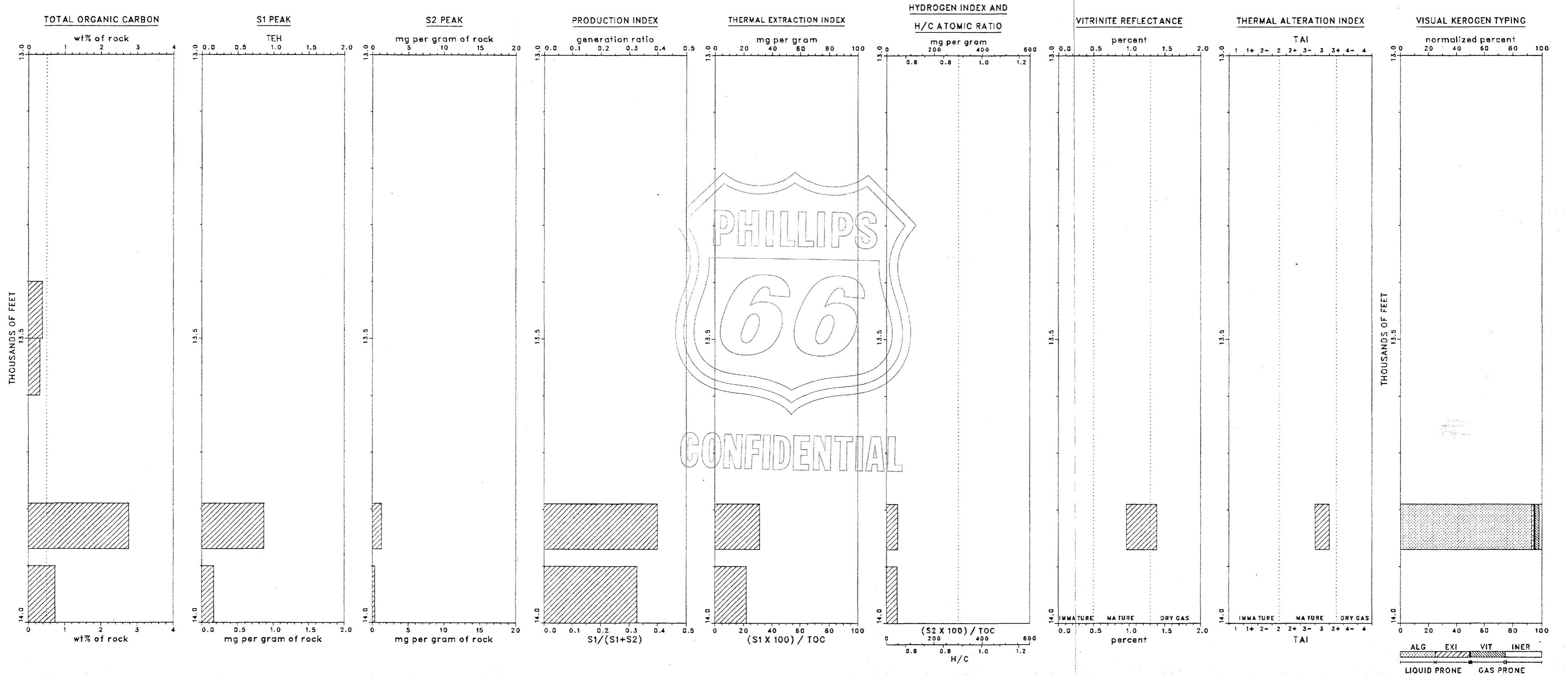
Tables 1-4. Pyrolysis Results, Thermal Alteration, and Source Rock Potential Data.



