statoil

ORGANIC GEOCHEMISTRY OF 6610/7-1

TRÆNABANKEN

Den norske stats oljeselskap a.s

ORGANIC GEOCHEMISTRY OF 6610/7-1

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POTENTIAL SOURCE ROCKS

PRE-JURASSIC Poor potential for hydrocarbons.

TOC <1.5%; HI <50; type IV kerogen.

JURASSIC

a) UPPER JURASSIC HOT SHALE (2271 - 2315m) Good-rich potential for oil.

TOC 4.2 -14.4%; HI 207 - 564; type II/III - II kerogen.

Source rock potential decreases fairly steadily down this zone. The organic matter consists of a considerable proportion of herbaceous and cuticular material along with amorphous sapropel pollen and spores.

The original source potential of these rocks is high and about 2% of this potential has already been realised. Pyrolysis - GC shows these shales should produce moderate amounts of gas with light oil up to about C25.

6610/7-1
SOURCE ROCK POTENTIAL
UPPER JURASSIC HOT SHALE

TOC	RANGE	4.19-14.4 %	
	AVE	8.0 %	
S1+S2	RANGE	9.19-86.82	(kg HC/TON ROCK)
	AVE	32.34	"
HI	RANGE	207-564	(i.e. 33.3 % OF REMAINING
	AVE	333	KEROGEN WILL GENERATE HC
GEN.POT	AVE	35.6 %	(I.E.35.6 % OF KEROGEN
			ORIGINALLY COULD GENERATE
HC)			

OVERALL 2.3 % OF ORIGINAL HC POTENTIAL HAS BEEN REALISED.

HOT SHALES

	TOC	H1	S_1+S_2	ORIG GEN POT	POT USED	KEROGEN TYPE
A6463	14.4	564	86.82	60.4	4.0	II
A6424	6.17	387	26.64	43.5	4.8	II/III
A5841	11.29	376	46.65	41.6	4.0	II/III
A6425	6.17	277	18.12	29.0	1.3	II/III
A6426	9.11	330	31.03	34.0	1.0	II/III
A5846	4.19	207	9.19	21.9	1.2	II/III
A5848	6.35	248	16.88	26.6	1.8	II/III
A5850	6.41	273	18.35	28.1	0.8	II/III
AVERAGE	8.0	333	32.43	35.6		II/III

b) UPPER JURASSIC COLD SHALE (2315 - 2675m) Poor potential for oil

TOC 0.93 - 3.57%; HI 62 - 168; type IV/III-III kerogen.

HEATHER EQUIVALENT

	TOC	HI	S_1+S_2	ORIG GEN POT	POT USED	KEROGEN TYPE
A5846	1.03	112	1.31	13%	1.8%	IV/III
A5848	1.01	66	0.77	8%	1.4%	IV/III
A5850	0.93	70	0.73	7%	0	IV
A5853	1.04	85	1.05	10%	1.5%	IV/III
A5855	1.21	97	1.38	11%	1.3%	IV/III
A5857	1.38	101	1.61	12%	1.9%	IV/III
A5859	1.09	62	0.76	6%	0.2%	IV
A5869	3.57	168	6.26	18%	1.2%	IV/III
A5861	0.99	89	0.98	10%	1.1%	IV
A5864	2.17	112	2.61	12%	1.8%	IV/III
A5866	1.28	110	1.54	12%	1.0%	IV/III
A6427	4.65	48	2.44	5%	0.2%	IV
A6428	2.30	42	1.05	4%	0.2%	IV
AVERAGE	1.7	89	1.73	AVE9.90		IV/III

c) LOWER JURASSIC SHALE (2679 - 2746m) Poor potential for hydrocarbons.

TOC 0.94 - 1.05%; HI 76 - 96; type IV/III kerogen.

d) LOWER JURASSIC COAL UNIT (2854 - 3194m) Fair good potential for oil and gas

TOC 0.89 - 5.96%; HI 100 - 293; type III-III/II kerogen.

Pyrolysis - GC shows the shale and coals would generate waxy oil and large volumes of methane. Per unit volume the shales and coals have rich hydrocarbon potential but the overall potential is dependent on the frequency and thickness of these interbeds.

