3

Institute for energy technology

ADDRESS TELEPHONE TELEX	KJELLER N-2007 Kjeller, Norway (02)712560 - 713560 76361 energ n	HALDEN N-1751 Halden, Norway (031)83100 76335 energ n	AVAILABILITY Private confidential

REPORT TYPE		DATE
	REPORT NO. IFE/KR/F-84/028	DATE 1984-02-29
Service report	REPORT TITLE AN ORGANIC GEOCHEMICAL EVALUATION OF SAGA'S 6609/10-1 WELL OFFSHORE NORWAY	DATE OF LAST REV. REV. NO.
	CLIENT Saga Petroleum A/S	NUMBER OF PAGES
	CLIENT REF.	NUMBER OF ISSUES 20

SUMMARY

The 6609/10-1 well penetrated only one stratigraphic unit with significant source rock potential. The Coal Unit has a rich potential for gas and condensate.

The maturity increases continously with depth reaching the transitional zone (Ro = 0.35) at 2000 m. The early mature zone (Ro = 0.55) is not reached in the well.

Headspace gas component and isotopic composition clearly exclude the possibility of migrated thermogenic hydrocarbons in the well section.

BA 84-1591-1

27 MARS 1984

REGISTRERT

DISTRIBUTION

Saga, 10
Andresen, B.
Berg, J.O.
Brevik, E.M.
Garder, K.
Gaudernack, B.
Råheim, A.
Throndsen. T.O.

KEYWORDS

	NAME	DATE	SIGNATURE
PREPARED BY	Torbjørn O. Throndsen Bjørg Andresen Einar M. Brevik Arne Råheim	1984-02-29	Torbjørn Throndsen
REVIEWED BY			
APPROVED BY	Karen Garder	1984-02-29	Karen Garder

TABLE OF CONTENTS

1. Exploration summary

Well 6609/10-1 was drilled into Triassic Red Beds with possible Middle and Lower Jurassic sandstones as the main targets. The well penetrated as prognosticated a Lower Jurassic sandstone bearing unit which, however, proved to be dry and without any shows.

This report contains an organic geochemical evaluation primarily of the Jurassic, Cretaceous and lowermost Tertiary intervals with a brief note on the Triassic Grey Beds and Red Beds intervals. Items to be discussed include source rock identification, maturity evaluation, and detection of migrated hydrocarbons.

1.1 Source rocks (Figure I)

The well encountered one stratigraphic unit with significant source rock potential : the Coal Unit.

The Triassic Grey Beds interval below the Coal Unit appears to have a moderate potential presumably for gas.

The remaining claystone units being studied the Hordaland Group, Rogaland Group, Shetland Group, the Middle Jurassic Claystone interval and the Triassic Red Beds interval have practically no potential for generation of hydrocarbons.

The Coal Unit (208 m) consists of alternating coal, shale and sandstone lithologies. Altogether the Coal Unit contains 39.6 m of coaly lithologies. The major portion of these are carbonaceous shales and carbominerites. Very little is true coal. The organic carbon values range up to 45.94 weight percent, the pyrolysate yields (S2-peak) up to 95.29 mg/g rock and the corresponding hydrogen indices up to 234.

Maceral analysis and solvent extraction data indicate that the organic matter is of humic nature. The composition is dominated by vitrinite with a potential principally for dry gas at high maturity levels (Ro > 1.0). Exinitic components with potential for heavier hydrocarbons are also abundant.

The Coal Unit has a considerable thickness, contains abundant organic matter and represents a rich potential for wet gas and condensate at relatively high maturity levels (Ro = > 0.9).

1.2 Maturity (Figure I and II)

The maturity appears to increase continously with depth reaching the transitional zone (Ro = 0.35) around 2000 m. The early mature zone (Ro = 0.55) is not reached in the well section.

1.3 Migrated hydrocarbons (Figure III)

Headspace gas component and isotopic composition, and solvent extraction data clearly exclude the possibility of migrated thermogenic hydrocarbons in the well section, only biogenic gas and indigenous bitumen are present.

FIGURE : I

SOURCE ROCK AND MATURITY EVALUATION

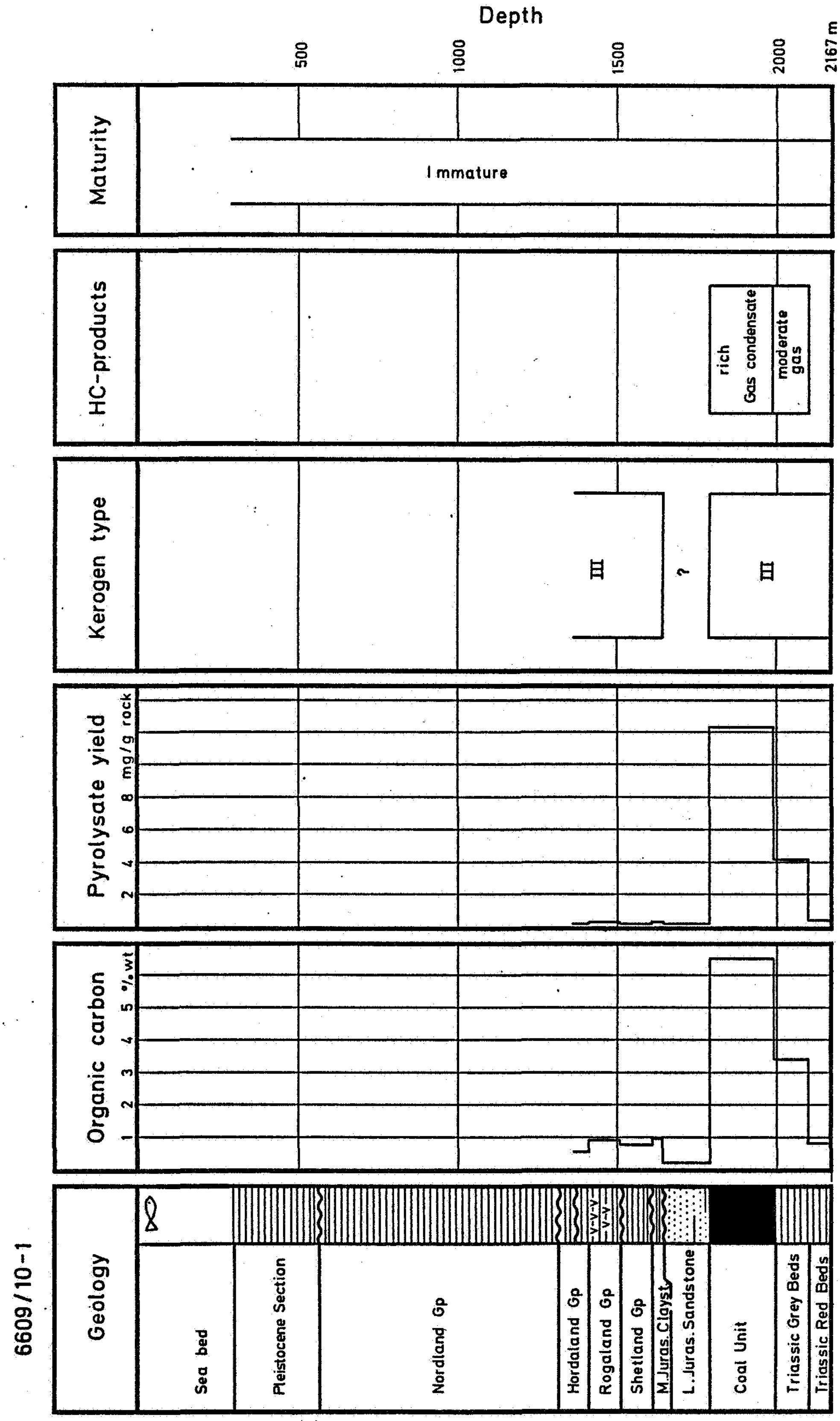


FIGURE : II

VITRINITE REFLECTANCE PROFILE

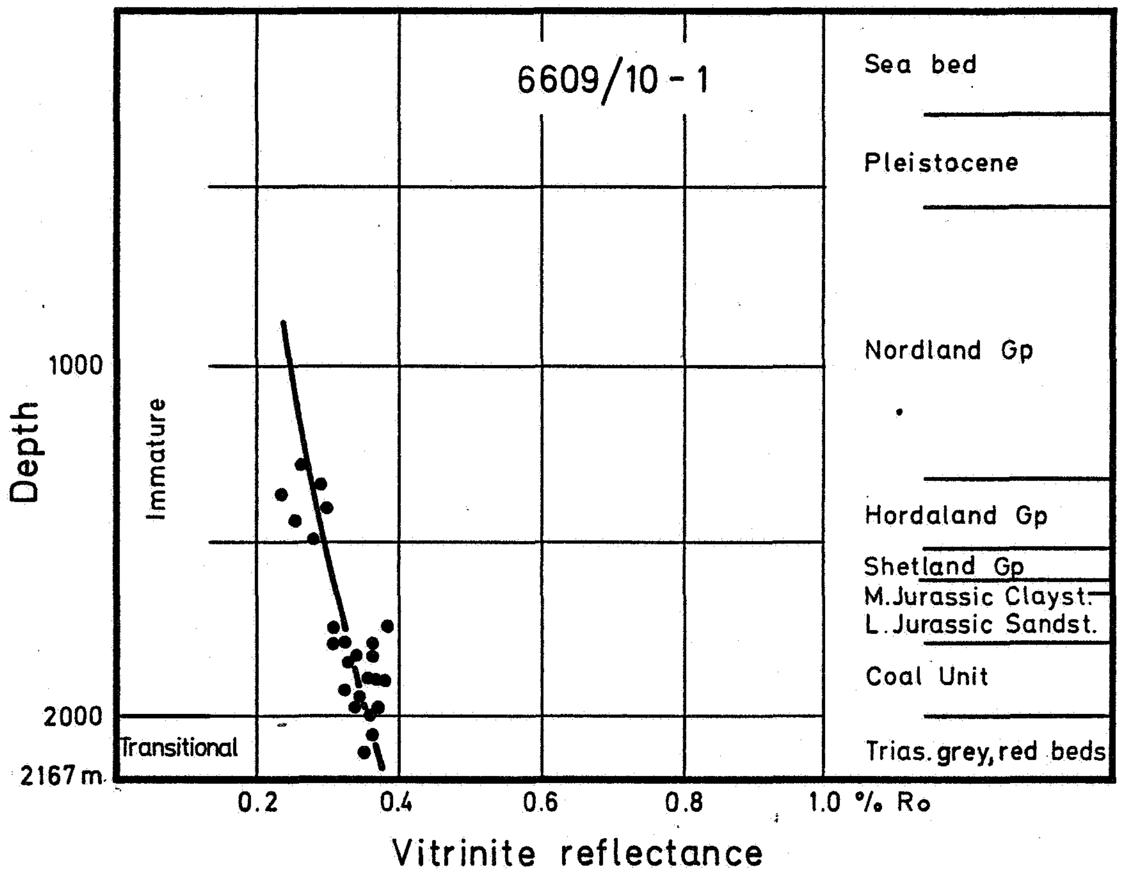
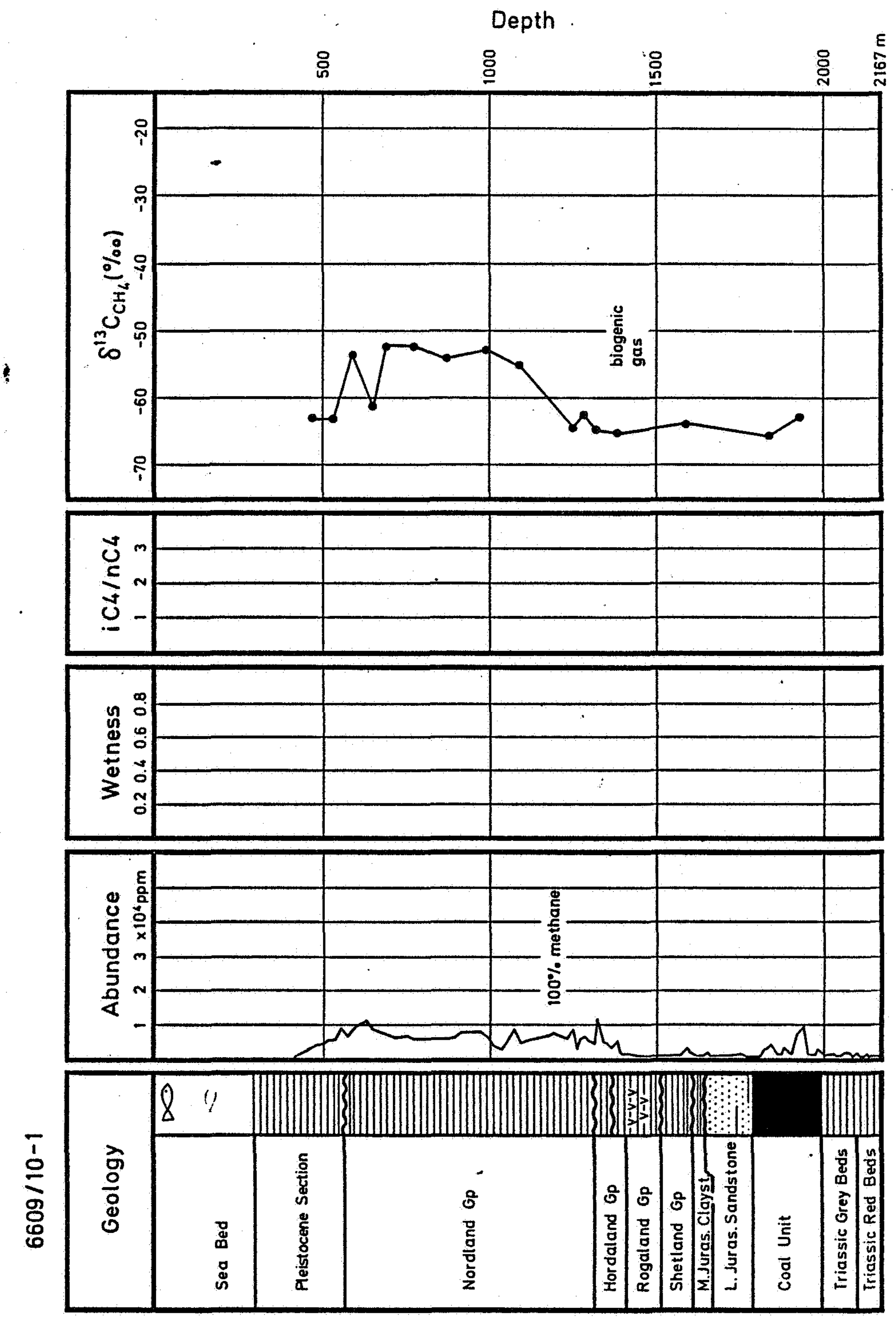


FIGURE : III

HEADSPACE GAS COMPOSITION



2. Discussion and results

2.1 Introduction

Well 6609/10-1 was drilled into Triassic Red Beds with possible Middle and Lower Jurassic sandstones as the main targets. The well penetrated as prognosticated a Lower Jurassic sandstone interval which, however, proved to be dry and without any shows.

This report contains an organic geochemical evaluation primarily of the Jurassic, Cretaceous and lowermost Tertiary intervals with a brief note on the Triassic Grey Beds and Red Beds intervals below the Coal Unit. Items to be discussed include source rock identification, maturity evaluation, and detection of migrated hydrocarbons.

The methods being used represent well established routine analytical techniques and hence are not described here.

The organic carbon measurements, rock-eval pyrolysis, visual kerogen, maceral and vitrinite reflectance analysis have been carried out in the geological laboratory at Saga Petroleum A/S, whereas the pyrolysis gas chromatography, extraction, fractionation and GC of alkanes have been carried out by IKU. The headspace gas component and isotopic composition have been measured by IFE.

2.2 Source rocks

2.2.1 Hordaland Group (Enclosure 1)

The Hordaland Group has been penetrated with a total thickness of 107 m. The lower part of the unit (1360-1405 m) is discussed here.

The lithology consists predominantly of light to medium greenish grey claystone. The log responses are relatively homogenous with Gamma Ray values mostly between 40 and 50 API units. The analysed interval is dated as being of Early Eocene age.

Three cuttings and one sidewall core sample have been subjected to geochemical analysis by means of organic carbon measurements and rock-eval pyrolysis.