— CORE
 // CUTTINGS

FLYNDRE 1/5-2X, NORWEGIAN SECTOR, NORTH SEA
 PYROLYSIS AND VISUAL KEROGEN DATA

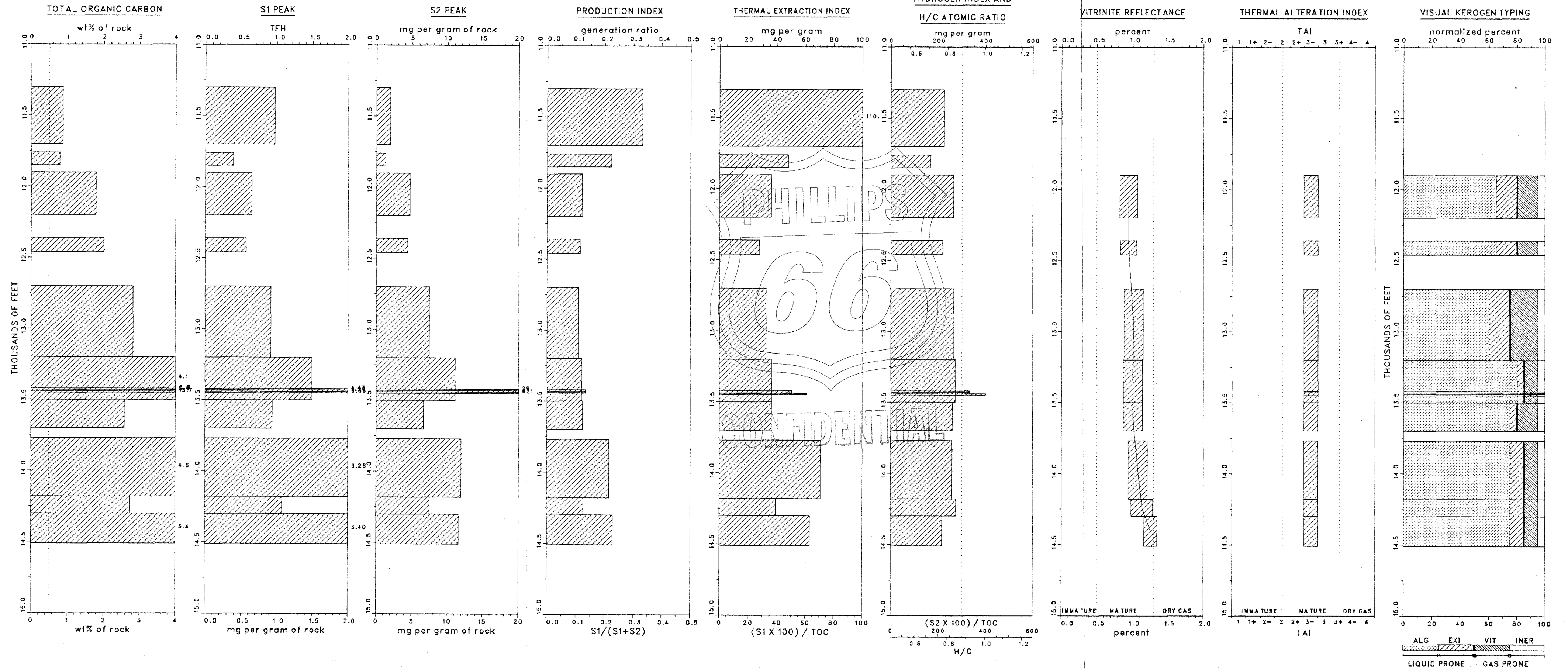
FIGURE 1
 EPS REPORT #2643A



ELDFISK 2/7-15X, NORWEGIAN SECTOR, NORTH SEA