LOWER JURASSIC COAL UNIT

	TOC	HI	S_1+S_2	Orig.Gen. Potential	Potential Used
Cuttings	0.94 %	85	0.89	9.5 %	1
	1.13 %	125	1.54	13.6 %	1.1
	5.96 %	293	18.56	31.1 %	.8
	0.89 %	100	0.98	11.0 %	1
SWC	37.38 %	198	76.32	20.4 %	0.6
SWC	5.60 %	189	11.24	20.0 %	1.1

LEVEL OF MATURATION

Vitrinite Reflectance.

There is a sparsity of true vitrinite; bitumen staining is ubiquitous leading to low values; a few samples are caved, and much material is reworked. Therefore there is a large spread of data points. The best measurement is on coal. Taking these facts into account the following estimate of maturity was made:

Early oil	(Ro% 0.5)	2300m
Oil window	(Ro% 0.7)	3100m
Peak generation	(Ro% 0.75)	3400 - 3500m.

TAI and fluoresence estimates of maturity are in fair agreement with this. Projection of the trend indicates the base of the oil window - condensate zone would be encountered at 4100 - 4200m.

Consideration of the generation potential, hydrogen index and Tmax shows that significant hydrocarbon generation has begun in the Jurassic shales at 2270m and below.
The estimates above apply to type II kerogen; type III kerogen will begin to mature at a deeper level where Ro = 0.7%.

MIGRANT HYDROCARBONS

PRE JURASSIC SEQUENCE

The high production indices and moderate extractablilities are believed to be due to contaminants from mud rather than from migrant hydrocarbons.

UPPER JURASSIC SHALES

Most of the hydrocarbons were generated in-situ. Contamination from mud and mud addititves is visible when TOC and hydrocarbon potential is low.

LOWER JURASSIC SANDSTONE.

Hydrocarbons extracted from the potential reservoir interval were of waxy oil from a dominantly terrestrial type source rock. There is a smooth hydrocarbon envelope from C_{13} - C_{35}, peaking at C_{17}, with an odd over even carbon preference. The pristane/phytane ratio is fairly high. There is a fairly high proportion of nonhydrocarbons probably indicating the residual nature of the oil.

FIGURES

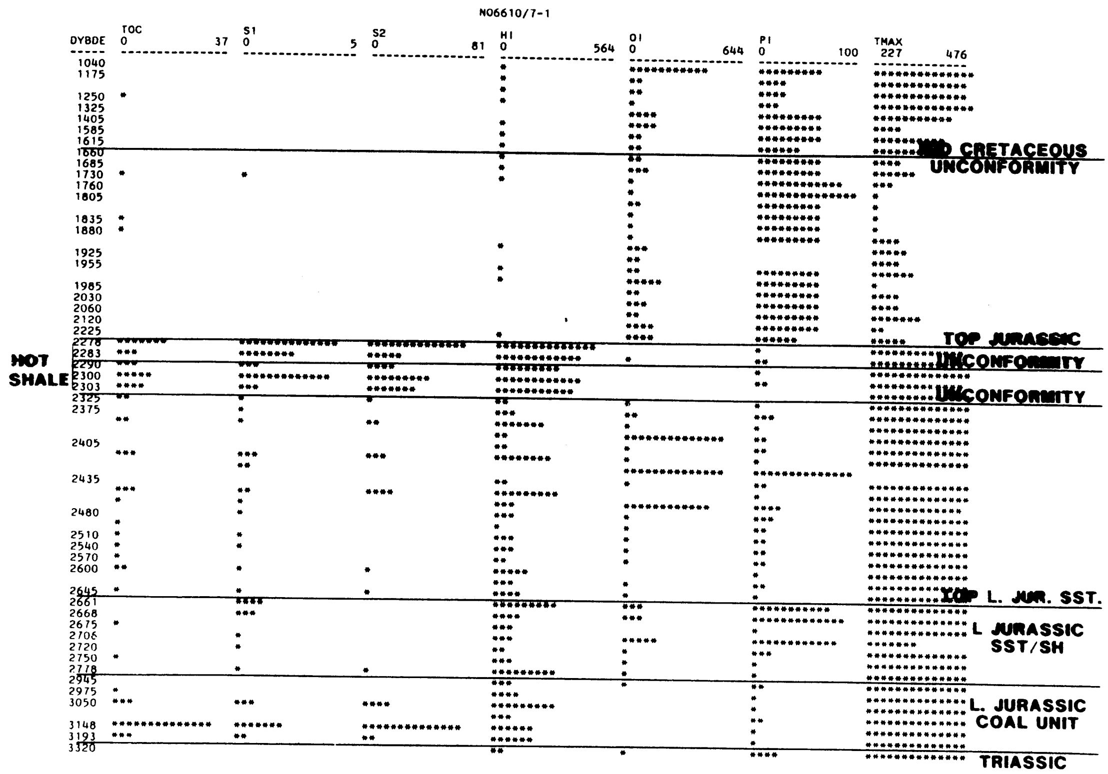


Figure 1

The low TMAX and high production indices in the Lower Cretaceous are due to low amounts of organic matter and contamination from mud additives.