Organic carbon. The organic carbon data are shown in Table I. The values range from 0.34 to 0.65 weight percent averaging at 0.55 weight percent which is poor to fair.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are poor ranging from 0.09 to 0.28 mg/g rock with corresponding hydrogen index values ranging from 16 to 62. This gives average values of 0.19 mg/g rock and 39 which are poor and suggest type III kerogen.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated on Figure I. The lower part of the Hordaland Group has no potential for generation of hydrocarbons.

2.2.2 Rogaland Group (Enclosure 1)

The Rogaland Group has been penetrated with a total thickness of 104 m, and consists of the Balder and Lista/Sele Formations.

The lithology consists predominantly of medium to dark grey claystones with interbeds of greenish grey claystone and tuffaceous interbeds in the Balder Formation. The log responses are moderately homogeneous with gamma ray values somewhat increased compared to the unit above. The interval is dated as being of Late Paleocene to Early Eocene age.

Numerous cuttings and one sidewall core sample have been subjected to geochemical analysis by means of organic carbon measurements, rock-eval pyrolysis, pyrolysis gas chromatography, solvent extraction, fractionation, gas chromatography of alkanes and visual kerogen.

Organic carbon. The organic carbon data are shown in Table I. The values range from 0.36 to 1.54 weight percent averaging at 0.92 weight percent which is fair.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are poor ranging from 0.03 to 0.73 mg/g rock with corresponding hydrogen index values ranging from 8 to 50. This gives average values of 0.29 mg/g rock and 31 which are poor and suggest type III kerogen.

Pyrolysis-GC. Two cuttings samples (1460-70 m, 1480-90 m) have been analysed in more detail using pyrolysis gas chromatography. The pyrograms are shown in Figure IV a-b. The two samples show a narrow range of compounds and high abundances of aromatics relative to the short range C_7 to C_9 aliphatic homology. Generally the pyrograms show kerogen type III fingerprints.

Visual kerogen. The two cuttings samples being analysed for pyrolysis-GC have also been studied microscopically in transmitted light combined with fluorescence. The data are given in Table VI. Both samples are dominated by amorphous organic matter with minor amounts of herbaceous, woody and coaly material. The amorphous components are for the main part non-fluorescent supporting the lean capacity of the organic matter.

<u>Solvent extraction</u>. The same two samples have been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The extraction data are given in Table V a-d, and the gas chromatograms are shown in Figure V a-b. The abundance of extractable bitumen is 916 ppm and 323 ppm of rock in the 1460-70 m and the 1480-90 m sample respectively. These are poor to fair values. The ratio of extractable bitumen normalised to organic carbon is 218.1 mg/g and 55.7 mg/g organic carbon respectively. The former value is very high for an immature sediment. It is, however, mainly due to extractable non-hydrocarbons present in the rock sample. Extractable bitumen crossplotted versus organic carbon indicates a fair oil source and poor source respectively for the two samples. The two gas chromatograms are very different. The extract-enriched sample (1460-70 m) shows a unimodal n-alkane distribution peaking at n-C_{18}. An odd over even predominance is distinct beyond n-C_{25} (CPI = 1.2). The pristane to phytane ratio of 1.4 is moderate. The presence of non-indigenous hydrocarbons could be suspected for this sample based on the high extractable bitumen to organic carbon ratio, and the dominance and mature appearance of the n-C_{20}- alkanes. However, the very low hydrocarbon to non-hydrocarbon ratio is not in favour migrated thermogenic hydrocarbons. The next sample (1480-90 m) shows a very immature pattern. The gas chromatogram is characterised by a marked dominance of pristane and phytane over n-C_{17} (hardly present) and n-C_{18} and a very pronounced dominance of C_{23+} n-alkanes indicating a terrestrially derived nature of the parent organic matter. An odd over even dominance is prominent (CPI=1.5). The pristane to phytane ratio of 1.7 is relatively high. An indigeneous origin is clearly evident for this extract.

<u>Hydrocarbon potential</u>. The interpreted hydrocarbon potential is illustrated in Figure I. The Rogaland Group has no potential for generation of hydrocarbons.

2.2.3 Shetland Group (Enclosure 1)

The Shetland Group has been penetrated with a total thickness of 96 m.

The lithology consists predominantly of grey claystones. The log responses are homogenous with Gamma Ray values around 80 API units. The interval is dated as being of Campanian age.

Several cuttings and sidewall core samples have been subjected to geochemical analysis by means of organic carbon measurements, rock-eval pyrolysis, pyrolysis gas chromatography, solvent extraction, fractionation, gas chromatography of alkanes and visual kerogen.

Organic carbon. The organic carbon data are shown in Table I. The values range from 0.50 to 1.29 weight percent averaging at 0.73 weight percent which is fair.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are poor ranging from 0.05 to 0.48 mg/g rock with corresponding hydrogen index values ranging from 9 to 56. This gives average values of 0.19 mg/g rock and 26 which are poor and suggest type III kerogen.

Pyrolysis-GC. Three cuttings samples (1520-30 m, 1540-50 m, 1580-90 m) have been analysed in more detail by pyrolysis gas chromatography. The pyrograms are shown in Figure IV c-e. The three samples are very similar showing a narrow range of compounds and high abundances of aromatics relative to the short range C_7 to C_9 aliphatic homology. Generally the pyrograms show kerogen type III fingerprints.

Visual kerogen. The same samples being analysed for pyrolysis-GC have also been studied microscopically in transmitted light combined with fluorescence. The data are given in Table VI. They show a mixed composition. The amorphous components are subcolloidal and non-fluorescent, supporting the lean capacity of the organic matter.

Solvent extraction. The same three samples have also been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The extraction data are given in Table V a-d. and the gas chromatograms are shown in Figure V c-e. The abundance of extractable bitumen ranges from 58 to 356 ppm. These are poor values. The ratio of extractable bitumen normalised to organic carbon ranges from 10.2 to 59.0 mg/g which is normal for this type of immature sediments. Extractable bitumen crossplotted versus organic carbon is indicative of a poor source capacity. The gas chromatograms are characterized by a dominance of C_{23+} n-alkanes indicating a terrestrially derived nature of the parent organic matter. An odd over even predominance is prominent (CPI = 1.4-2.0). The pristane to phytane ratio is above unity (1.1-1.3). An indigenous origin is clearly inferred for these extracts.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated in Figure I. The Shetland Group has no potential for generation of hydrocarbons.

2.2.4 Middle Jurassic Claystone (Enclosure 1)

A Middle Jurassic claystone interval has been penetrated with a total thickness of 27 m.

The lithology consists predominantly of grey claystones. The log responses are homogenous with Gamma Ray values around 90 to 100 API units and clear "mud-separations" on the Densilog-Neutron trace. The interval is dated as being og Late Toarcian to Early Bajocian age.

Four cuttings and two sidewall core samples have been subjected to geochemical analysis. The analytical programme includes organic carbon measurements, rock-eval pyrolysis, pyrolysis gas chromatography, solvent extraction, fractionation, gas chromatography of alkanes and visual kerogen.

Organic carbon. The organic carbon data are shown in Table I. The values range from 0.62 to 1.40 weight percent averaging at 0.94 weight percent which is fair.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are poor ranging from 0.07 to 0.39 mg/g rock with corresponding hydrogen index values ranging from 11 to 59. This gives average values of 0.27 mg/g rock and 30 which are poor and suggest type III kerogen.

Pyrolysis-GC. One cuttings sample (1610-20 m) has been analysed by pyrolysis gas chromatography. The pyrogram is shown in Figure IV f. It shows a narrow range of compounds and high abundances of aromatics relative to the short range C_7 to C_9 aliphatic homology. Generally the pyrogram shows a kerogen type III fingerprint.

Visual kerogen. The sample being analysed for pyrolysis-GC has also been studied microscopically in transmitted light combined with fluorescence. The data are given in Table VI. The sample has a mixed kerogen composition. The amorphous is subcolloidal and in parts degraded and clotty. It is non-fluorescent supporting the lean capacity of the organic matter.

Solvent extraction. The same sample has also been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The extraction data are given in Table VI a-d, and the gas chromatogram is shown in Figure V f. The abundance of extractable bitumen is 720 ppm of which 644 ppm are non-hydrocarbons. The ratio of extractable bitumen normalised ot organic carbon is 118.0 mg/g. Extractable bitumen crossplotted versus organic carbon indicates a poor source. The gas chromatogram is characterised by a high background envelope and a dominance of C_{23+} odd number n-alkanes (CPI = 2.8) indicating a predominantly terrestrially derived nature of the parent organic matter. The pristane to phytane ratio is 1.2 which is moderate. An indigenous origin is inferred for this extract.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated in Figure I. The Middle Jurassic Claystone interval has no potential for generation of hydrocarbons.

2.2.5 Coal Unit (Enclosure 1)

The Coal Unit has been penetrated with a total thickness of 208 m.

The sequence consists of alternating coal, shale and sandstone lithologies, and is dated as being of Late-Middle Rhaetian to Pliensbachian-Sinemurian age.

Amount of coal and carbonaceous shale. The amount of coal and carbonaceous shale in the Coal Unit can be estimated from the Densilog trace. The principle behind this approach is the density contrast between organic and mineral matter.

Organic matter in coal-bearing series have densities in the range of 1.0 to 1.5 g/cm^3, whereas mineral matter have densities ranging from 2.65 to 2.87 g/cm^3 for clay minerals, quartz and the most common carbonates. Associations of organic and mineral matter thereby result in intermediate densities. A density of 1.5 g/cm^3 corresponds to approximately 55 weight percent organic carbon, 1.7 g/cm^3 to 45 weight percent, and 2.0 g/cm^3 to 30 weight percent.

The cumulative thickness of coal and carbonaceous shale are given in Table X. Altogether the Coal Unit contains 39.35 m of low density (<2.0 g/cm^3) carbonaceous lithologies. Complementary to these carbon enriched lithologies the Coal Unit contains considerable amounts of shaly lithologies with variable and in parts high organic matter contents.

Several cuttings and a few sidewall core samples have been subjected to geochemical analysis. The analytical programme includes organic carbon measurements, rock-eval pyrolysis, pyrolysis gas chromatography, solvent extraction, fractionation, gas chromatography of alkanes, and maceral analysis. The samples being analysed are not representative for the Coal Unit as a whole, but give an idea of the size and variability in organic richness in the carbonaceous lithologies.

Organic carbon. The organic carbon data are shown in Table I. The values range from 25.72 to 45.94 weight percent averaging at 35.53 weight percent which is very high.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) range from 26.83 to 95.29 mg/g rock with corresponding hydrogen index values ranging from 99 to 234. This gives average values of 67.16 mg/g rock and 186 which are very high and moderate values respectively and suggests type III to II kerogens.

Pyrolysis-GC. Several cuttings samples have been analysed by pyrolysis gas chromatography. The pyrograms are shown in Figure IV g-m. They show distinct low molecular weight aromatics followed by a long range aliphatic homology extending beyond $n\text{-}C_{25}$ indicating a significant input of lipid material (spores, cuticles, resins). The pyrograms can be interpreted as kerogen type II to III fingerprints.

Maceral analysis. Polished rock specimens of the cuttings samples analysed for pyrolysis-GC have been studied microscopically in reflected light combined with incident light fluorescence (maceral analysis). All the samples have a high content fo mineral matter making up 30 to 57% of the total sample. This is in accordance with the organic carbon data. Pyrite is a variable component making up from zero to 22% of the total sample. The higher values are indicative of marine influence. The maceral composition is dominated by vitrinite (44-86%) over inertinite (8-33%) and exinite (5-27%), a typical succession of humic coal series. The exinite macerals have a yellow to orange-yellow fluorescence typical for terrestrially derived exinite (sporinite, cutinite, resinite). Alginite is not a significant component.

Solvent extraction. The same cuttings samples have been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The extraction data are given in Table V a-d, and the gas chromatograms are shown in Figure V g-m. The abundance of extractable bitumen is ranging from 1639 to 3938 ppm weight of rock averaging at 2691 ppm of rock which is high. The ratio of extractable bitumen normalised to organic carbon is, however, low ranging from 5.0 to 9.4 mg/g organic carbon with an average at 7.2 mg/g. Extractable bitumen crossplotted versus organic carbon indicates good gas to oil source capacities. The gas chromatograms are characterised by a prominent pristane peak and a marked dominance of C_{23+} n-alkanes supporting the terrestrially derived nature of the parent organic matter. An odd over even predominance is prominent beyond n-C_{19} (CPI = 2.4 - 2.9). The pristane to phytane ratio ranging from 2.3 to 6.0 is very high further supporting the humic nature of the organic matter.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated in Figure I. The Coal Unit has a considerable thickness, contains abundant organic matter, and represent a rich potential for hydrocarbon generation. The major portion of the organic matter is contained in carbonaceous shales, carbominerites, and only to a limited extent in pure coal. The organic matter is of humic nature. The composition is dominated by vitrinite with a potential principally for dry gas at high maturity levels (Ro > 1.0). Exinitic components with potential for heavier hydrocarbons are also abundant.

The above considerations can be summarized with respect to hydrocarbon potential as follows : The Coal Unit has a considerable thickness, contains abundant organic matter and represents a rich potential for wet gas and condensate at relatively high maturity levels, Ro > 0.9.

2.2.6 Triassic Grey Beds (Enclosure 1)

The Triassic Grey Beds interval has been penetrated with a total thickness of 109 m.

The lithology consists predominantly of medium to dark grey claystones and siltstones. The log responses are relatively variable reflecting sandy interbeds. The Gamma Ray values in the shaly intervals are around 90 to 100 API units. The interval is dated as being of Early to Late-Middle Rhaetian age.

Several cuttings and sidewall core samples have been subjected to geochemical analysis by means of organic carbon measurements and rock-eval pyrolysis.

Organic carbon. The organic carbon data are shown in Table I. The values range from 1.12 to 5.24 weight percent averaging at 3.40 weight percent which is relatively high.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are ranging from 0.86 to 10.71 mg/g rock with corresponding hydrogen index values ranging from 60 to 204. This gives average values of 4.09 mg/g rock and 111 which are moderate, and suggest type III kerogen.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated in Figure I. The Triassic Grey Beds interval has a moderate potential for generation of hydrocarbons, presumably gas.

2.2.7 Triassic Red Beds (Enclosure 1)

The well penetrated 65 m of the upper part of the Triassic Red Beds interval.

The lithology consists predominantly of interbedded light greenish grey and redbrown claystones. The log responses are moderately homogenous with Gamma Ray values somewhat depressed compared to the unit above ranging mostly between 50 and 70 API units. The interval is dated as being of Early Rhaetian age.

Five cuttings samples have been subjected to geochemical analysis by means of organic carbon measurements and rock-eval pyrolysis.

Organic carbon. The organic carbon data are shown in Table I. The measured values range from 0.59 to 4.35 weight percent. The higher values, however, are most likely caved material from the unit above, only the two lowermost samples being analysed are thought to be representative for the formation. They contain 0.59 and 0.93 weight percent organic carbon averaging at 0.76 weight percent which is fair.

Rock-eval pyrolysis. The rock-eval pyrolysis results are given in Table II. The pyrolysate yields (S2-peak) are ranging from 0.33 to 9.70 mg/g rock. However, again the higher values are thought to be representatives of caved material. Only the lowermost samples are interpreted as indigenous to the formation. They range from 0.33 to 0.38 mg/g rock with corresponding hydrogen index values ranging from 41 to 56. This gives average values of 0.36 mg/g rock and 49 respectively which are poor, and suggest type III kerogen.

Hydrocarbon potential. The interpreted hydrocarbon potential is illustrated in Figure I. The Triassic Red Beds interval has no potential for generation of hydrocarbons.

2.3 Maturity

Vitrinite reflectance. Although the material quality in this well for the main part is unfavourable, it has been possible to establish a reliable vitrinite reflectance versus depth profile (Figure II) owing to the excellent material obtained from the Coal Unit. The vitrinite reflectance profile represents the base to which the maturity level will be referred. More secondary maturity indicators including spore colour, rock-eval pyrolysis and solvent extraction data are used primarily to confirm the vitrinite reflectance data.

The vitrinite reflectance data are given in Table VIII and IX.