 PYROLYSIS AND VISUAL KEROGEN DATA

FIGURE 2
 EPS REPORT #2643A

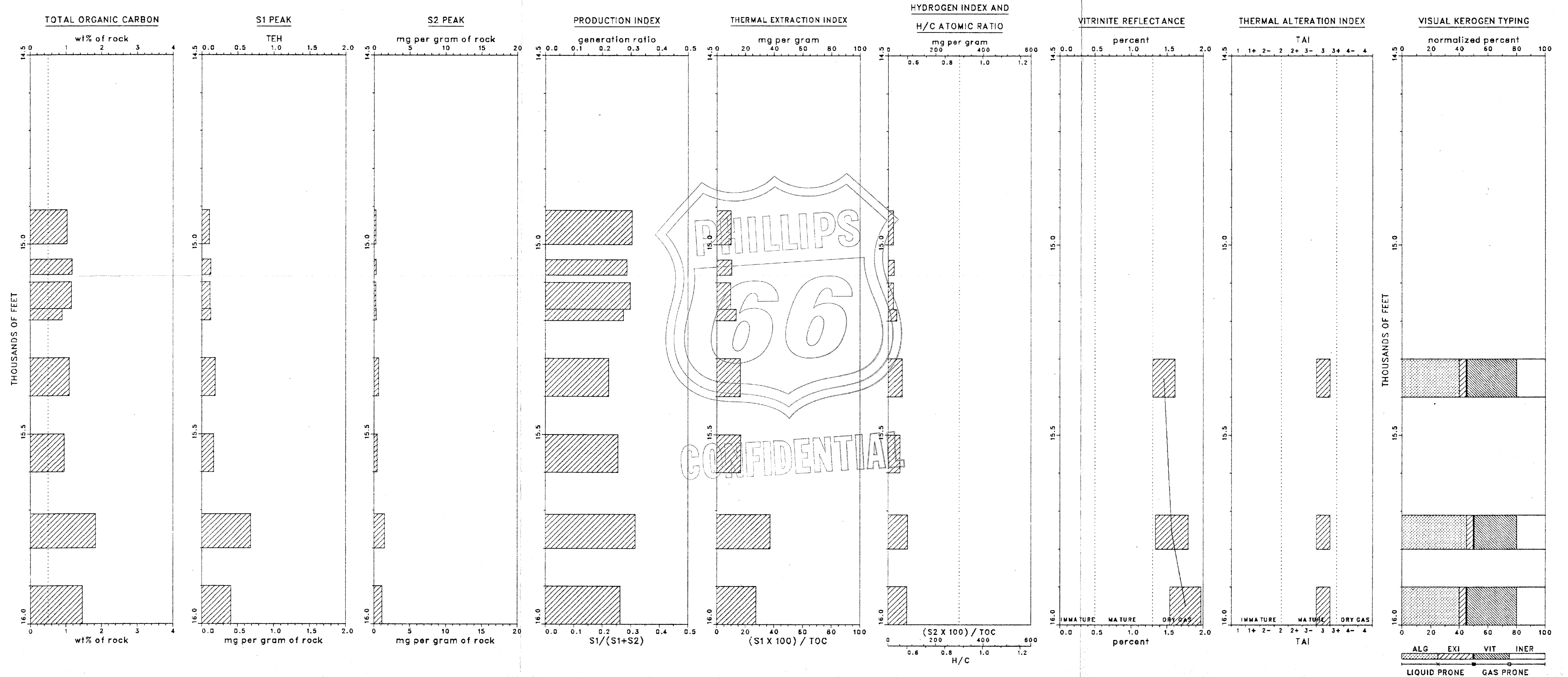
— CORE
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 // CUTTINGS