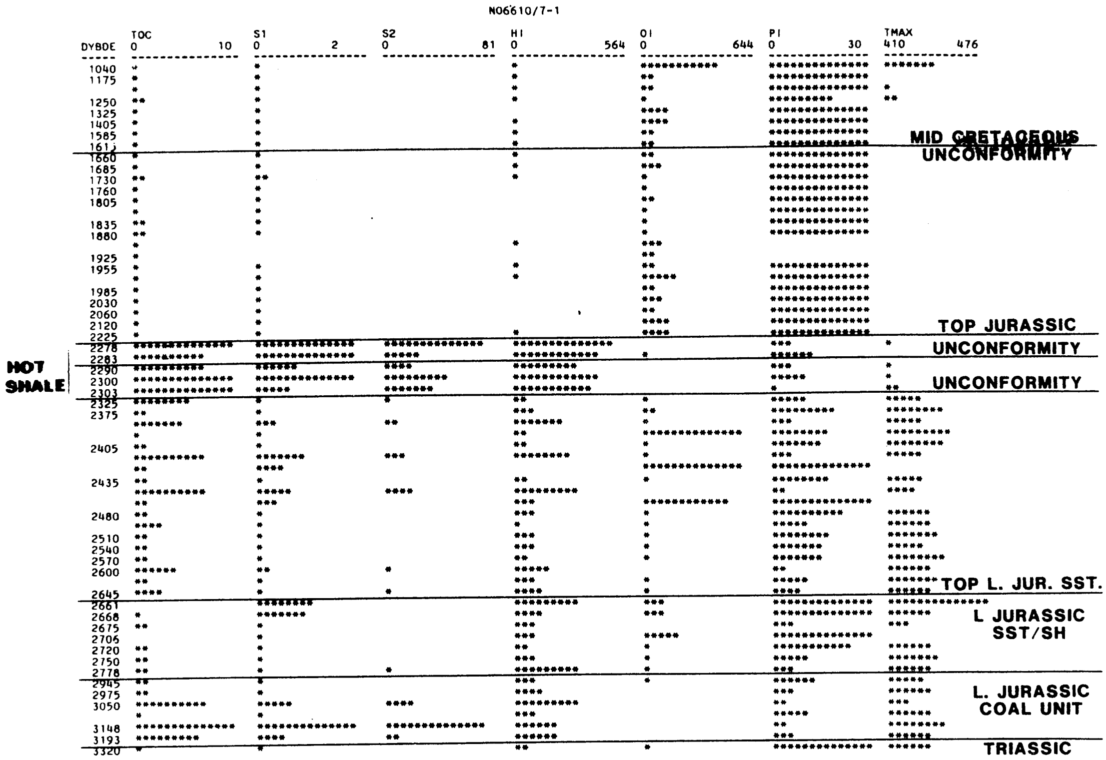


Figure 2
The good potential source rocks are in the Upper Jurassic "hot" shales and the Lower Jurassic coal unit. The good source rocks are characterised by high TOC, high HI and moderate TMAX. Contamination by migrant hydrocarbons in the Lower Jurassic sandstone and shale is characterised by high production indices.