The vitrinite reflectance appears to increase continously with depth reaching RO = 0.35 at approximately 2000 m. A vitrinite reflectance value of Ro = 0.55 is not reached in this well.

Spore colour. Spore colour estimates have been run over the Rogaland Group, Shetland Group and the Middle Jurassic Claystone interval. The results are contained in Table VI. A TAI value of 1.5 is inferred for all the samples, which is in accordance with the vitrinite reflectance data.

Rock-eval pyrolysis. The rock-eval pyrolysis data are given in Table II. The pyrolysis T-max values measured are variable mostly due to very low pyrolysate yields (S2-peak) and consequently difficult T-max pick. Reliable readings, however, are obtained from the Coal Units with values ranging from 416^0C to 426^0C averaging at 424^0C. This is in agreement with the vitrinite reflectance data.

Solvent extraction. Several cuttings samples over the interval from the Rogaland Group to the Kimmeridge Clay Formation have been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The results are shown in Table V a-d and Figure V.

Prominent immature features are evident throughout. There is a notable odd over even predominance with CPI-values ranging from 1.2 to 2.9, C_{22+} n-alkanes are abundant, and the ratios of extractable organic matter to organic carbon and hydrocarbons to non-hydrocarbons are low.

Maturity levels. Based on the discussion above, it is reasonable to interpret the established vitrinite reflectance profile as reliable. The vertical maturity trend can be summarized as shown in Figure II. The maturity increases continously with depth reaching the transitional zone (Ro = 0.35) around 2000 m. The early mature zone (Ro = 0.55) is not reached in the well section.

2.4 Migrated hydrocarbons

Migrated hydrocarbons are not present in the well section. This is clearly evident from the various parameters which are sensitive to thermogenic hydrocarbons.

Solvent extraction. Altogether 13 cuttings samples covering the interval from the Rogaland Group to the Coal Unit have been subjected to solvent extraction, fractionation and gas chromatography of alkanes. The results are shown in Table V a-d and Figure V. Solvent extraction data are sensitive to the presence of thermogenic C_{15+} hydrocarbons in immature sections.

None of the samples being analysed show any evidence of migrated hydrocarbons. All the features and parameters point towards an indigenous and immature setting for the extracted bitumen. The gas chromatograms show prominent immature features (odd over even predominance and abundant C_{22+} n-alkanes), and the ratios of extractable organic matter to organic carbon and hydrocarbons to non-hydrocarbons are too low to suspect a thermogenic origin.

Headspace gas. The headspace gas in numerous canned cuttings samples covering the interval from 410 m (Pleistocene section) to 2167 m (Triassic Red Beds, T.D.) has been analysed by means of component and carbon isotope composition. The results are given in Table III and IV, and illustrated in Figure III.

Throughout the analysed interval the abundance of gaseous hydrocarbons is low to moderate. The higher values are obtained from the Coal unit. Only methane are recorded. This suggests a low maturity and indigenous origin for these gases. The isotopic composition of the methane confirms this suspicion and clearly idicates biogenic gas throughout with $\delta^{13}C$ values below -51.8 $^{0}/oo$ and for the main part below - 60 $^{0}/oo$.

Migrated hydrocarbons. There is no evidence of thermogenic migrated hydrocarbons in the well section.

3. Tables and figures

3.1 List of tables

3.2 List of figures

3.3 Abbreviations used in figures

Figure IV : C_8-C_{29} = n-alkene/n-alkane doublets of the corresponding carbon number

T	=	toluene
X	=	xylenes (m/p)
3	=	styrene + o-xylene
4	=	C_3-benzenes and phenol
5	=	naphtalene
6	=	2- and 1-methylnaphtalene
P	=	phenol
C_1P	=	C_1-alkylphenol
C_2P	=	C_2-alkylphenol
Pr	=	pristene

Figure V : Numbered peaks = n-alkanes of the corresponding carbon number

pr	=	pristane
ph	=	phytane

TABLE : I a

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
HORDALAND GP 1312-1405 m			
1360-70	ctgs	70% Claystone, light to medium green, occasionally grey, firm, subfissile, occasionally silty, in parts glauconitic, non calcareous.	0.65
		30% Claystone/siltstone, brown to redbrown, firm, blocky to subfissile, in parts very glauconitic, non calcareous.	
		Tr Pyrite, rock fragments, sand, glauconite.	
1380-90	ctgs	90% Claystone, light to medium green, occasionally grey, firm, subfissile, occasionally silty, in parts glauconitic, non calcareous.	0.34
		10% Claystone/siltstone, brown to redbrown, firm, blocky to subfissile, in parts very glauconitic, non calcareous	
		Tr Pyrite, rock fragments, tuff, sand, glauconite.	
1395.0	swc	Claystone, variegated light to dark greenish grey in parts brownish, tuffaceous, firm, silty, non calcareous.	0.64
1400-10	ctgs	50% Claystone, variegated, light to dark grey grey occasionally dark greenish and brownish grey, firm, blocky, occasionally silty and glauconitic, non calcareous.	0.58
		40% Claystone, light to medium green occasionally grey, firm, subfissile, occasionally silty, in parts glauconitic, non calcareous.	
		10% Claystone, tuffaceous, greenish grey with white and black specs, firm, blocky, non calcareous.	
		Tr Pyrite, rock fragments, sand, glauconite.	

TABLE : I b

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
ROGALAND GP 1405-1509 m			
1420-30	ctgs	Sample as above	0.36
1430-40	ctgs	60% Claystone, medium grey, firm, subfissile, silty, non to slightly calcareous.	0.89
		40% Claystone, greenish grey, in parts tuffaceous, firm, blocky, non to slightly calcareous.	
		Tr Limestone, pyrite, glauconite, tuff	
1440-50	ctgs	90% Claystone, medium grey, firm, subfissile, silty, non to slightly calcareous.	1.00
		10% Claystone, greenish grey in parts tuffaceous, firm, blocky, non to slightly calcareous,	
		Tr Pyrite, limestone, glauconite, tuff, sand.	
1450-60	ctgs	Sample as above	1.54
1460-70	ctgs	50% Claystone, medium to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.42
		50% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Sand, pyrite, limestone, glauconite, tuff	
1470-80	ctgs	70% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	0.77
		30% Claystone, medium to dark grey, firm, subfissile, silty, non to slightly calcareous.	
		Tr Pyrite, limestone, glauconite, sand.	
1480-90	ctgs	60% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.58
		40% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Pyrite, limestone, glauconite, sand.	

TABLE : I c

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
1490-00	ctgs	80% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	1.21
		20% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Limestone, glauconite	
1500-10	ctgs	70% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	1.23
		20% Claystone, greenish grey, firm, blocky non to slightly calcareous.	
		10% Claystone, redbrown, firm, blocky, silty, non calcareous.	
		Tr Limestone, glauconite, sand, pyrite	
1505.0	swc	Claystone, medium grey, firm, blocky, non to slightly calcareous.	1.22
SHETLAND GP 1509-1605 m			
1510-20	ctgs	60% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	1.21
		30% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		10% Claystone, redbrown, firm, blocky, silty, non calcareous.	
		Tr Limestone, pyrite, glauconite.	
1515.0	swc	Claystone, light greenish grey, firm, subfissile, non calcareous.	1.29

TABLE : I d

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
1520-30	ctgs	80% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.58
		10% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		10% Claystone, redbrown, firm, blocky, silty, non calcareous	
		Tr Sand, limestone,. glauconite, pyrite.	
1530-40	ctgs	Sample as above	1.06
1535.0	swc	Claystone, light to medium grey, firm, blocky, non calcareous.	0.50
1540-50	ctgs	80% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.67
		10% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		10% Claystone, redbrown, firm, blocky, silty, non calcareous.	
		Tr Sand, limestone, glauconite, pyrite	
1550-60	ctgs	90% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.61
		10% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		10% Claystone, redbrown, firm, blocky, silty, non calcareous.	
		Tr Limestone, glauconite, pyrite.	
1560-70	ctgs	95% Claystone, light grey occasionally dark grey, firm, subfissile, silty, non to slightly calcareous.	0.89
		5% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Glauconite, limestone, pyrite, sand, redbrown claystone.	

TABLE : I e

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
1570-80	ctgs	Sample as above	0.52
1580-90	ctgs	Sample as above	0.57
1585.0	swc	Claystone, light to medium grey, firm, blocky, non to slightly calcareous.	0.60
1590-00	ctgs	95% Claystone, light grey occasionally dark grey, firm, subfissile, silty, non to slightly calcareous.	0.64
		5% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Glauconite, limestone, pyrite, sand, redbrown claystone.	
1595.0	swc	Claystone, medium grey, firm, blocky, silty, non calcareous.	0.65
1600.0	swc	Sample as above	0.60
1600-10	ctgs	95% Claystone, light grey occasionally dark grey, firm, subfissile, silty, non to slightly calcareous.	0.75
		5% Claystone, greenish grey, firm, blocky, non to slightly calcareous	
		Tr Glauconite, limestone, pyrite, sand, redbrown claystone,	
1603.0	swc	Claystone, medium to dark grey, firm, blocky, silty, non calcareous.	0.73
MIDDLE JURASSIC CLAYSTONE 1605-1632 m			
1610-20	ctgs	80% Claystone, light grey occasionally medium grey, firm, subfissile, silty, non to slightly calcareous.	0.66
		10% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		10% Claystone, dark grey, firm, blocky, non to slightly calcareous.	
		Tr Redbrown claystone, glauconite, pyrite, limestone, sand.	

TABLE : I f

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
1610-20	ctgs	Picked : Claystone, dark grey, firm, blocky, non to slightly calcareous.	1.06
1620.0	swc	Claystone, light to medium grey, firm, subfissile, silty, non to slightly calcareous.	1.40
1620-30	ctgs	90% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.93
		10% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		Tr Redbrown claystone, glauconite, pyrite, limestone sand.	
1625.0	swc	Claystone, medium grey, firm, subfissile, silty, non to slightly calcareous.	0.94
1630-40	ctgs	90% Claystone, light to dark grey, firm, subfissile, silty, non to slightly calcareous.	0.62
		5% Claystone, greenish grey, firm, blocky, non to slightly calcareous.	
		5% Sand	
		Tr Pyrite, limestone, glauconite, redbrown claystone.	
COAL UNIT 1785-1993 m			
1780-90	ctgs	95% Claystone, black, carbanaceous, firm, fissile to blocky, earthy.	25.72
		5% Claystone, light grey, firm, blocky, plant fragments, non calcareous, earthy.	
		Tr Sand, pyrite	
1811.5	swc	Claystone, black, carbanaceous, firm, blocky.	27.20

TABLE : I g

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
1820-30	ctgs	90% Claystone, brown to black, carbonaceous, firm, fissile to blocky, earthy.	34.64
		10% Coal/carbominerite, black, firm to brittle, in parts vitrinitic.	
		Tr Sand, pyrite.	
1830-40	ctgs	90% Claystone, brown to black, carbonaceous, firm, fissile to blocky, earthy.	45.94
		5% Coal/carbominerite, black, firm to brittle, in parts vitrinitic.	
		5% Sand.	
		Tr Pyrite, rock fragments.	
1833.0	swc	Coal, black brittle, vitrinitic	
1880-90	ctgs	90% Claystone, brown to black, carbonaceous, firm, fissile to blocky, earthy, plant fragments.	35.27
		10% Coal/carbominerite, black, firm to brittle, in parts vitrinitic,	
		Tr Pyrite, sand, rock fragments.	
1920-30	ctgs	Sample as above	40.68
1940-50	ctgs	Sample as above	41.88
1970-80	ctgs	Sample as above	32.90
TRIASSIC GREY BEDS 1993-2102 m			
1997.5	swc	Claystone, medium grey, firm, subfissile, micromicaceous, non calcareous.	3.35
2057.0	swc	Claystone, medium to dark grey, firm, silty, micromicaceous, slightly calcareous.	2.53

TABLE : I h

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
2060-70	ctgs	100% Claystone/siltsone, medium to dark grey, firm, subfissile to fissile, micromicaceous, non calcareous. Tr Sand, pyrite, rock fragments.	5.15
2070-80	ctgs	Sample as above	3.35
2080-90	ctgs	Sample as above	3.79
2089.5	swc	Claystone interbedded with siltstone. Claystone, brown, firm, micromicaceous, subfissile, calcareous. Siltstone, light to greenish grey, micromicaceous, sandy, shell fragments.	2.15
2090-00	ctgs	100% Claystone, medium to dark grey, firm, blocky to subfissile, silty, non to slightly calcareous. Tr Sand, pyrite, light grey siltstone, rock fragments, shell fragments, limestone/ dolomite.	5.24
2100-10	ctgs	Sample as above	3.91
2100.5	swc	Claystone, medium grey, firm, blocky to subfissile, non calcareous.	1.12

TABLE : I i

LITHOLOGY AND ORGANIC CARBON

Sample depth m	Sample type	Analysed lithology	Organic carbon % wt
TRIASSIC RED BEDS 2102-2167 m			
2110-20	ctgs	100% Claystone, medium to dark grey, firm, blocky to subfissile, silty, non to slightly calcareous.	4.35
		Tr Pyrite, light grey siltstone, shell fragments, limestone/dolomite.	
2120-30	ctgs	Sample as above	4.12
2130-40	ctgs	Sample as above	3.34
2150-60	ctgs	60% Claystone, light greenish grey, firm, blocky, slightly calcareous.	0.93
		40% Claystone, redbrown, firm, blocky, calcareous.	
		Tr Limestone/dolomite, shell fragments.	
2160-70	ctgs	Sample as above	0.59

TABLE : II a

ROCK-EVAL PYROLYSIS

Sample depth m	Sample type	Organic carbon % wt	S1	S2	S3	S1/(S1+S2)	S2/S3	HI	OI	T_{max} °C
			mg/g rock							
HORDALAND GP 1312-1405 m										
1360-70	ctgs	0.65	0.23	0.28	1.53	0.46	0.17	43	245	425
1380-90	ctgs	0.34	0.21	0.15	1.33	0.58	0.11	62	391	406
1395.0	swc	0.64	1.19	0.22	1.85	0.85	0.11	34	289	379
1400-10	ctgs	0.58	0.18	0.09	1.06	0.69	0.08	16	183	378
ROGALAND GP 1403-1509 m										
1420-30	ctgs	0.36	0.25	0.03	1.30	0.89	0.02	8	361	312
1430-40	ctgs	0.89	0.22	0.22	0.91	0.50	0.24	25	102	412
1440-50	ctgs	1.00	0.35	0.32	1.19	0.53	0.26	32	119	422
1450-60	ctgs	1.54	0.47	0.73	0.77	0.39	0.94	47	50	411
1460-70	ctgs	0.42	0.84	0.21	1.97	0.81	0.10	50	469	356
1470-80	ctgs	0.77	0.46	0.13	1.01	0.79	0.12	17	131	386
1480-90	ctgs	0.58	1.44	0.26	2.60	0.85	0.10	45	448	264
1490-00	ctgs	1.21	0.57	0.30	1.46	0.66	0.20	25	121	423
1500-10	ctgs	1.23	0.65	0.21	1.15	0.76	0.18	17	74	415
1505.0	swc	1.22	0.06	0.49	0.72	0.11	0.68	40	59	412
SHETLAND GP 1509-1605 m										
1510-20	ctgs	1.21	0.68	0.22	1.33	0.76	0.16	18	10	374
1515.0	swc	1.29	0.02	0.17	0.22	0.11	0.77	13	17	448
1520-30	ctgs	0.64	0.05	0.12	1.82	0.31	0.06	18	284	419
1530-40	ctgs	1.06	1.03	0.23	1.36	0.82	0.16	22	128	350
1535.0	swc	0.50	0.02	0.23	0.38	0.08	0.60	46	76	473
1540-50	ctgs	0.60	0.06	0.09	0.80	0.43	0.11	15	133	314
1550-60	ctgs	0.61	0.31	0.10	1.00	0.77	0.10	16	164	269
1555.0	swc	0.58	0.02	0.19	0.42	0.10	0.45	33	72	456
1560-70	ctgs	0.89	1.40	0.48	2.22	0.74	0.21	54	249	362
1570-80	ctgs	0.52	0.14	0.07	1.04	0.70	0.06	13	200	366
1580-90	ctgs	0.57	0.04	0.05	0.79	0.50	0.06	9	139	299
1585.0	swc	0.60	0.01	0.14	0.72	0.07	0.19	23	120	444
1590-00	ctgs	0.64	0.48	0.13	1.09	0.80	0.11	20	170	339
1595.0	swc	0.65	0.02	0.26	0.67	0.07	0.38	40	103	428
1600.0	swc	0.60	0.03	0.21	0.92	0.12	0.22	35	153	412
1600-10	ctgs	0.75	0.37	0.12	1.11	0.77	0.10	16	148	332
1603.0	swc	0.73	0.07	0.41	1.69	0.15	0.24	56	232	418
MIDDLE JURASSIC CLAYSTONE 1605-1632 m										
1610-20	ctgs	0.66	0.81	0.39	2.58	0.67	0.15	59	391	346
1620.0	swc	1.40	0.03	0.35	0.71	0.08	0.49	25	51	420
1620-30	ctgs	0.93	0.58	0.19	1.08	0.76	0.17	20	116	404
1625.0	swc	0.94	0.02	0.35	0.69	0.06	0.50	37	73	426
1630-40	ctgs	0.62	0.30	0.07	0.91	0.83	0.07	11	147	331