2/7-19, NORWEGIAN SECTOR, NORTH SEA
 PYROLYSIS AND VISUAL KEROGEN DATA

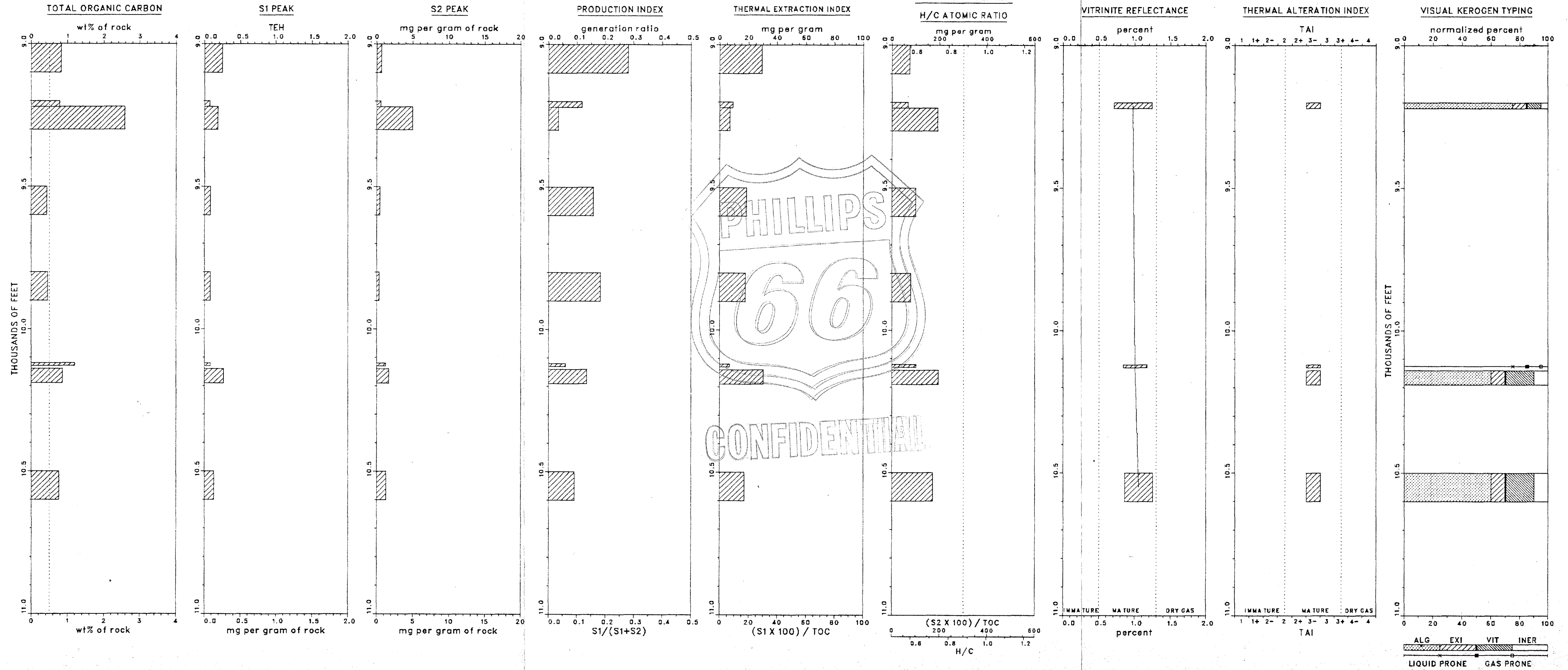
FIGURE 3
 EPS REPORT #2643A



— CORE
 ▨ CUTTINGS

8/11-1, NORWEGIAN SECTOR, NORTH SEA
 PYROLYSIS AND VISUAL KEROGEN DATA

FIGURE 4
 EPS REPORT #2643A



G GREEN Y YELLOW O ORANGE B BROWN N NIL ☒ HIGH INTENSITY / VERY ABUNDANT ☒ INTENSE / ABUNDANT ☒ MEDIUM INTENSITY / COMMON ☐ LOW INTENSITY / RARE ☐ VERY LOW INTENSITY / VERY RARE ● NIL / ABSENT	FLUORESCENCE COLOR & INTENSITY (SUBJECTIVE) (BLUE LIGHT FLUORESCENCE)			OXIDIZING vs. REDUCING CHARACTERISTICS OF DEPOSITIONAL ENVIRONMENT		
	INCREASING MATURITY →	AMORPHOUS KEROGEN	MOUNTING MEDIUM	MORE REDUCING ENVIRONMENT →	MORE REDUCING ENVIRONMENT →	PYRITE
	POLLEN/SPORE			% AMORPHOUS THAT SURVIVES PALY. PROCESS (SUBJECTIVE ESTIMATE)	KEROGEN COLOR FROM RED SAFRANINE-O STAIN	FB=FRAMBOIDAL FD=FINELY DISSEMINATED VC=VISIBLE CRYSTALS T=TISSUE REPLACEMENT
	G Y O B N	G Y O B N	G Y N	0 50 100	RED R/P PINK P/N NO STAIN	FB FD VC T
FLYNDRE 1/5-2X:						
13790' - 13870' AZK						
ELDFISK 2/7-15X:						
11900' - 12200' AYR						
12360' - 12460' AYS						
12700' - 13200' AYT						
13420' - 13430' BAC						
13430' - 13440' BAD						
13440' - 13450' BAE						
13200' - 13500' AYU						
13500' - 13700' AYV						
13770' - 14180' AYW						
14180' - 14300' AYW						
14300' - 14510' AYY						
EBBA 2/7-19X:						
15300' - 15400' AZE						
15710' - 15800' AZG						
15900' - 16000' AZH						
8/11-1:						
9220' - 9300' BAH						
10120' - 10130' BAK						
10140' - 10190' BAL						
10500' - 10600' BAM						