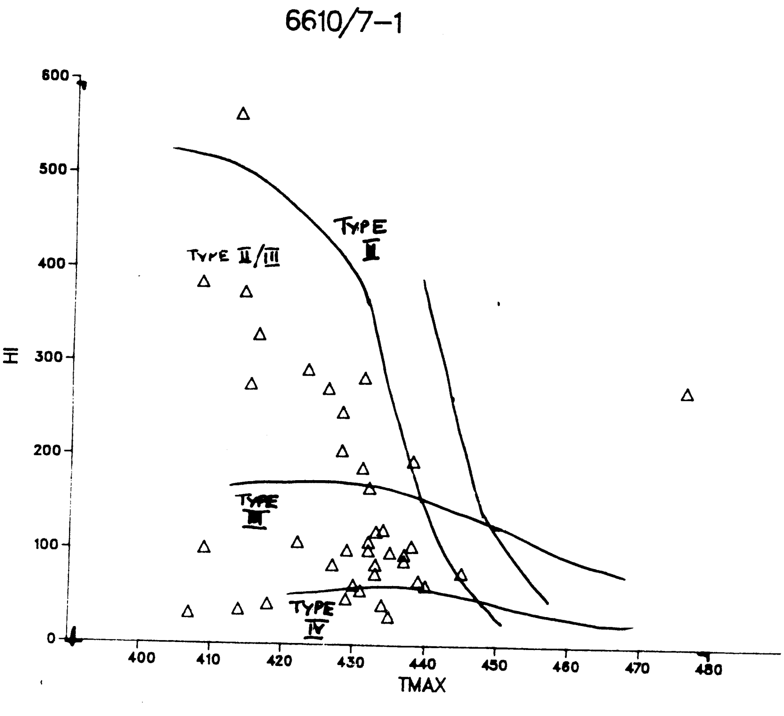
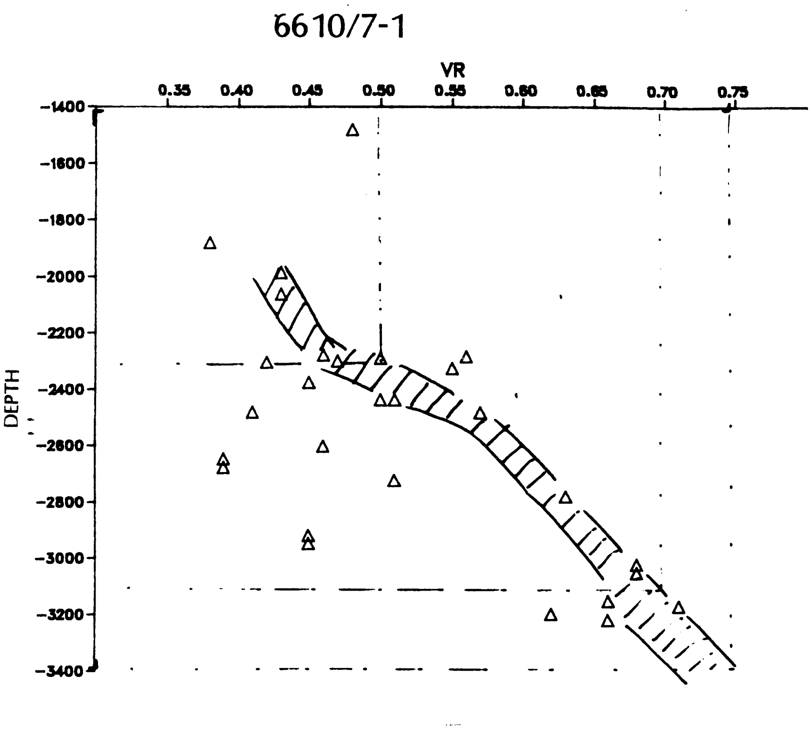
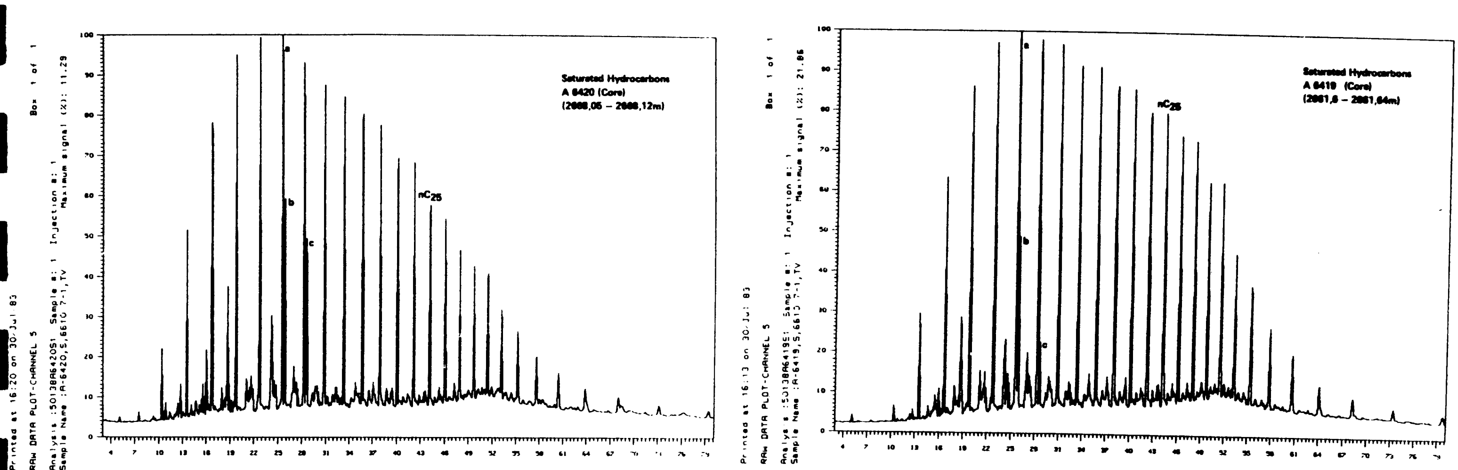