TABLE : II b

ROCK-EVAL PYROLYSIS

Sample depth m	Sample type	Organic carbon % wt	S1	S2	S3	S1/(S1+S2)	S2/S3	HI	OI	T_{max} °C
			mg/g rock							
COAL UNIT 1785-1993 m										
1780-90	ctgs	25.72	1.49	51.27	8.68	0.03	5.91	199	34	426
1811.5	swc	27.20	0.33	26.83	13.25	0.01	2.02	99	49	421
1820-30	ctgs	34.64	0.54	47.47	8.73	0.01	5.43	137	25	425
1830-40	ctgs	45.94	1.07	88.86	13.97	0.01	6.36	193	30	424
1833.0	swc		2.74	62.47	25.74	0.04	2.42			416
1880-90	ctgs	35.27	1.51	81.78	10.91	0.02	7.49	231	31	425
1920-30	ctgs	40.68	1.21	95.29	10.84	0.01	8.79	234	27	424
1940-50	ctgs	41.88	1.19	90.15	11.39	0.01	7.91	215	27	426
1970-80	ctgs	32.90	0.75	60.30	8.40	0.01	7.17	183	26	426
TRIASSIC GREY BEDS 1993-2102 m										
1997.5	swc	3.35	0.06	4.69	1.00	0.01	4.69	140	30	424
2057.0	swc	2.53	0.04	1.95	0.66	0.02	2.95	77	26	433
2060-70	ctgs	5.15	0.08	3.11	0.72	0.03	4.31	60	14	433
2070-80	ctgs	3.35	0.10	4.00	1.09	0.02	3.66	119	33	433
2080-90	ctgs	3.79	0.15	3.73	0.83	0.04	4.49	98	22	433
2089.5	swc	2.15	0.04	1.30	0.60	0.03	2.16	60	28	433
2090-00	ctgs	5.24	0.12	10.71	0.84	0.01	12.75	204	16	435
2100-10	ctgs	3.91	0.12	6.47	0.60	0.02	10.78	165	15	439
2100.5	swc	1.12	0.03	0.86	0.66	0.03	1.30	77	59	429
TRIASSIC RED BEDS 2120-2167 m (T.D)										
2110-20	ctgs	4.35	0.11	9.70	0.66	0.01	14.69	233	15	436
2120-30	ctgs	4.12	0.13	8.07	0.61	0.02	13.22	196	15	437
2130-40	ctgs	3.34	0.13	7.34	0.61	0.02	12.03	220	18	441
2140-50	ctgs	2.47	0.13	2.59	0.59	0.05	4.38	105	24	441
2150-60	ctgs	0.93	0.08	0.38	0.28	0.17	1.35	41	30	435
2160-70	ctgs	0.59	0.07	0.33	0.16	0.17	2.06	56	27	436

TABLE : III a

HEADSPACE GAS

Sample depth m	C_1-C_4 ppm	C_1-C_4 ppm	C_1 % of C_1-C_4	C_2	C_3	iC_4	nC_4	$\frac{C_2-C_4}{C_1-C_4}$	$\frac{iC_4}{nC_4}$
PLEISTOCENE SECTION 288-556 m									
410-30	480	-	100	-	-	-	-	-	-
450-70	2700	-	100	-	-	-	-	-	-
470-90	3200	-	100	-	-	-	-	-	-
490-10	3870	-	100	-	-	-	-	-	-
510-30	5000	-	100	-	-	-	-	-	-
530-50	5200	-	100	-	-	-	-	-	-
550-70	8500	-	100	-	-	-	-	-	-
NORDLAND GP 556-1311 m									
570-90	6700	-	100	-	-	-	-	-	-
590-10	8700	-	100	-	-	-	-	-	-
630-50	11200	-	100	-	-	-	-	-	-
650-70	8100	-	100	-	-	-	-	-	-
690-10	6600	-	100	-	-	-	-	-	-
710-30	5900	-	100	-	-	-	-	-	-
750-70	6600	-	100	-	-	-	-	-	-
770-90	5700	-	100	-	-	-	-	-	-
870-90	5400	-	100	-	-	-	-	-	-
890-10	6100	-	100	-	-	-	-	-	-
910-30	7200	-	100	-	-	-	-	-	-
930-50	7200	-	100	-	-	-	-	-	-
950-70	7400	-	100	-	-	-	-	-	-
970-99	7200	-	100	-	-	-	-	-	-
990-10	6000	-	100	-	-	-	-	-	-
1010-30	3500	-	100	-	-	-	-	-	-
1030-50	2700	-	100	-	-	-	-	-	-
1070-90	7900	-	100	-	-	-	-	-	-
1090-10	4400	-	100	-	-	-	-	-	-
1110-30	4800	-	100	-	-	-	-	-	-
1150-70	5900	-	100	-	-	-	-	-	-
1170-90	6100	-	100	-	-	-	-	-	-
1190-10	7200	-	100	-	-	-	-	-	-
1210-30	6400	-	100	-	-	-	-	-	-
1230-50	5500	-	100	-	-	-	-	-	-
1250-60	8500	-	100	-	-	-	-	-	-
1260-70	2600	-	100	-	-	-	-	-	-
1270-80	5100	-	100	-	-	-	-	-	-
1280-90	5600	-	100	-	-	-	-	-	-
1290-00	4800	-	100	-	-	-	-	-	-
1310-20	4500	-	100	-	-	-	-	-	-

TABLE : III b

HEADSPACE GAS

Sample depth m	C_1-C_4 ppm	C_1-C_4 ppm	C_1 % of C_1-C_4	C_2	C_3	iC_4	nC_4	$\frac{C_2-C_4}{C_1-C_4}$	$\frac{iC_4}{nC_4}$
HORDALAND GP 1312-1405 m									
1320-30	11500	-	100	-	-	-	-	-	-
1340-50	4700	-	100	-	-	-	-	-	-
1350-60	4000	-	100	-	-	-	-	-	-
1360-70	3300	-	100	-	-	-	-	-	-
1380-90	4700	-	100	-	-	-	-	-	-
1390-00	1100	-	100	-	-	-	-	-	-
1400-10	1200	-	100	-	-	-	-	-	-
ROGALAND GP 1405-1509 m									
1410-20	1100	-	100	-	-	-	-	-	-
1430-40	350	-	100	-	-	-	-	-	-
1450-60	140	-	100	-	-	-	-	-	-
1480-90	160	-	100	-	-	-	-	-	-
1500-10	150	-	100	-	-	-	-	-	-
SHETLAND GP 1509-1605 m									
1510-20	110	-	100	-	-	-	-	-	-
1520-30	270	-	100	-	-	-	-	-	-
1540-50	80	-	100	-	-	-	-	-	-
1550-60	95	-	100	-	-	-	-	-	-
1560-70	74	-	100	-	-	-	-	-	-
1590-00	2920	-	100	-	-	-	-	-	-
1600-10	1610	-	100	-	-	-	-	-	-
MIDDLE JURASSIC CLAYSTONE 1605-1632 m									
1620-30	200	-	100	-	-	-	-	-	-
1630-40	120	-	100	-	-	-	-	-	-
LOWER JURASSIC SANDSTONE 1632-1785 m									
1640-50	140	-	100	-	-	-	-	-	-
1650-60	1620	-	100	-	-	-	-	-	-
1660-70	480	-	100	-	-	-	-	-	-
1670-80	360	-	100	-	-	-	-	-	-
1680-90	365	-	100	-	-	-	-	-	-
1690-00	970	-	100	-	-	-	-	-	-
1700-10	210	-	100	-	-	-	-	-	-
1710-20	250	-	100	-	-	-	-	-	-
1720-30	2	-	100	-	-	-	-	-	-
1730-40	270	-	100	-	-	-	-	-	-
1750-60	675	-	100	-	-	-	-	-	-
1760-70	80	-	100	-	-	-	-	-	-
1780-90	70	-	100	-	-	-	-	-	-

TABLE : III c

HEADSPACE GAS

Sample depth m	C_1-C_4 ppm	C_1-C_4 ppm	C_1 % of C_1-C_4	C_2 % of C_1-C_4	C_3 % of C_1-C_4	iC_4 % of C_1-C_4	nC_4 % of C_1-C_4	$\frac{C_2-C_4}{C_1-C_4}$	$\frac{iC_4}{nC_4}$
COAL UNIT 1785-1993 m									
1810-20	180	-	100	-	-	-	-	-	-
1820-30	2340	-	100	-	-	-	-	-	-
1830-40	2600	-	100	-	-	-	-	-	-
1840-50	3505	-	100	-	-	-	-	-	-
1850-60	2410	-	100	-	-	-	-	-	-
1860-70	1040	-	100	-	-	-	-	-	-
1870-80	1260	-	100	-	-	-	-	-	-
1880-90	2960	-	100	-	-	-	-	-	-
1890-00	1780	-	100	-	-	-	-	-	-
1900-10	710	-	100	-	-	-	-	-	-
1920-30	7100	-	100	-	-	-	-	-	-
1930-40	9185	-	100	-	-	-	-	-	-
1940-50	4290	-	100	-	-	-	-	-	-
1950-60	1330	-	100	-	-	-	-	-	-
1960-70	960	-	100	-	-	-	-	-	-
1970-80	690	-	100	-	-	-	-	-	-
1980-90	2370	-	100	-	-	-	-	-	-
TRIASSIC GREY BEDS 1993-2102m									
2000-10	960	-	100	-	-	-	-	-	-
2010-20	665	-	100	-	-	-	-	-	-
2020-30	960	-	100	-	-	-	-	-	-
2030-40	960	-	100	-	-	-	-	-	-
2040-50	445	-	100	-	-	-	-	-	-
2050-60	380	-	100	-	-	-	-	-	-
2060-70	1000	-	100	-	-	-	-	-	-
2070-80	890	-	100	-	-	-	-	-	-
2080-90	630	-	100	-	-	-	-	-	-
2090-00	185	-	100	-	-	-	-	-	-
2100-10	670	-	100	-	-	-	-	-	-
TRIASSIC RED BEDS 2102-2167 m (T.D.)									
2110-20	75	-	100	-	-	-	-	-	-
2120-30	720	-	100	-	-	-	-	-	-
2130-40	150	-	100	-	-	-	-	-	-
2140-50	310	-	100	-	-	-	-	-	-
2150-60	260	-	100	-	-	-	-	-	-
2160-70	130	-	100	-	-	-	-	-	-

TABLE : IV

ISOTOPIC COMPOSITION OF HEADSPACE GAS, $\delta^{13}C$ ($^{0}/oo$)

Sample depth m	C_1	C_2	C_3	nC_4
470-90	- 62.7	-	-	-
530-50	- 62.8	-	-	-
590-10	- 53.3	-	-	-
650-70	- 61.0	-	-	-
690-10	- 51.8	-	-	-
770-90	- 51.8	-	-	-
870-90	- 53.7	-	-	-
990-10	- 52.7	-	-	-
1190-10	- 54.9	-	-	-
1250-60	- 64.3	-	-	-
1280-90	- 62.2	-	-	-
1320-30	- 64.6	-	-	-
1380-90	- 65.1	-	-	-
1590-00	- 63.6	-	-	-
1840-50	- 65.6	-	-	-
1930-40	- 62.6	-	-	-

TABLE : V a

SOLVENT EXTRACTION

Sample depth m	Sample type	Organic carbon % wt	Abundance (ppm wt of rock) EOM	Sat	Aro	HC	non-HC
ROGALAND GP 1405-1509 m							
1460-70	ctgs	0.42	916	23	17	40	876
1480-90	ctgs	0.58	323	12	37	50	273
SHETLAND GP 1509-1605 m							
1520-30	ctgs	0.64	356	22	11	32	324
1540-50	ctgs	0.60	354	43	37	81	273
1580-90	ctgs	0.57	58	10	5	15	44
MIDDLE JURASSIC CLAYSTONE 1605-1632 m							
1610-20	ctgs	0.61	720	40	36	76	644
COAL UNIT 1785-1993 m							
1780-90	ctgs	25.72	1999	90	307	398	1602
1820-30	ctgs	34.64	2200	133	398	530	1670
1830-40	ctgs	45.94	3475	130	519	649	2826
1880-90	ctgs	35.27	2074	367	341	709	1365
1920-30	ctgs	40.68	3414	287	738	1025	2489
1940-50	ctgs	41.88	3938	476	649	1125	2813
1970-80	ctgs	32.90	1639	143	430	573	1065

TABLE : V b

SOLVENT EXTRACTION

Sample depth m	Sample type	Organic carbon % wt	Abundance (mg/g organic carbon) EOM	Sat	Aro	HC	non-HC
ROGALAND GP 1405-1509 m							
1460-70	ctgs	0.42	218.1	5.5	4.0	9.5	208.6
1480-90	ctgs	0.58	55.7	2.1	6.4	8.6	47.1
SHETLAND GP 1509-1605 m							
1520-30	ctgs	0.64	55.6	3.4	1.7	5.0	50.6
1540-50	ctgs	0.60	59.0	7.2	6.2	13.5	45.5
1580-90	ctgs	0.57	10.2	1.8	0.9	2.6	7.7
MIDDLE JURASSIC CLAYSTONE 1605-1632 m							
1610-20	ctgs	0.61	118.0	6.6	5.9	12.5	105.6
COAL UNIT 1785-1993 m							
1780-90	ctgs	25.72	7.8	0.4	1.2	1.5	6.2
1820-30	ctgs	34.64	6.4	0.4	1.1	1.5	4.8
1830-40	ctgs	45.94	7.6	0.3	1.1	1.4	6.2
1880-90	ctgs	35.27	5.9	1.0	1.0	2.0	3.9
1920-30	ctgs	40.68	8.6	0.7	1.8	2.5	6.1
1940-50	ctgs	41.88	9.4	1.1	1.6	2.7	6.7
1970-80	ctgs	32.90	5.0	0.4	1.3	1.7	3.2

TABLE : V c

SOLVENT EXTRACTION

Sample depth m	Sample type	Ratios Sat / EOM	Aro / EOM	HC / EOM	Sat / Aro	non-HC / EOM	HC / non-HC
ROGALAND GP 1405-1509 m							
1460-70	ctgs	0.03	0.02	0.04	1.33	0.96	0.05
1480-90	ctgs	0.04	0.12	0.15	0.33	0.85	0.18
SHETLAND GP 1509-1605 m							
1520-30	ctgs	0.06	0.03	0.09	2.00	0.91	0.10
1540-50	ctgs	0.12	0.11	0.23	1.17	0.77	0.30
1580-90	ctgs	0.17	0.08	0.25	2.00	0.75	0.33
MIDDLE JURASSIC CLAYSTONE 1605-1632 m							
1610-20	ctgs	0.06	0.05	0.11	1.11	0.89	0.12
COAL UNIT 1785-1993 m							
1780-90	ctgs	0.05	0.15	0.20	0.29	0.80	0.25
1820-30	ctgs	0.06	0.18	0.24	0.33	0.76	0.32
1830-40	ctgs	0.04	0.15	0.19	0.25	0.81	0.23
1880-90	ctgs	0.18	0.17	0.34	1.08	0.66	0.52
1920-30	ctgs	0.08	0.21	0.29	0.39	0.71	0.41
1940-50	ctgs	0.12	0.17	0.29	0.73	0.71	0.40
1970-80	ctgs	0.09	0.26	0.35	0.33	0.65	0.54