Grp. Lic. Area, Norw. No. Sea

Loaded 18 total samples

COPY 15 OF 20 COPIES

GROUP LICENCE AREA
NORWEGIAN NO. SEA
EPS REPORT #2643A

Log % Reflectance
Unedited Vitrinite Data

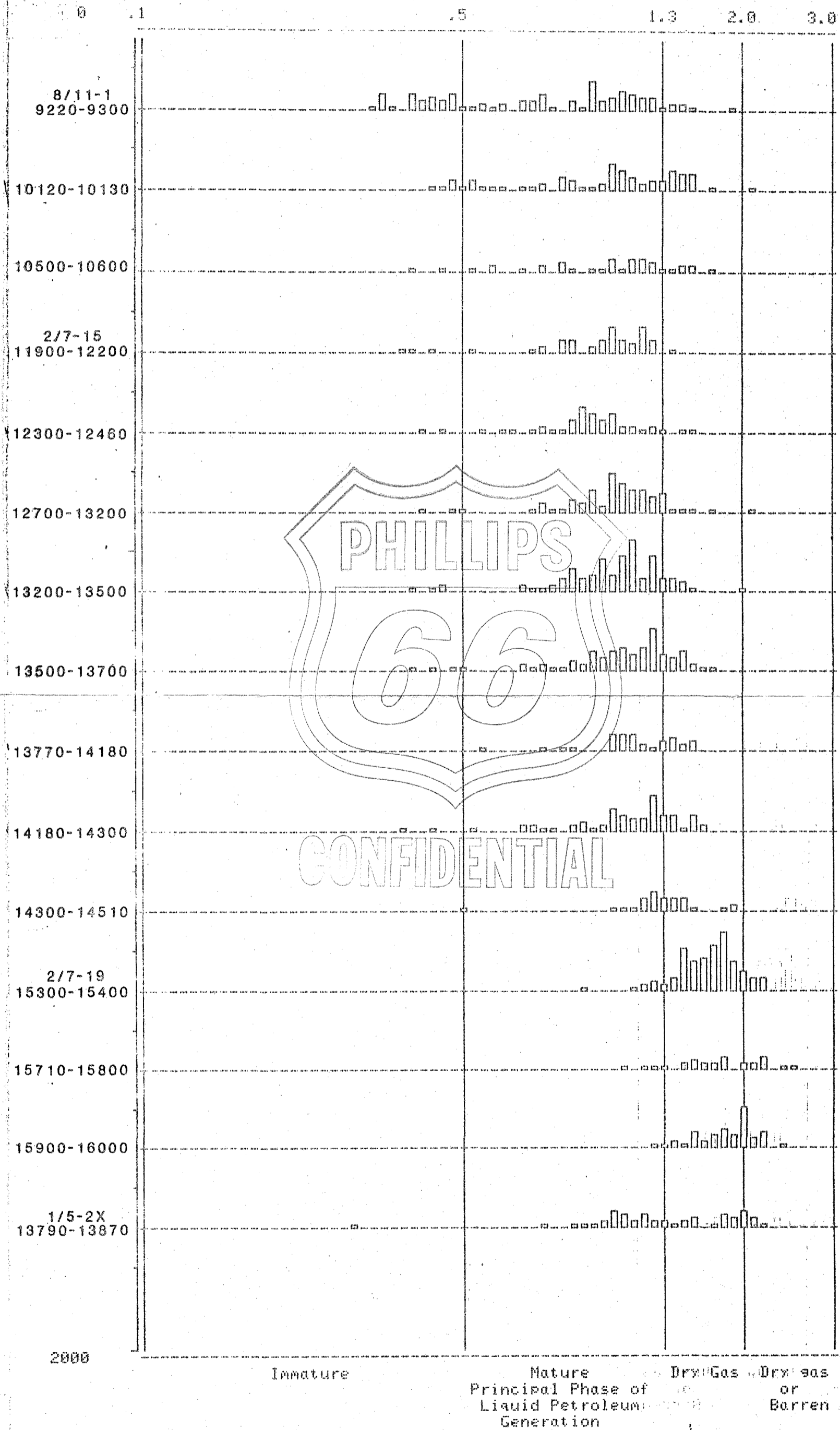


FIGURE 6

GEOCHEMICAL DATA FOR SAMPLES FROM THE FLYNDRE 175-2X, NORWEGIAN SECTOR, NORTH SEA

BIOSTRAT		SPL	SAMPLE	LEPTH	TOTAL	S1	S2	PRODUC-	THERMAL	HYDRO-	H/C	PERCENT	THERMAL	VISUAL	KEROGEN	PERCENT		GEOCHEM
INTERVAL	TYP		DEPTH	(TOC)	ORGANIC	MG.HC	MG.HC	TION	EXTRAC-	GEN	ATOMIC	VITRINITE	ALTERA-	NORMALIZED	DIL PRONE	GAS PRONE		SAMPLE
			FEET	WT. %	PER	PER	PER	INDEX	INDEX	INDEX	RATIO	REFLECTANCE	TION	EXT	EXT	VIT	INERT	CODE
					WT. %	G.ROK	G.ROK	(S1/S2)	MG/G	MG/G		MEAN	DEW	PTS				
CUT			13400-13500		.38													EP84A2I
CUT			13500-13600		.31													EP84A2J
CUT			13700-13800		2.75	.86	1.29	.400	31.16	46.7	.559	1.17	.21	31	3	93	2	3
CUT			13900-14000		.73	.16	.33	.327	21.92	45.2	.557							EP84A2K
																		EP84A2L