Figure 3
This plot of HI against TMAX shows the different types of kerogen present. The type II and II/III kerogens are from the Upper Jurassic Hot shales and the Lower Jurassic Coal Unit.



<u>Figure 4</u>

This is a plot of the maturity trend which has been placed through the most reliable data points.



<u>Figure 5 and 6</u>

Chromatograms of saturated hydrocarbons from residual oil in potential reservoir section. The oil is waxy with a low CPI, low pristane/n-C_{17} and variable pristane/phytane ratio.

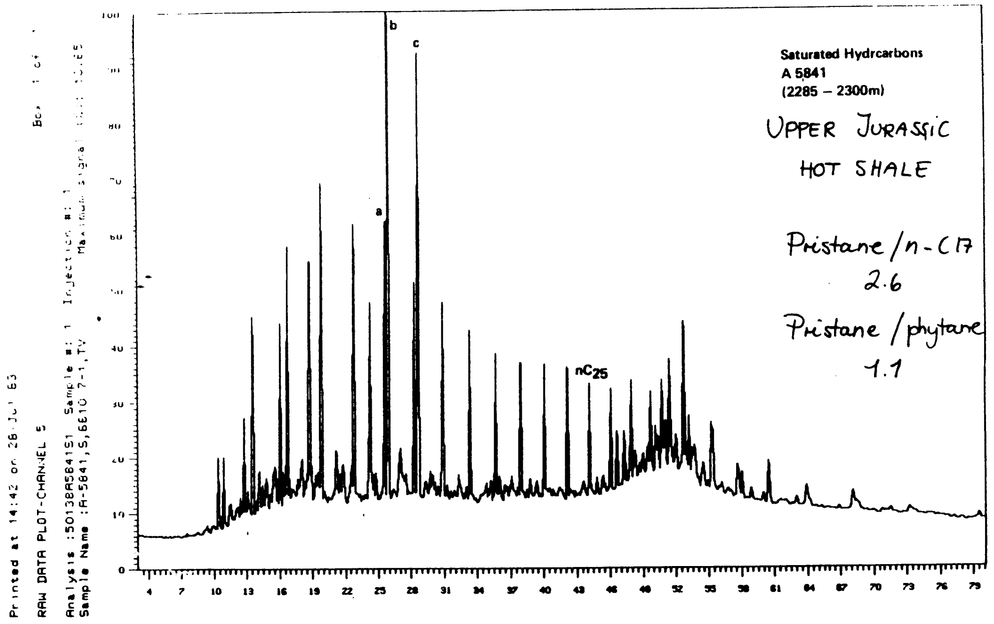


Figure 7

Extract from Upper Jurassic Hot Shale

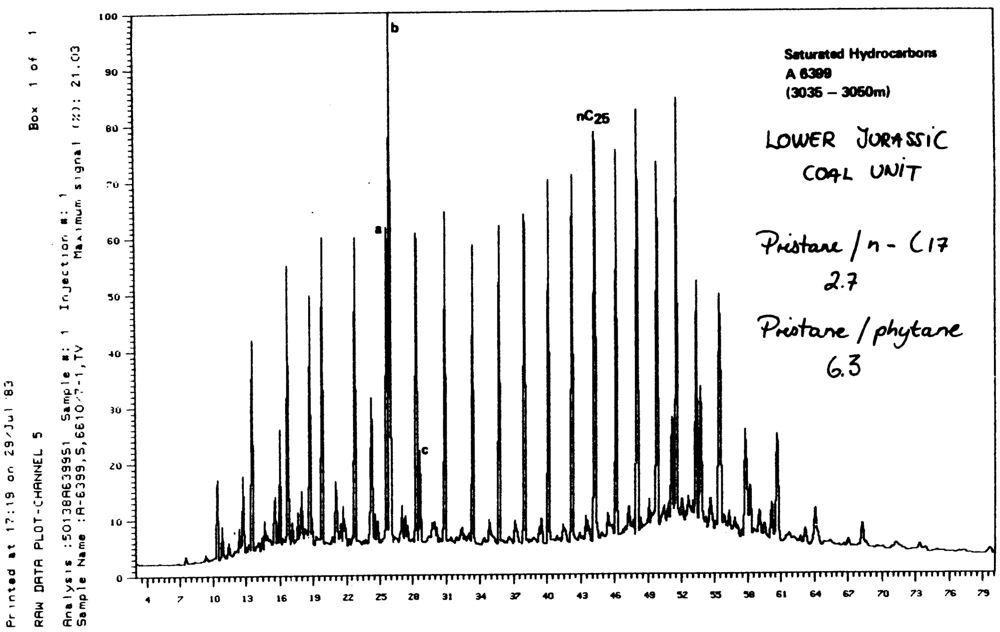


Figure 8

Extract from Lower Jurassic Coal Unit

- 96 -

- 105 -

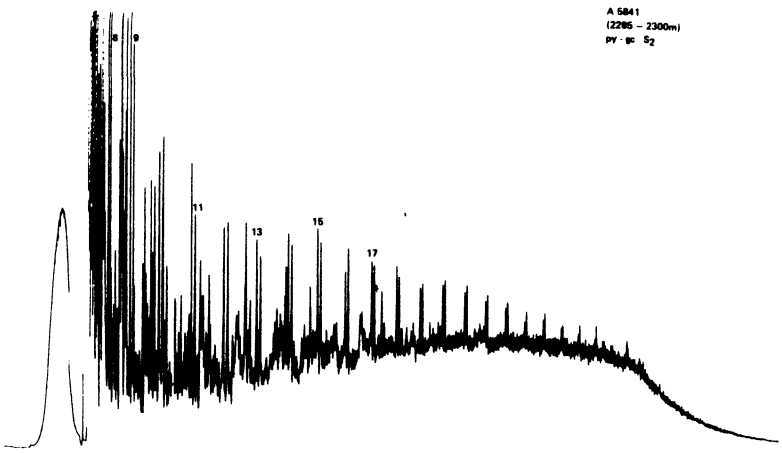


Figure 9

Pyrolysis-GC of Upper Jurassic Hot Shale showing that hydrocarbons are expected only up to C_{25}.

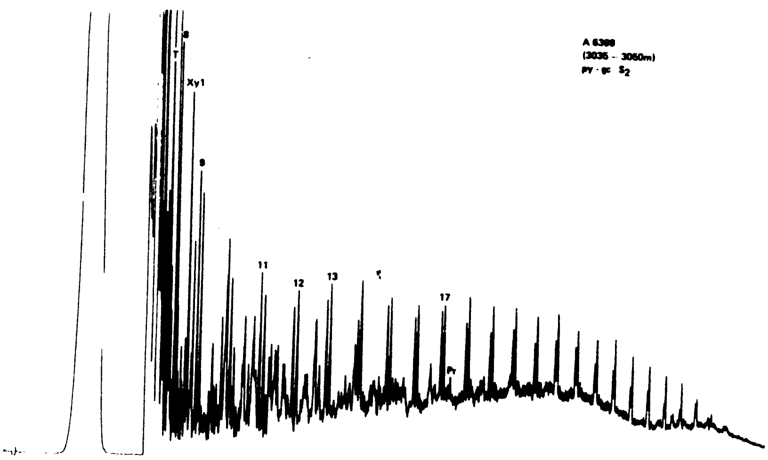


Figure 10

Pyrolysis-GC of shale from Lower Jurassic Coal Unit showing that hydrocarbons could be produced up to C_{30}.