TABLE : V d

SOLVENT EXTRACTION

Sample depth m	Sample type	Data from the chromatograms pristane / n-C17	pristane / phytane	CPI
ROGALAND GP 1405-1509 m				
1460-70	ctgs	0.7	1.4	1.2
1480-90	ctgs	-	1.7	1.5
SHETLAND GP 1509-1605 m				
1520-30	ctgs	0.7	1.3	1.6
1540-50	ctgs	0.7	1.1	1.4
1580-90	ctgs	-	-	2.0
MIDDLE JURASSIC CLAYSTONE 1605-1632 m				
1610-20	ctgs	0.7	1.2	2.8
COAL UNIT 1785-1993 m				
1780-90	ctgs	3.8	2.9	2.9
1820-30	ctgs	2.6	2.3	2.8
1830-40	ctgs	3.3	2.9	2.8
1880-90	ctgs	3.8	5.0	2.4
1920-30	ctgs	9.0	5.0	2.4
1940-50	ctgs	10.0	4.5	2.7
1970-80	ctgs	2.7	6.0	2.7

TABLE : VI a

VISUAL KEROGEN AND SPORE COLOUR

Sample depth m	Sample type	Visual kerogen	Spore colour TAI
1460-70	ctgs	75% Amorphous, degraded and clotty masses occasionally subcolloidal, predominantly non-fluorescent occasionally yellowish fluorescence.	1.5
		15% Herbaceous	
		5% Woody	
		5% Coaly	
1480-90	ctgs	70% Amorphous, degraded and clotty masses occasionally subcolloidal, non-fluorescent	1.5
		20% Herbaceous	
		5% Woody	
		5% Coaly	
1520-30	ctgs	80% Amorphous, subcolloidal, non-fluorescent	1.5
		5% Herbaceous	
		10% Woody	
		5% Coaly	
1540-50	ctgs	10% Amorphous, subcolloidal, non-fluorescent	1.5
		20% Herbaceous	
		40% Woody	
		30% Coaly	

TABLE VI b

VISUAL KEROGEN AND SPORE COLOUR

Sample depth m	Sample type	Visual kerogen	Spore colour TAI
1580-90	ctgs	10% Amorphous, subcolloidal, non-fluorescent	1.5
		30% Herbaceous	
		30% Woody	
		30% Coaly	
1610-20	ctgs	20% Amorphous, subcolloidal in parts degraded and clotty, non-fluorescent	1.5
		30% Herbaceous	
		20% Woody	
		30% Coaly	

TABLE : VII a

MACERAL COMPOSITION

Sample depth m	Sample type	Minerals and macerals % Min	Py	In	Vi	Ex
COAL UNIT 1785-1993 m						
1780-90	ctgs	57	22	3	12	6
1820-30	ctgs	30	-	7	55	8
1830-40	ctgs	36	-	20	37	6
1880-90	ctgs	43	2	9	33	13
1920-30	ctgs	48	-	17	23	12
1940-50	ctgs	32	15	5	46	3
1970-80	ctgs	45	8	4	40	3

Min : minerals
Py : pyrite
In : inertinite
Vi : vitrinite
Ex : exinite

TABLE : VII b

MACERAL COMPOSITION

Sample depth m	Sample type	Minerals and macerals % In	Vi	Ex
COAL UNIT 1785-1993 m				
1780-90	ctgs	16	57	27
1820-30	ctgs	10	79	11
1830-40	ctgs	32	58	9
1880-90	ctgs	16	60	24
1920-30	ctgs	33	44	23
1940-50	ctgs	9	86	5
1970-80	ctgs	8	86	7

In : inertinite
Vi : vitrinite
Ex : exinite

TABLE : VIII

VITRINITE REFLECTANCE DATA

Sample depth m	Sample type	Ro	Sample depth m	Sample type	Ro
1270.0	swc	0.26	1833.0	swc	0.33*
1327.5	swc	0.29	1880-90	ctgs bulk	0.36*
1355.0	swc	0.23	1880-90	ctgs	0.37*
1395.0	swc	0.30	1885.0	swc	0.38
1438.0	swc	0.25	1920-30	ctgs bulk	0.32*
1465.0	swc	0.28	1920-30	ctgs	0.32*
1535.0	swc	-	1940-50	ctgs bulk	0.36*
1555.0	swc	-	1940-50	ctgs	0.34*
1585.0	swc	-	1953.0	swc	-
1595.0	swc	-	1970-80	ctgs bulk	0.38*
1750-50	ctgs bulk	0.39*	1970-80	ctgs	0.34*
1750-60	ctgs	0.31*	1997.5	swc	0.36
1780-90	ctgs bulk	0.31*	2057.0	swc	0.36
1780-90	ctgs	0.32*	2089.5	swc	-
1786.0	swc	0.36*	2100.5	swc	0.35
1811.5	swc	0.34*			
1820-30	ctgs bulk	0.36*			
1820-30	ctgs	0.34*			
1830-40	ctgs bulk	0.33*			
1830-40	ctgs	0.33*			

* : very good sample quality

bulk : preparation of whole rock. All other samples are preparations of HF-residues.

TABLE : IX a

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1270.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
     .17
0.2-
     .24 .24 .25 .20
     .27 .27 .26 .27 .25 .26 .28 .28          True population
0.3-                                           mean Ro = 0.26
     .30 .30 .31
0.4-
     .46
0.5-

0.6-
     .67
0.7-

0.8-

0.9-
     .98
1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : IX b

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1327.5 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.28 .28 .25 .26 .25 — True population mean Ro = 0.29
0.3-
.32 .33 .31 .30 .31 .30 .32
0.4-
.40
0.5-
0.6-
0.7-
0.8-
0.9-
1.0-
1.1-
1.2-
1.3-
1.4-
1.5-
1.6-
1.7-

TABLE : IX c

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1355.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
      .12 .18 .17 .15 .15 .18 .18
0.2-
      .24 .21 .22 .22 .21 .23 .21                True population
      .26 .25 .27 .28 .25 .25 .29 .27
0.3-                                             mean Ro = 0.23
      .33 .34
0.4-

0.5-

0.6-

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : IX d

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1395.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
0.2-
     .21 .21 .22                              True population
     .28 .25 .28 .25 .29
0.3-                                          mean Ro = 0.30
     .32 .30 .33 .34 .34 .32 .33 .31 .32
     .36 .37
0.4-
     .40
0.5-

0.6-

0.7-

0.8-
     .83
0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : IX e

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1438.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
     .18
0.2-
     .22 .24 .24 .24 .22 .24 .23          True population
     .28 .27 .26 .26                      mean Ro = 0.25
0.3-
     .33 .30 .31
0.4-

0.5-
     .54
0.6-

0.7-

0.8-
     .83
0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : IX f

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1465.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
0.2-
      .29                                           True population
      .29 .28                                       mean Ro = 0.28
0.3-
      .30
      .37
0.4-

0.5-

0.6-
      .61
0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : IX g

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1535.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

0.5-

0.6-

barren

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX h

VITRINITE REFLECTANCE RAW DATA

Sample depth	:	1555.0 m
Sample type	:	swc
Preparation	:	HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

0.5-

0.6-

barren

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX i

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1585.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

0.5-

0.6-

barren

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX j

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1595.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

0.5-

0.6-

barren

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX k

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1750-60 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-

0.3-
.33
.39 .38 .38 .35 .39 .35 .36 .39 .36 .38 .36 .36 .38 .37
.36 .39 .38 .39 .36 .38 .37 .37 .39 .37 .38 .38 .39 .38 .37 .36

0.4-
.40 .41 .44 .40 .40 .43 .40 .40 .40 .40 .41 .40 .40 .40
.40 .44 .409 .40 .40

0.5-

0.6-

True population
mean Ro = 0.39

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX 1

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1750-60 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

.19
0.2-
.28 .29 .26 .29 .28 .29 .29 .28 .27 .28 .29 .29 .26 .27 .28
0.3-
.32 .30 .32 .30 .30 .31 .32 .32 .30 .32 .30 .30 .32 .32 .31 .31
.31 .33 .31 .33 .34 .33 .34 .32 .30 .33 .30
.35 .36 .35 .35 .35 .35
0.4-
.40
0.5-

0.6-

0.7-

True population
mean Ro = 0.31

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX m

VITRINITE REFLECTANCE RAW DATA

Sample depth	: 1780-90 m
Sample type	: ctgs
Preparation	: bulk coal

Vitrinite reflectance (Ro) values :

0.2-

.25 .27 .29 .28 .28 .28 .29 .29 .28 .29 .27 .27 .26 .28 .29 .27

0.3-

.30 .32 .33 .34 .30 .31 .30 .30 .31 .30 .34 .31 .30 .30 .31 .30
.33 .33 .30 .30 .30 .33 .30
.35 .37 .38 .35 .37 .37 .39 .37 .35 .37 .38

0.4-

.40

0.5-

0.6-

True population
mean Ro = 0.31

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX n

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1780-90 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.26 .27 .26 .26 .28 .26 .29 .29 .29 .29 .29 .28
0.3-
.33 .30 .33 .33 .34 .33 .32 .32 .32 .33 .32 .32 .32 .30 .30 .33
.30 .32 .34 .30 .32 .30 .33 .33 .33
.37 .35 .35 .39 .35 .39 .35 .38 .36 .37 .37 .35
0.4-
.41 .40
0.5-

0.6-

True population
mean Ro = 0.32

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX o

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1786.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

.34 .31 .33 .33 .33 .32 .32 .30 .34 .34 .34 .34 .34 .32 .33 .33
.35 .36 .39 .36 .35 .36 .38 .37 .35 .37 .39 .39 .36 .36 .36 .36
.36 .36 .39 .36 .36 .38 .38 .39 .37 .38 .38 .38 .37 .36 .35

0.4-

.41 .40

0.5-

0.6-

True population
mean Ro = 0.36

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX p

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1811.5 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.27 .29 .29
0.3-
.31 .34 .31 .30 .32 .32 .33 .32 .34 .31 .34 .32 .33 .31 .32 .33
.33 .34 .33 .33 .34
.35 .36 .35 .39 .35 .36 .36 .38 .37 .35 .35 .38 .36 .38 .37 .37
.35 .35. 39 .35 .38 .38 .37 .35
0.4-
.41 .40

0.5-

0.6-

True population
mean Ro = 0.34

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX q

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1820-30 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-
.27 .28
0.3-
.30 .33 .34 .33 .33 .31 .32 .33 .32 .33 .32 .31 .33 .34 .33
.39 .36 .37 .36 .38 .37 .37 .37 .39 .36 .38 .39 .39 .39 .39 .37 .38
.36 .39 .35 .38 .36 .35 .37 .36 .36
0.4-
.41 .40 .44 .41 .43 .43 .41
.48
0.5-

0.6-

True population
mean Ro = 0.36

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX r

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1820-30 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.29 .29 .27 .29 .27 .27 .28 .29
0.3-
.34 .32 .32 .30 .31 .34 .34 .33 .32 .33 .31 .33 .33 .31 .30 .31
.34 .34 .31 .34 .32 .30 .31 .31 .34
.35 .36 .35 .36 .35 .36 .37 .36 .35 .36 .35 .35
0.4-
.43 .41 .42
.45 .49
0.5-

0.6-

0.7-

True population
mean Ro = 0.34

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX s

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1830-40 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-
.24
.28 .27 .28 .26 .29 .29 .29 .29
0.3-
.30 .30 .30 .32 .30 .31 .30 .31 .31 .31 .33 .34 .34 .31 .30 .31
.33 .30 .31 .34
.38 .39 .38 .37 .39 .38 .37 .37 .36 .35 .36 .38 .38 .37 .36 .36
.36 .38 .38
0.4-
.43 .42 .41
0.5-

0.6-

True population
mean Ro = 0.33

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX t

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1830-40 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.24
.27 .29 .26 .28 .28 .29 .29 .25 .28 .28
0.3-
.34 .32 .32 .34 .30 .30 .31 .33 .34 .32 .34 .34 .34 .30 .33 .32
.34 .33 .31 .33 .34
.39 .37 .38 .37 .36 .38 .35 .36 .36 .39 .35 .35 .35 .39 .36 .38
0.4-
.42 .42
0.5-

0.6-

True population
mean Ro = 0.33

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX u

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1833.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.29
0.3-
.31 .31 .33 .33 .33 .31 .33 .31 .34 .31 .33 .30 .32 .33 .31 .34
.33 .34 .34 .33 .33 .32 .31 .34 .33 .32 .34 .31 .32 .30 .33 .34
.34 .33 .33 .32
.36 .35 .35 .37 .36 .35 .35 .35 .36 .35 .35 .35 .36
0.4-
.42 .42
0.5-

0.6-

True population
mean Ro = 0.33

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX v

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1880-90 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-
.27 .26 .29 .28 .28 .28
0.3-
.32 .30 .30 .31 .33 .34 .33 .31 .30 .33 .33 .33 .31 .30 .33 .32 .32
.35 .35 .37 .37 .39 .37 .36 .35 .35 .38 .38 .36 .36
0.4-
.42 .41 .42 .41 .43 .40 .40 .40 .41
.49 .45 .47
0.5-
.51 .52
0.6-

True population
mean Ro = 0.36

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX w

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1880-90 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.29 .29 .28 .28 .28
0.3-
.30 .31 .30 .33 .31 .32 .32 .34
.37 .38 .39 .35 .35 .37 .37 .37 .37 .38 .37 .39 .37 .38 .35 .36 .35
.37 .38 .37
0.4-
.40 .41 .40 .41 .41 .40 .42 .43 .40 .40 .40
.47 .49 .48
0.5-
.50
0.6-
0.7-
0.8-
0.9-
1.0-
1.1-
1.2-
1.3-
1.4-
1.5-
1.6-
1.7-

True population
mean Ro = 0.37

TABLE : IX x

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1885.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-
.31 .32 .31 .32
.38 .36 .39 .39 .39 .36 .38 .38 .39 .36 .35 .35 .38 .38
0.4-
.41 .41 .42 .41 .43 .43 .43 .41
.46 .45
0.5-

0.6-

True population
mean Ro = 0.38

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX y

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1920-30 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-
.24 .24 .22
.27 .28 .28 .25 .27 .27 .27 .28 .28 .26
0.3-
.32 .30 .30 .31 .31 .32 .30 .34 .34 .33 .31 .31 .30 .34 .31 .30
.33 .34 .33 .33 .33
.39 .38 .35 .37 .38 .37 .36 .35 .39 .37 .39 .37
0.4-
.40 .40 .41 .41
0.5-

0.6-

0.7-

True population
mean Ro = 0.32

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX z

VITRINITE REFLECTANCE RAW DATA

Sample depth	:	1920-30 m
Sample type	:	ctgs
Preparation	:	HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.26 .25 .26 .25 .29 .29 .25 .27 .29 .29 .29 .26 .28 .28 .27
0.3-
.30 .31 .32 .32 .30 .31 .31 .31 .30 .30 .30 .31 .32 .31 .33 .32
.34 .33 .33
.38 .35 .35 .37 .35 .35 .37 .36 .35 .35 .37 .37 .37 .39
0.4-
.40 .41
.47
0.5-

0.6-

True population
mean Ro = 0.32

0.7-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX aa

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1940-50 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-
.27 .28
0.3-
.32 .30 .31 .32 .33 .30 .31 .30 .31 .32 .33 .32 .34 .33 .34 .33
.34 .31 .34
.37 .36 .38 .37 .37 .37 .36 .35 .36 .37 .35 .39 .38 .37 .37 .36
.37 .37 .36 .39
0.4-
.43 .41 .42
.45 .45 .46 .45 .47 .45
0.5-

0.6-

0.8-

True population
mean Ro = 0.36

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ab

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1940-50 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.28 .25 .26 .27 .28 .28 .29
0.3-
.30 .32 .34 .30 .30 .32 .30 .34 .31 .33 .32 .32 .33 .30 .33 .31
.33 .33 .32 .33 .32 .32
.39 .37 .35 .39 .35 .36 .36 .35 .39 .35 .38 .35 .38 .39 .37 .39
0.4-
.41 .40 .41 .41
.49
0.5-

0.6-

0.8-

True population
mean Ro = 0.34

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ac

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1953.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

barren

0.5-

0.6-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ad

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1970-80 m
Sample type : ctgs
Preparation : bulk coal