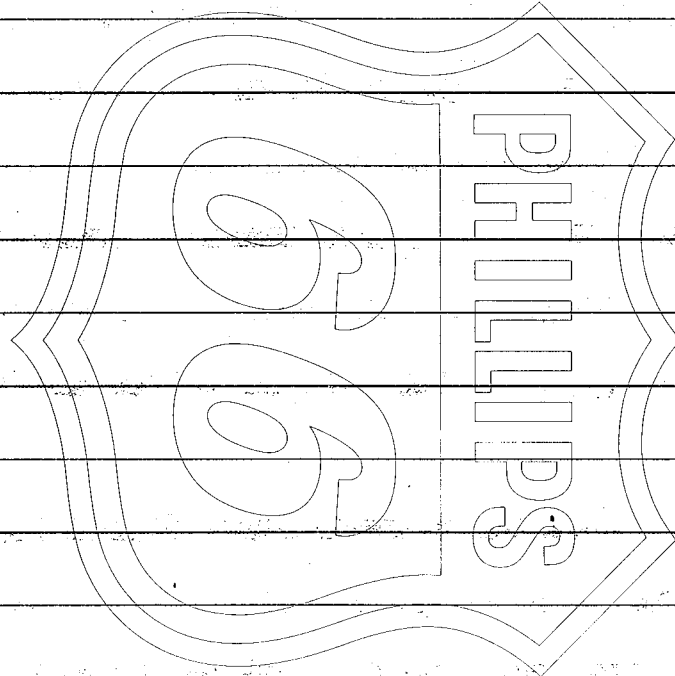


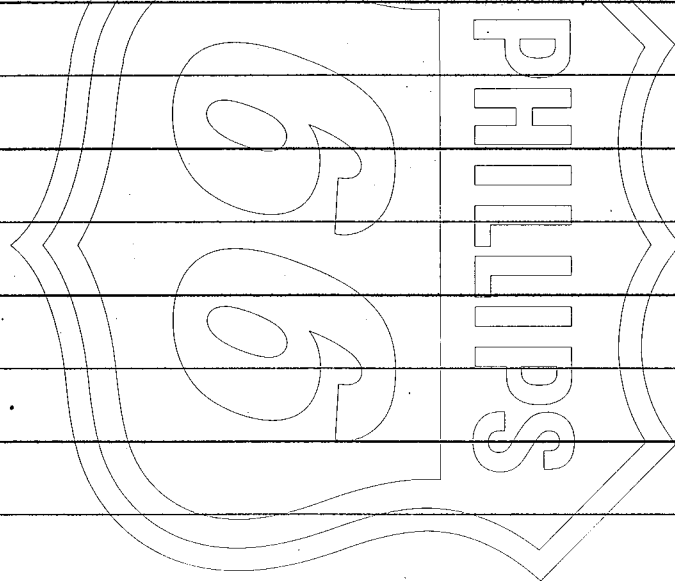
TABLE 2

EPS REPORT #2643A

GEOCHEMICAL DATA FOR SAMPLES FROM THE ELDFISK 2/7-15X, NORWEGIAN SECTOR, NORTH SEA

PAGE 1 OF 1

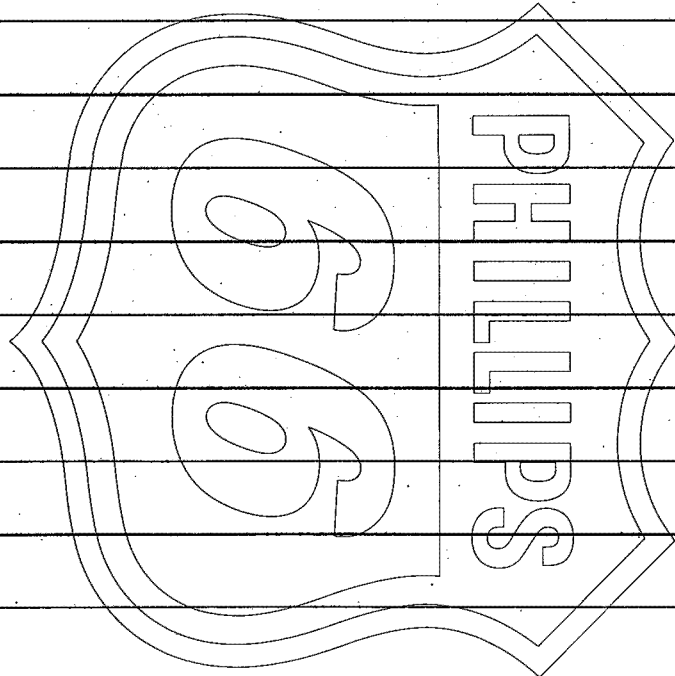
		*****										*****				*****		
BIOSTRAT INTERVAL	SPL TYPE	SAMPLE DEPTH FEET	TOTAL	S1	S2	PRODUC-	THERMAL	HYDRO-	H/C	PERCENT	THERMAL	VISUAL KEROGEN			GEOCHEM SAMPLE CODE			
			ORGANIC CARBON WT. %	MG. HC PER G. ROCK	MG. HC PER G. ROCK	TION INDEX (S1+S2)	EXTRAC- TION MG/G.	GEN- INDEX MG/G.	ATOMIC RATIO	VITRINITE REFLECTANCE STD MEAN DEV PTS	ALTERA- TION INDEX (TAI)	NORMALIZED OIL PRONE ALG	PERCENT GAS PRONE EXI	PERCENT VIT INERT				
CUT	11300-11700		.87	.96	1.94	.331	110.34	223.0	.781						EP84AYP			
CUT	11760-11850		.79	.38	1.32	.224	48.10	167.1	.711						EP84AYQ			
CUT	11901-12200		1.79	.64	4.76	.120	35.96	264.0	.833	.94	.12	30	3-	65	15	15	5	EP84AYR
CUT	12360-12460		2.00	.56	4.39	.113	28.00	219.5	.777	.94	.11	37	3-	65	15	15	5	EP84AYS
CUT	12700-13200		2.01	.91	7.46	.109	32.38	265.5	.835	1.01	.13	53	3-	60	15	20	5	EP84AYT
CUT	13200-13500		4.08	1.48	11.09	.118	36.27	271.8	.842	1.00	.13	68	3-	80	5	10	5	EP84AYU
CUT	13420-13430		8.00	4.43	29.22	.132	50.34	332.0	.918				3-	85	5	5	5	EP84BAC
CUT	13430-13440		5.89	2.99	19.56	.133	50.76	332.1	.918				3-	85	5	5	5	EP84BAD
CUT	13440-13450		15.65	9.56	62.51	.133	61.09	399.4	1.003				3-	85	5	5	5	EP84BAE
CUT	13500-13700		2.57	.93	6.66	.123	36.19	259.1	.827	1.00	.13	42	3-	75	5	15	5	EP84AYV