Vitrinite reflectance (Ro) values :

0.2-

0.3-
.34 .34 .34
.39 .39 .37 .38 .39 .38 .38 .36 .39 .35 .39 .37 .36 .36 .36 .36
.37 .37 .37 .38 .39 .36 .36 .35 .38 .39 .37 .35 .38 .37 .37 .39
.39 .39

0.4-
.41 .40 .41 .43 .41 .41 .44 .43 .40 .40 .41 .40

0.5-
.50

0.6-

0.8-

True population
mean Ro = 0.38

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ae

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1970-80 m
Sample type : ctgs
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-
.26 .29 .29 .26 .29
0.3-
.32 .32 .34 .30 .32 .30 .30 .30 .33 .31 .33 .32 .32 .31 .34 .33
.33 .32 .30 .31 .33 .34 .31
.37 .36 .37 .35 .35 .35 .35 .35 .36 .36 .36 .39 .38 .38 .37 .35
.38 .36 .35
0.4-
.40 .43 .40
0.5-

0.6-

0.8-

True population
mean Ro = 0.34

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX af

VITRINITE REFLECTANCE RAW DATA

Sample depth : 1997.5 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-
.32 .34 .31 .31
.37 .36 .35 .36 .36 .39 .35 .37

0.4-
.40 .44 .44

0.5-

0.6-

0.8-

True population
mean Ro = 0.36

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ag

VITRINITE REFLECTANCE RAW DATA

Sample depth : 2057.0 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-
.34 .34 .30 .34 .31
.38 .39 .39
0.4-
.40 .40 .41
0.5-

0.6-

0.8-

True population
mean Ro = 0.36

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ah

VITRINITE REFLECTANCE RAW DATA

Sample depth : 2089.5 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

0.2-

0.3-

0.4-

0.5-

0.6-

0.8- barren

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-

TABLE : IX ai

VITRINITE REFLECTANCE RAW DATA

Sample depth : 2100.5 m
Sample type : swc
Preparation : HF-residue

Vitrinite reflectance (Ro) values :

```
0.2-
     .24 .20
     .29
0.3-
     .30 .30
     .35
0.4-
     .44                              poor sample
0.5-                                  Ro = 0.35 possibly true value

0.6-

0.8-

0.9-

1.0-

1.1-

1.2-

1.3-

1.4-

1.5-

1.6-

1.7-
```

TABLE : X

COAL UNIT : CUMULATIVE THICKNESS OF COAL AND CARBONACEOUS SHALE		
Density g/cm^3	Lithology	Cumulative thickness, m
< 1.5	Coal	1.4
1.5-1.7	Carbonaceous shale	9.6
1.7-2.0	Carbonaceous shale	28.6
	Total	39.6

FIGURE : I

SOURCE ROCK AND MATURITY EVALUATION

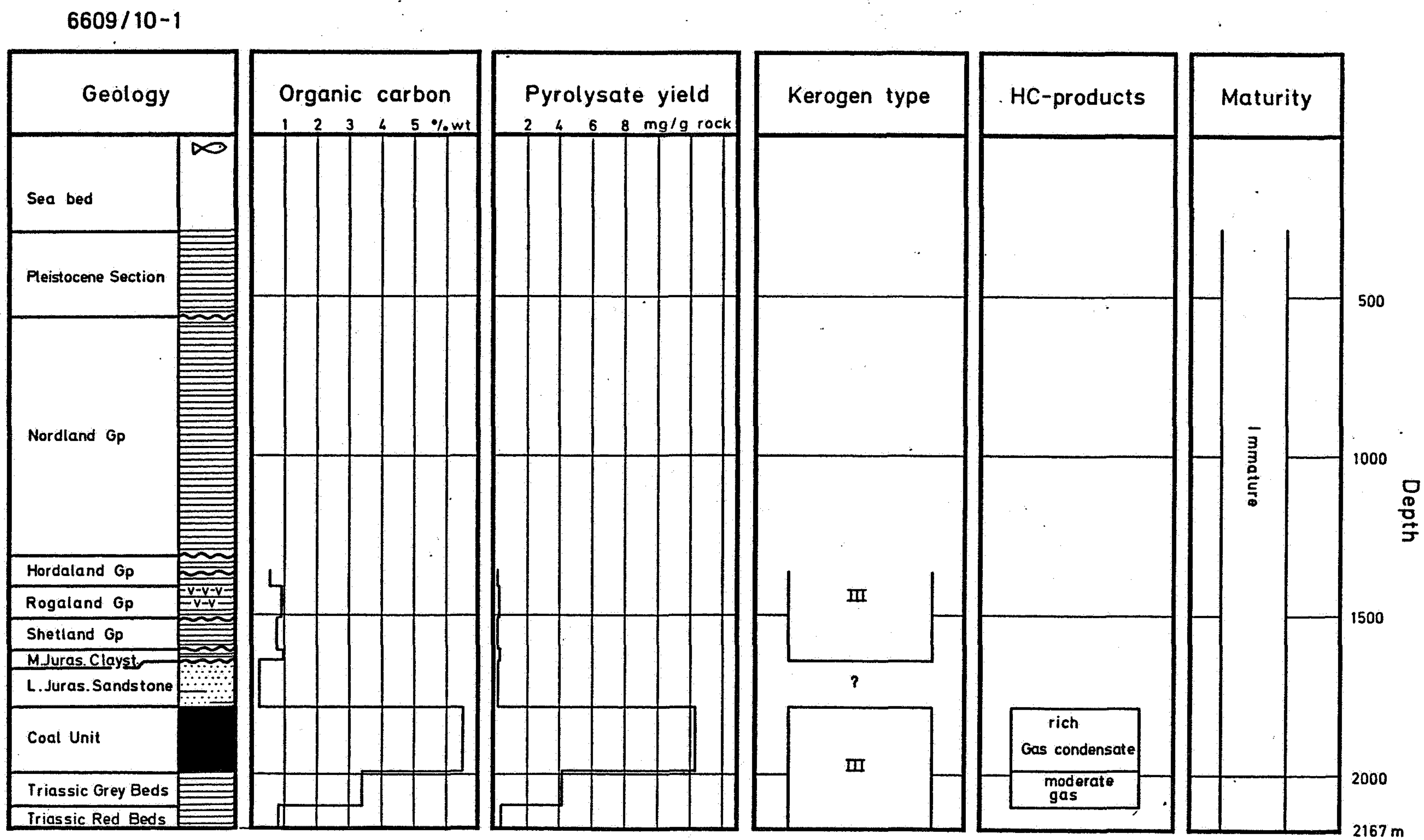


FIGURE : II

VITRINITE REFLECTANCE PROFILE

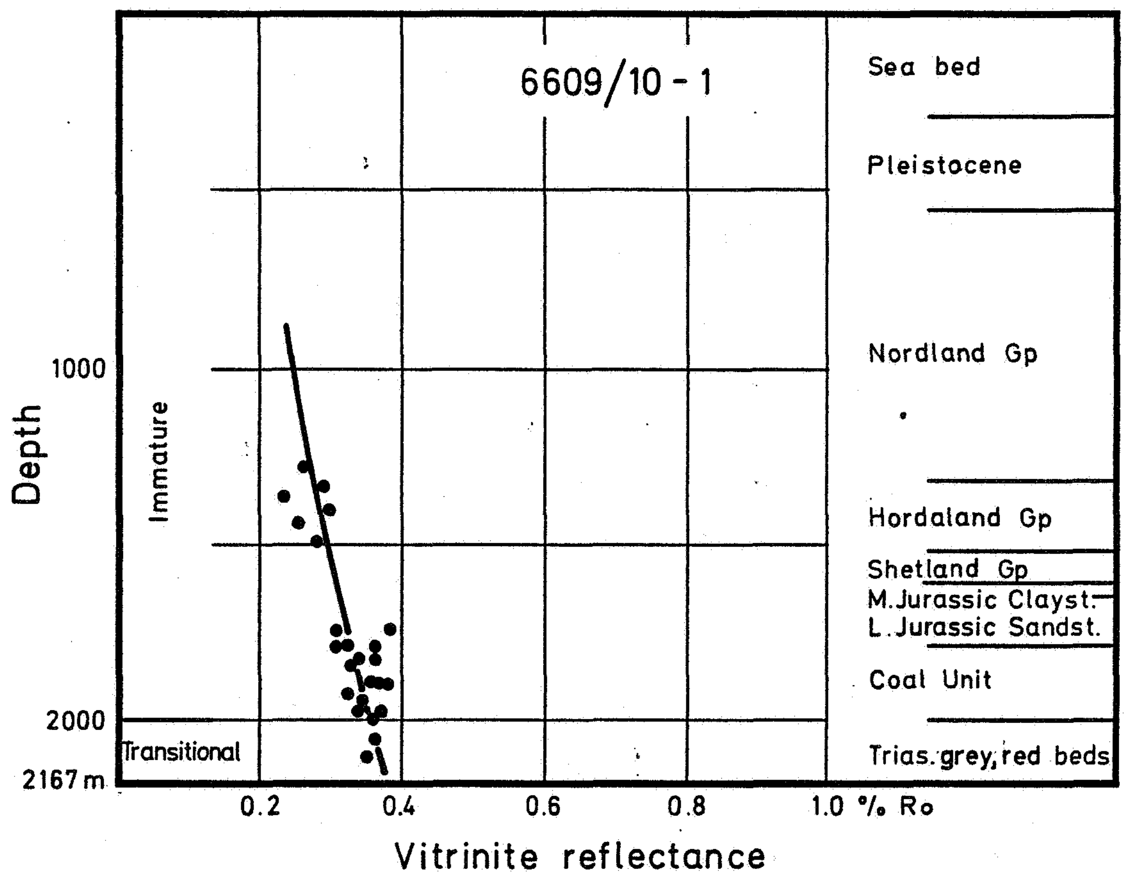
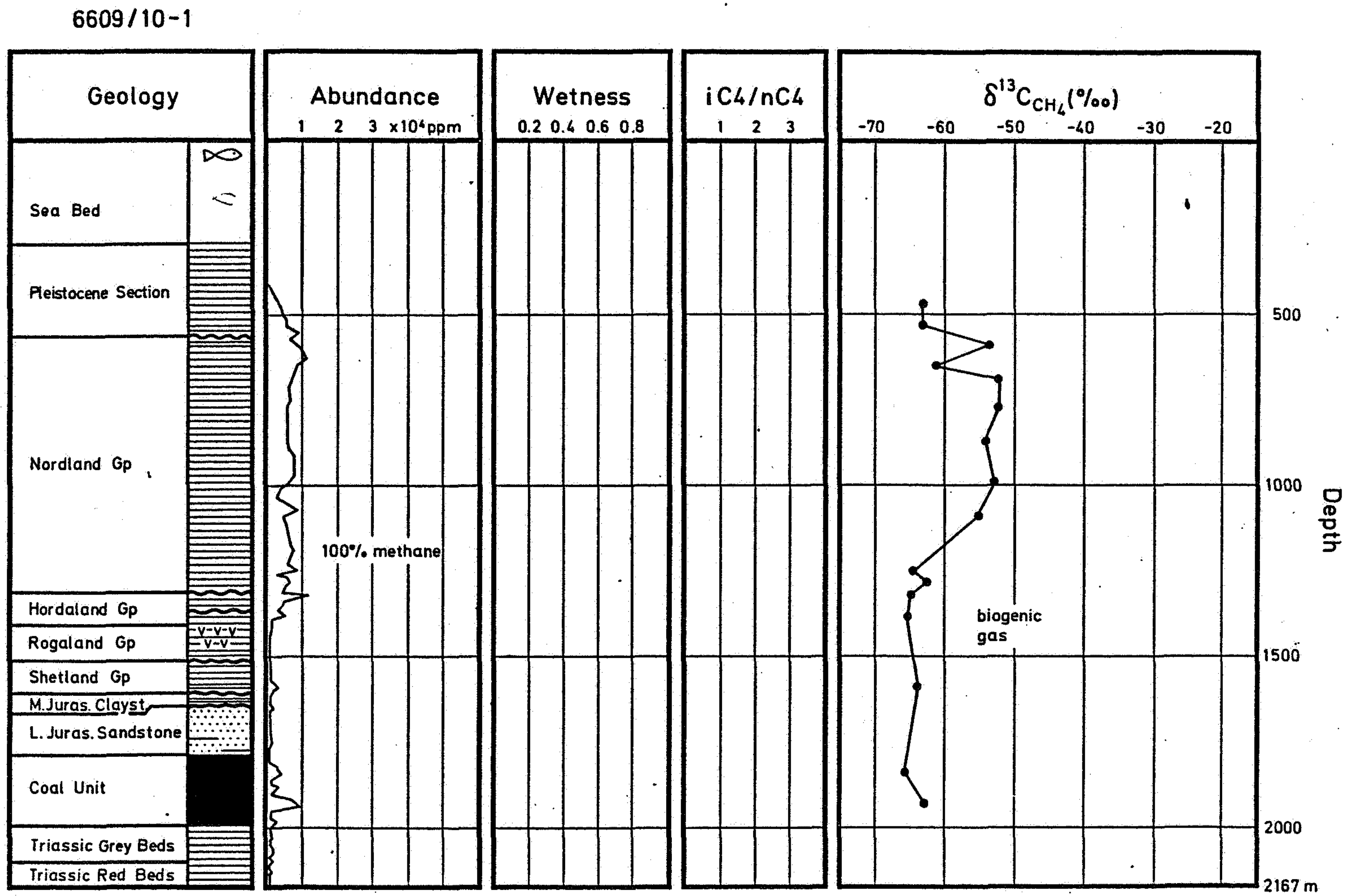


FIGURE : III

HEADSPACE GAS COMPOSITION



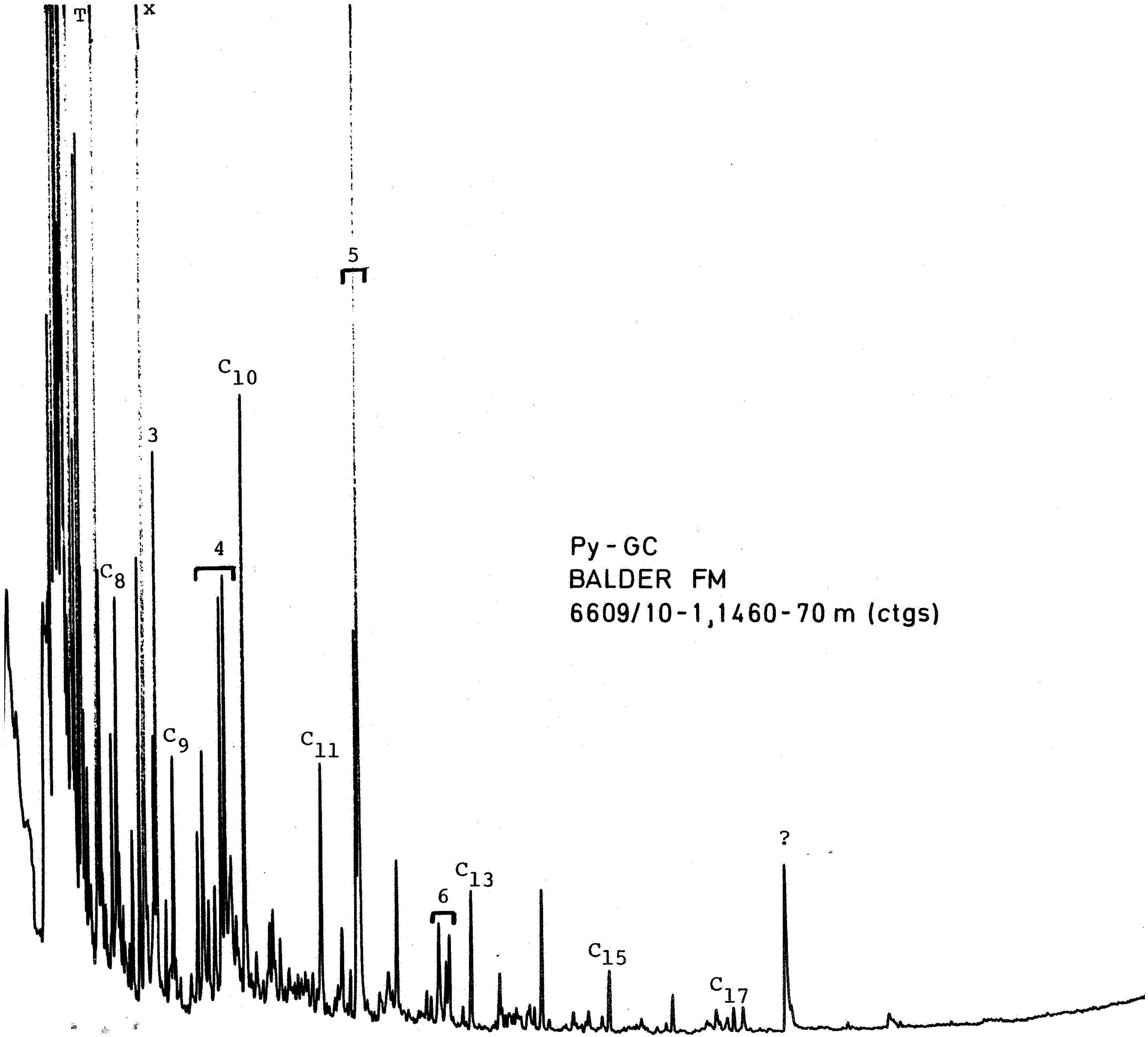


FIGURE : IV a

PYROGRAM (Pyrolysis gas chromatography)

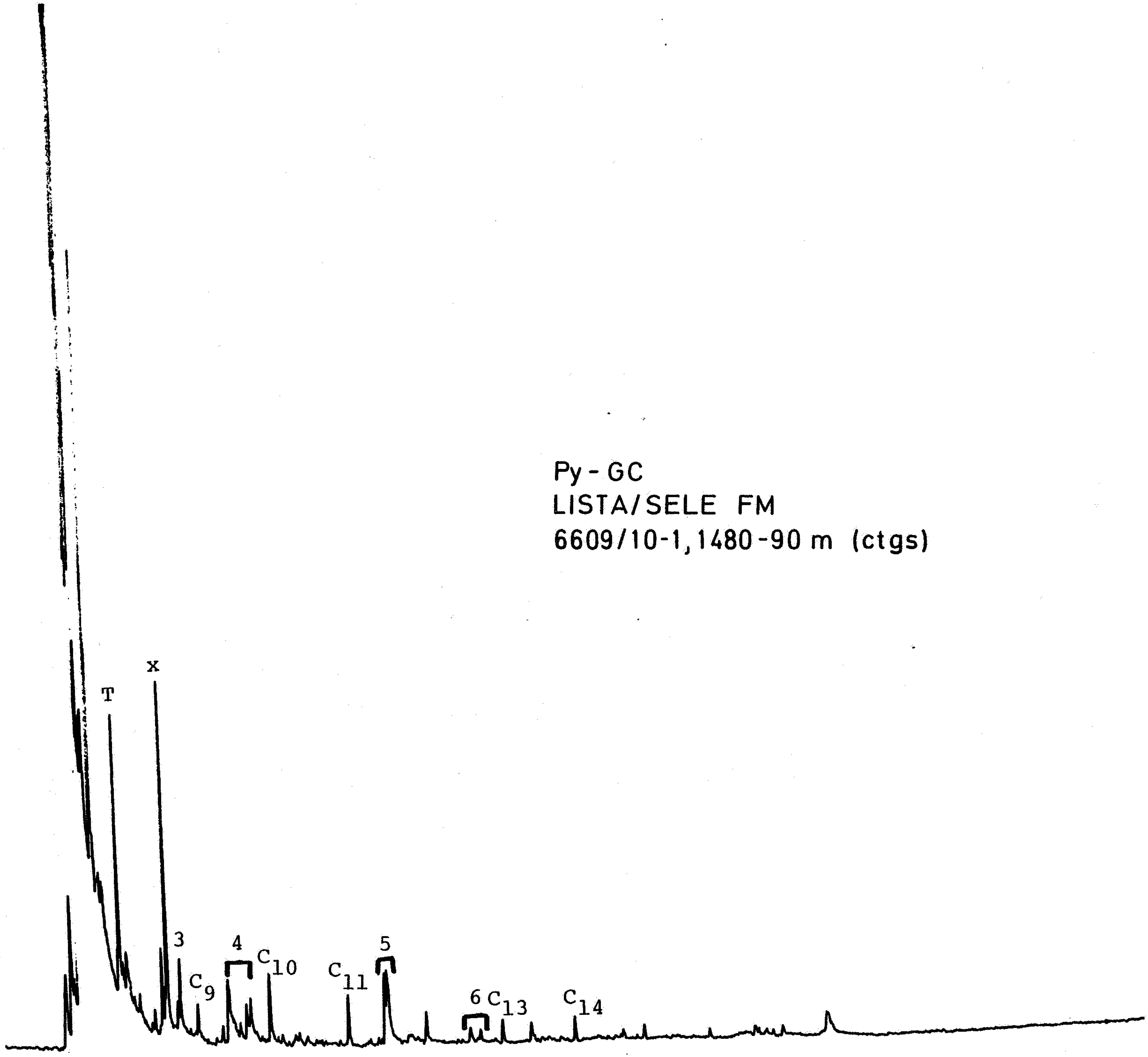
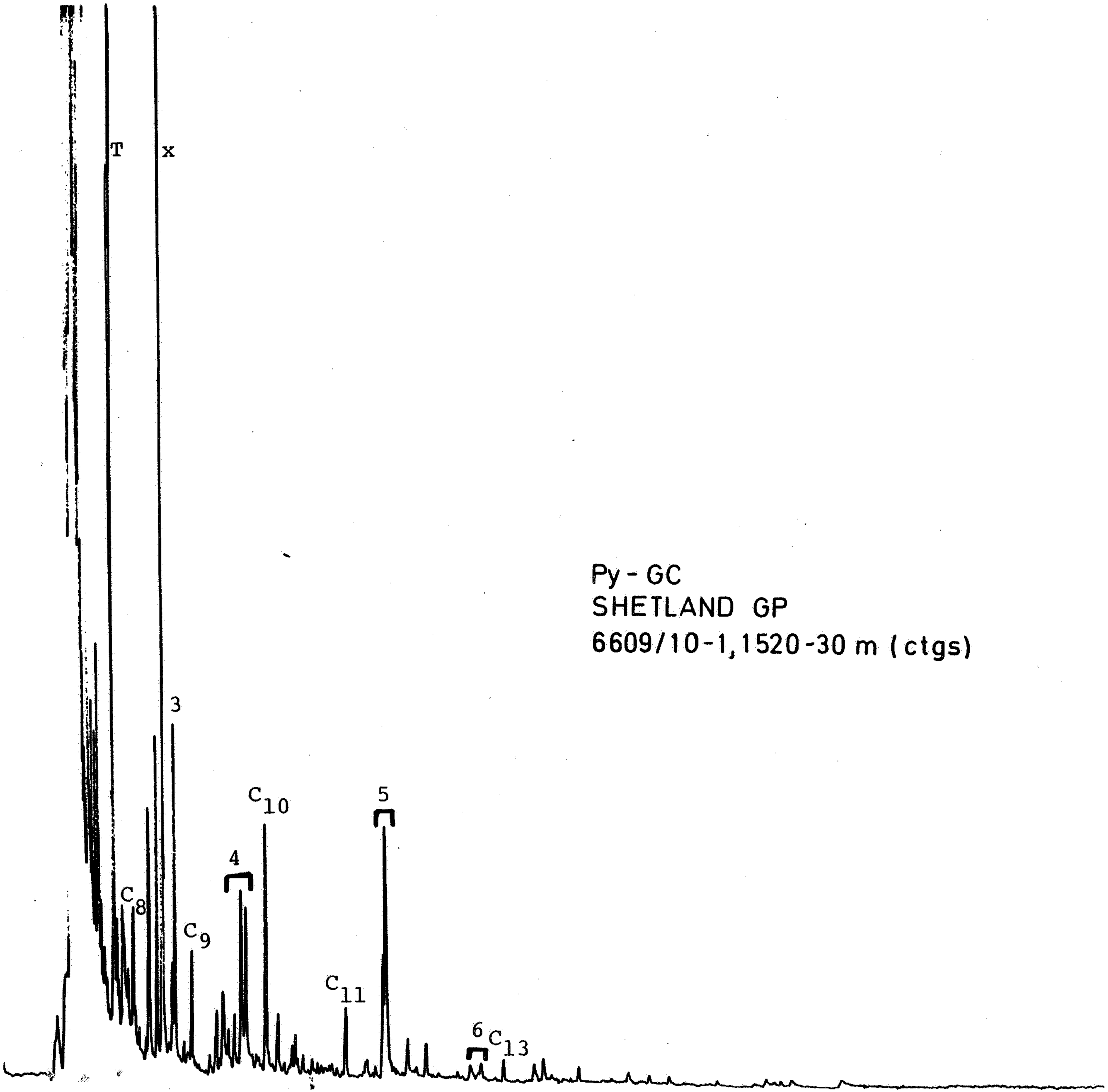


FIGURE : IV b

PYROGRAM (Pyrolysis gas chromatography)

FIGURE : IV C

PYROGRAM (Pyrolysis gas chromatography)



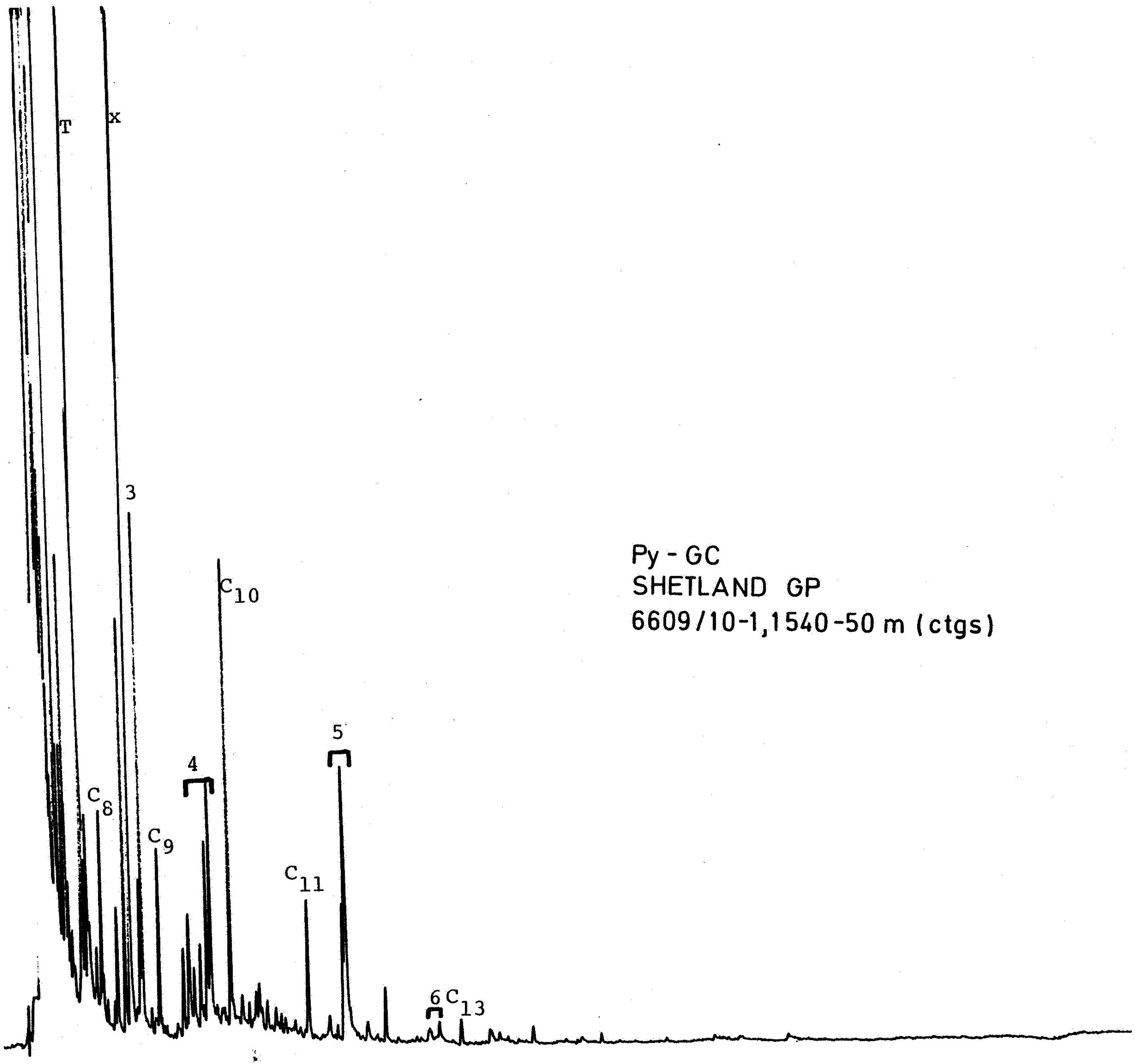
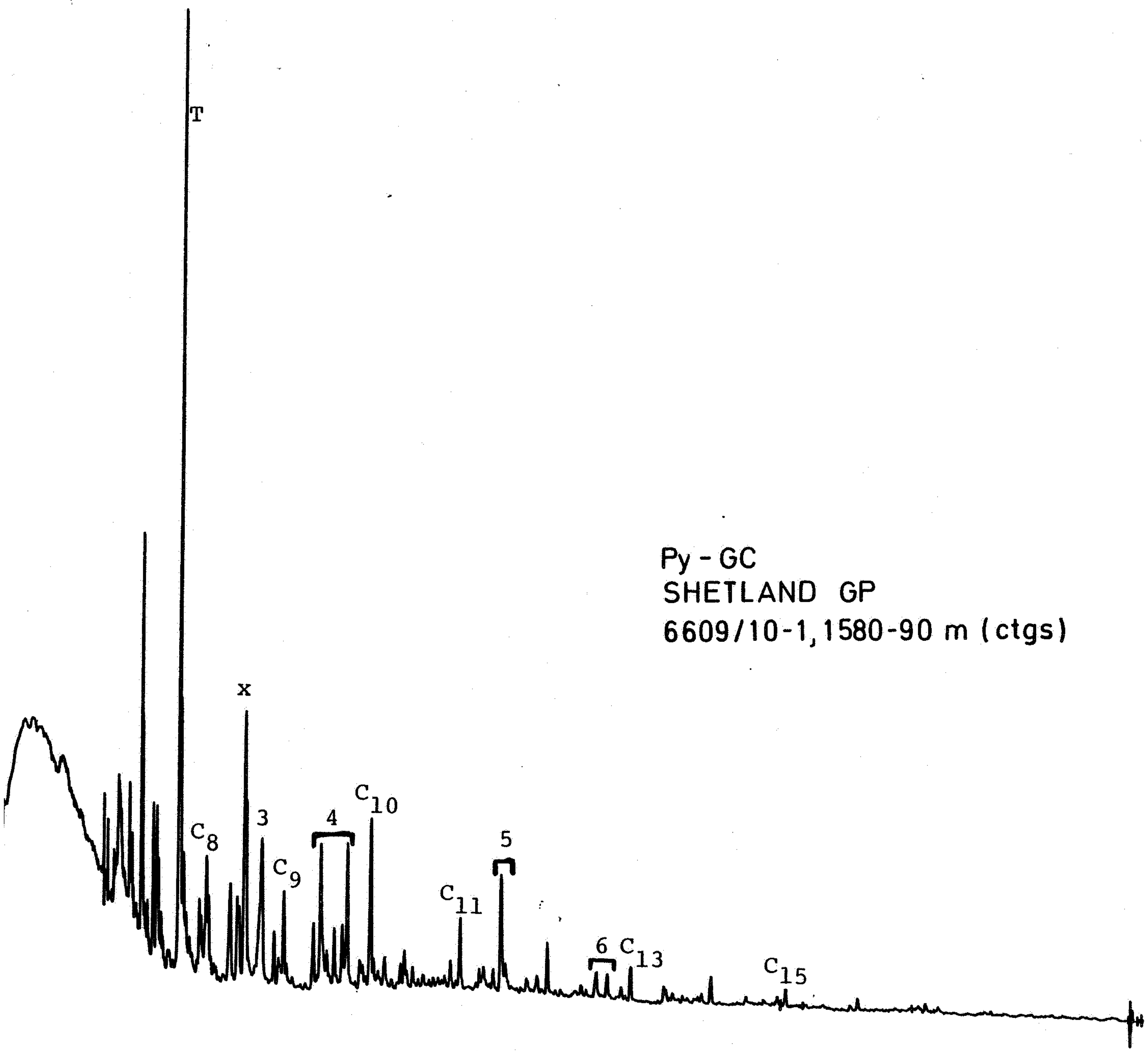