CUT	13770-14180		4.64	3.28	11.97	.215	70.69	258.0	.825	1.07	.13	21	3-	75	10	10	5	EP84AYW
CUT	14180-14300		2.73	1.07	7.50	.125	39.19	274.7	.846	1.13	.15	46	3-	75	10	10	5	EP84AYX
CUT	14300-14510		5.40	3.40	11.58	.227	62.96	214.4	.770	1.25	.09	21	3-	75	10	10	5	EP84AYY



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GEOCHEMICAL DATA FOR SAMPLES FROM THE 2/7-19, NORWEGIAN SECTOR, NORTH SEA

BIOSTRAT INTERVAL	SPL TYP	SAMPLE DEPTH FEET	TOTAL ORGANIC CARBON (TOC)		S1		S2		PRODUCTION INDEX		THERMAL EXTRACTION INDEX		HYDROGEN INDEX MG/G	H/C ATOMIC RATIO	PERCENT VITRINITE REFLECTANCE			THERMAL ALTERATION INDEX			VISUAL KEROGEN NORMALIZED PERCENT			GEOCHEM SAMPLE CODE
			WT. %	MG. PER G. ROCK	MG. PER G. ROCK	MG. PER G. ROCK	(S1+S2)	MG/G.	MG/G.	MG/G.	MEAN	DEV			PTS	(TAI)	ALC	EXI	VIT	INERT	GAS	PRONE		
CUT	14910-15000		1.03	.10	.23	.303	9.71	22.3	.528															EP84AZA
CUT	15040-15080		1.17	.12	.30	.286	10.26	25.6	.532															EP84AZB
CUT	15100-15170		1.15	.11	.26	.297	9.57	22.6	.528															EP84AZC
CUT	15170-15200		.89	.12	.32	.273	13.48	36.0	.545															EP84AZD
CUT	15300-15400		1.09	.18	.63	.222	16.51	57.8	.573	1.45	.15	45	3		40	5	35	20						EP84AZE
CUT	15500-15600		.95	.16	.47	.254	16.84	49.5	.562															EP84AZF
CUT	15710-15800		1.83	.68	1.48	.315	37.16	80.9	.602	1.56	.22	18	3		45	5	30	20						EP84AZG
CUT	15900-16000		1.46	.40	1.13	.261	27.40	77.4	.598	1.75	.21	40	3		40	5	35	20						EP84AZH

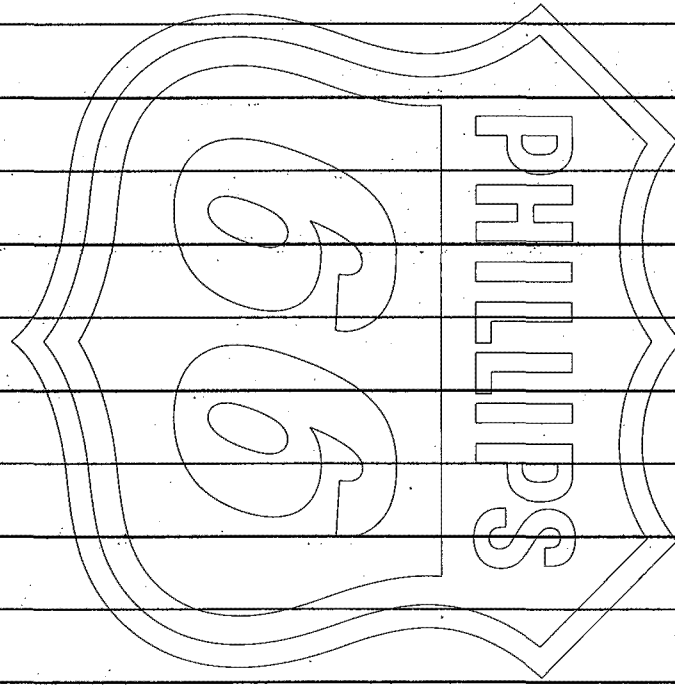


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TABLE 4
EPS REPORT #2643A

GEOCHEMICAL DATA FOR SAMPLES FROM THE 8/11-1, NORWEGIAN SECTOR, NORTH SEA

BIOSTRAT INTERVAL	SPL TYPE	SAMPLE DEPTH FEET	TOTAL ORGANIC CARBON		S1		S2		PRODUCTION INDEX		THERMAL EXTRACTION INDEX		HYDROGEN INDEX		H/C RATIO		PERCENT VITRINITE REFLECTANCE			THERMAL ALTERATION INDEX		VISUAL KEROGEN NORMALIZED PERCENT				GEOCHEM SAMPLE CODE
			WT. %	MG. HC PER G. ROCK	MG. HC PER G. ROCK	MG. HC PER G. ROCK	(S1+S2)	MG/G	MG/G	MG/G	MG/G	MG/G	MG/G	MG/G	MEAN	DEV	PTS	(TAI)	ALC	EXI	VIT	INERT				
CUT		9000-9100	.82	.24	.62	.279			29.27			75.6		.595			.97	.26	64	3-	75	10	10	5	EP84BAF	
CUT		9200-9220	.78	.07	.53	.117			8.97			67.9		.586											EP84BAG	
CUT		9220-9300	2.58	.18	4.97	.035			6.98			192.6		.743											EP84BAH	
CUT		9500-9600	.43	.08	.43	.157			18.60			100.0		.626											EP84BAI	
CUT		9800-9900	.45	.08	.36	.182			17.78			80.0		.601											EP84BAJ	
CUT		10120-10130	1.20	.08	1.23	.061			6.67			102.5		.629	1.00	.16	38	3-	75	10	10	5		EP84BAK		
CUT		10140-10190	.85	.26	1.68	.134			30.23			195.3		.746						3-	60	10	20	10	EP84BAL	
CUT		10500-10500	.76	.13	1.30	.091			17.11			171.1		.716	1.05	.19	27	3-	60	10	20	10		EP84BAM		



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