FIGURE : IV d

PYROGRAM (Pyrolysis gas chromatography)

FIGURE : IV e

PYROGRAM (Pyrolysis gas chromatography)



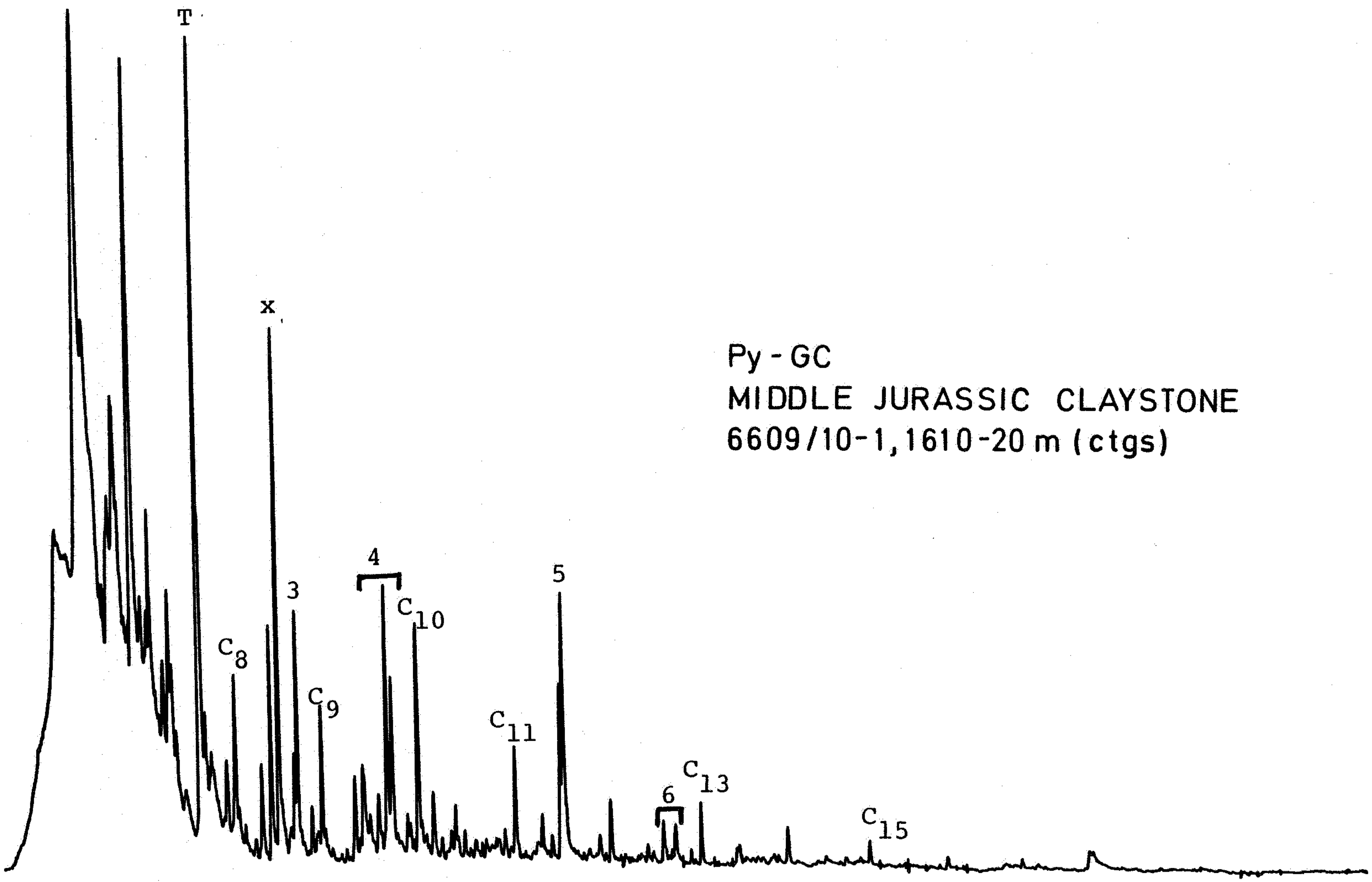


FIGURE : IV f

PYROGRAM (Pyrolysis gas chromatography)

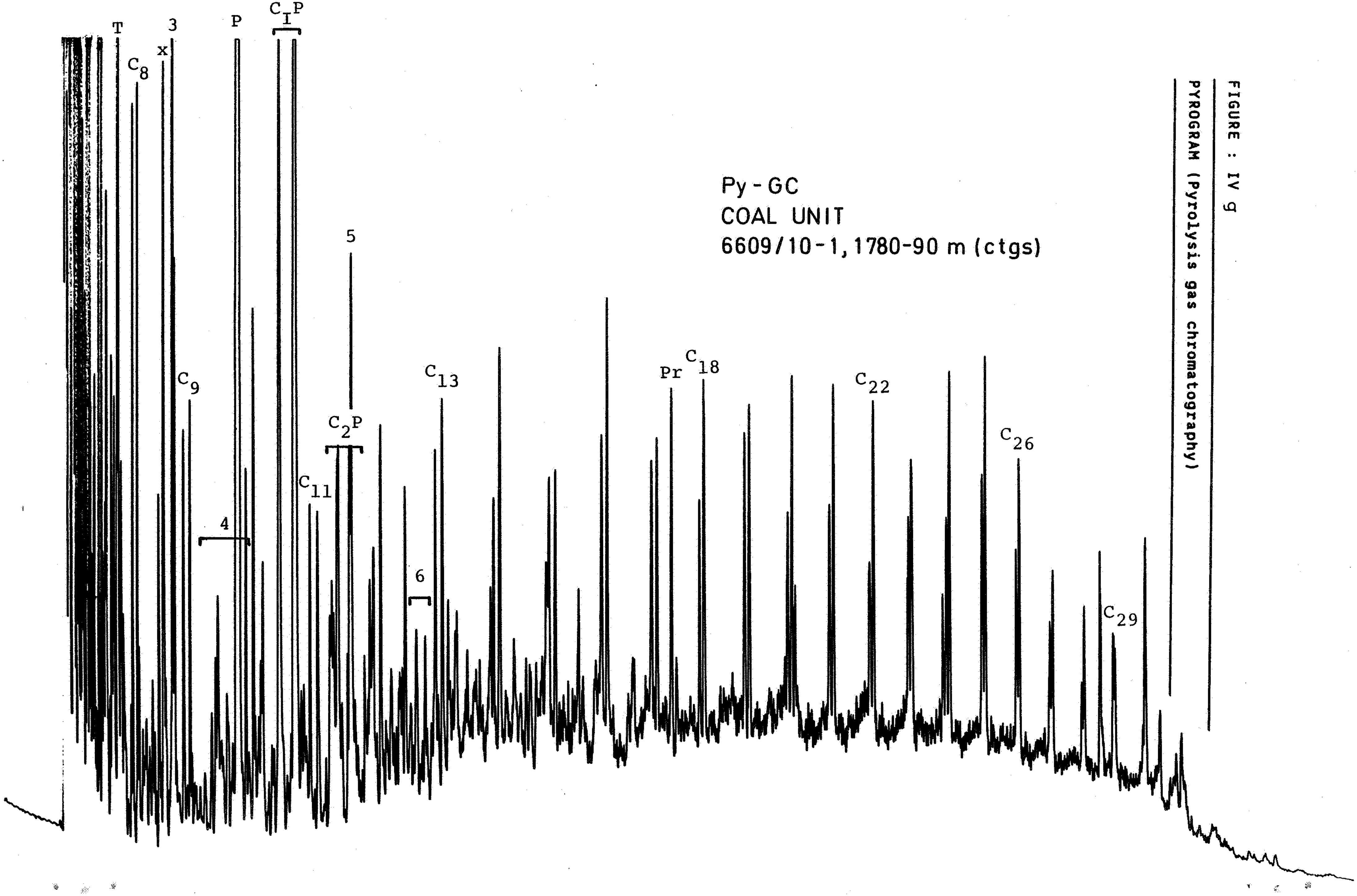


FIGURE : IV g

PYROGRAM (Pyrolysis gas chromatography)

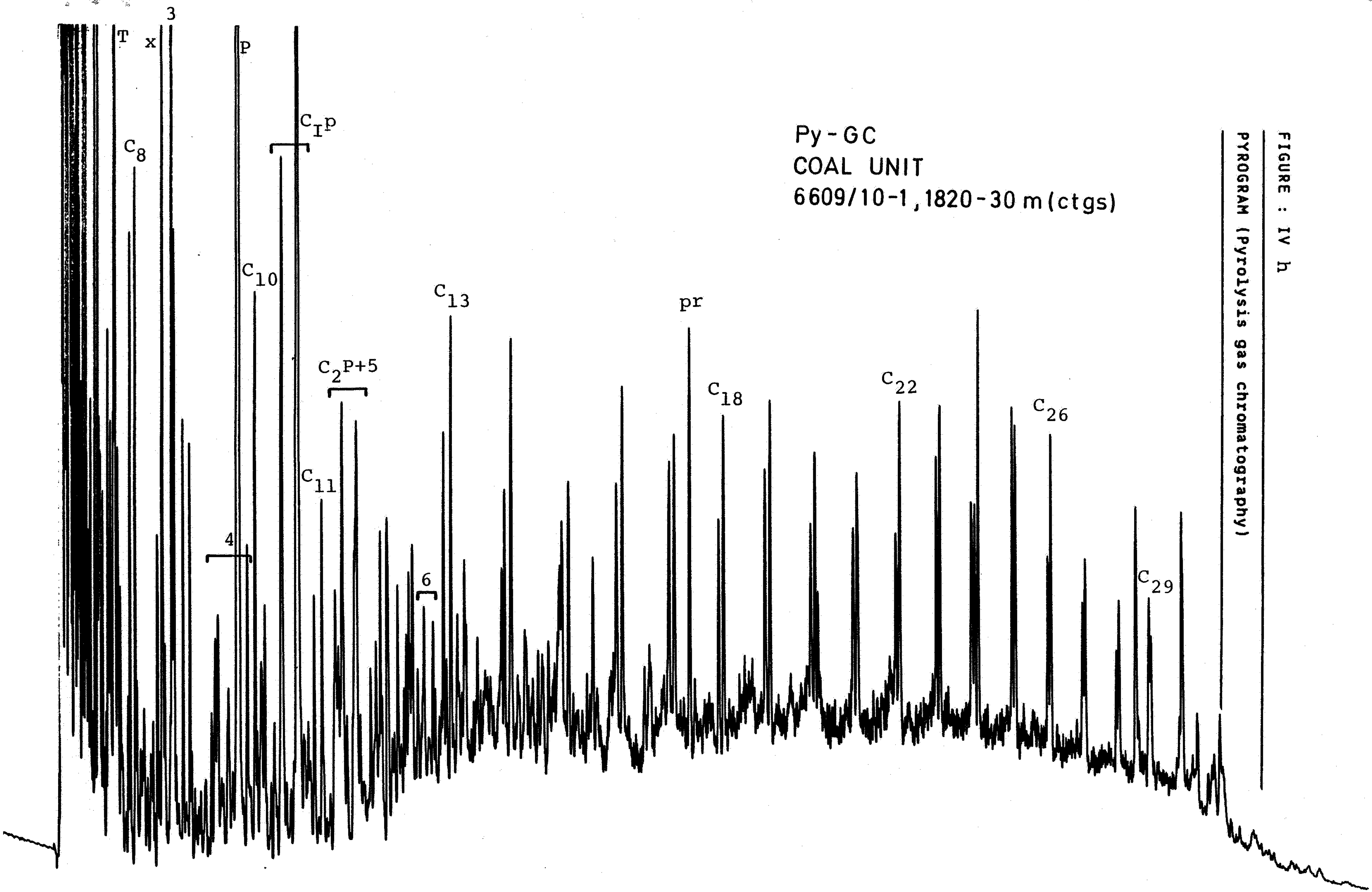


FIGURE : IV h

PYROGRAM (Pyrolysis gas chromatography)

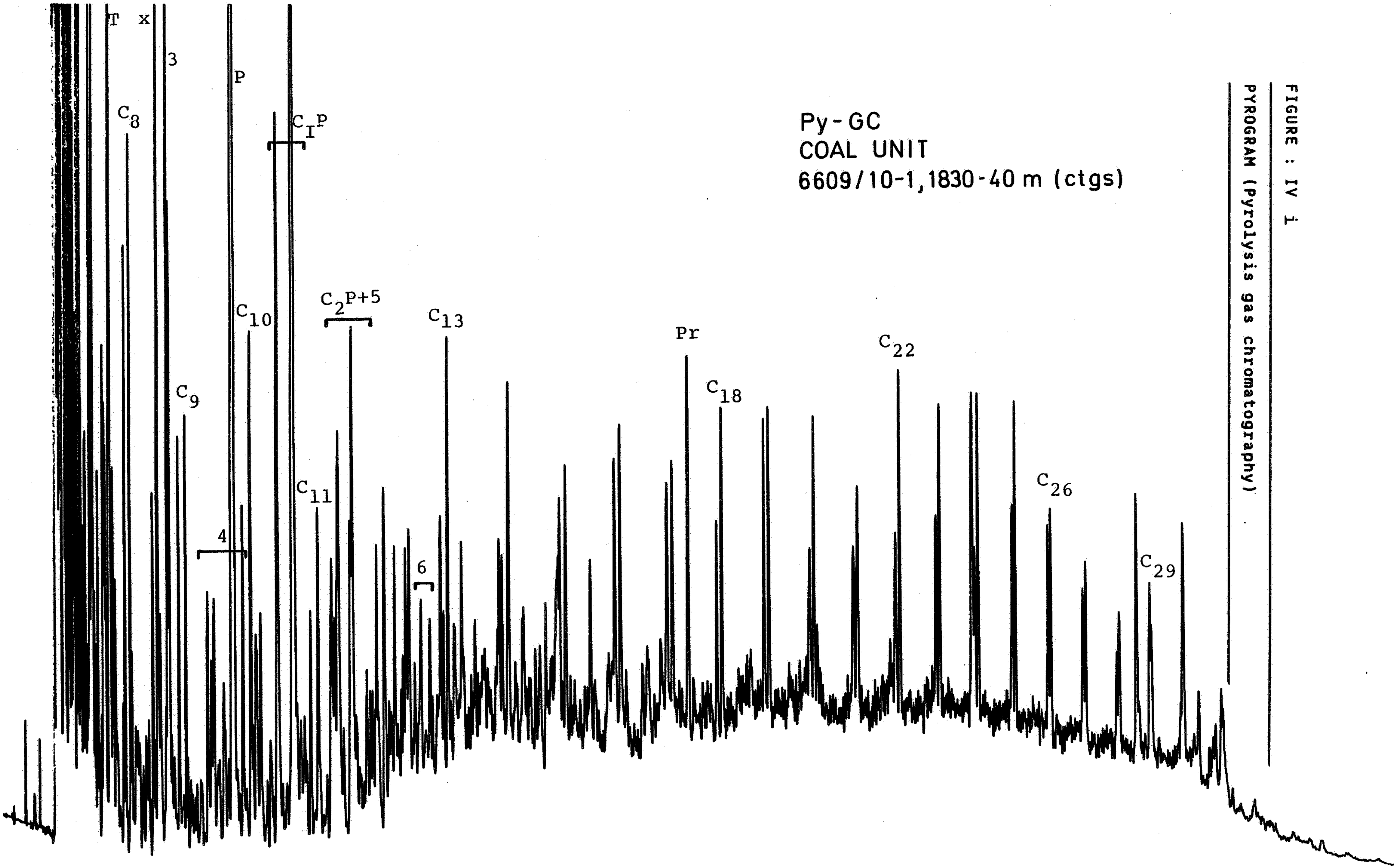


FIGURE : IV 1

PYROGRAM (Pyrolysis gas chromatography)

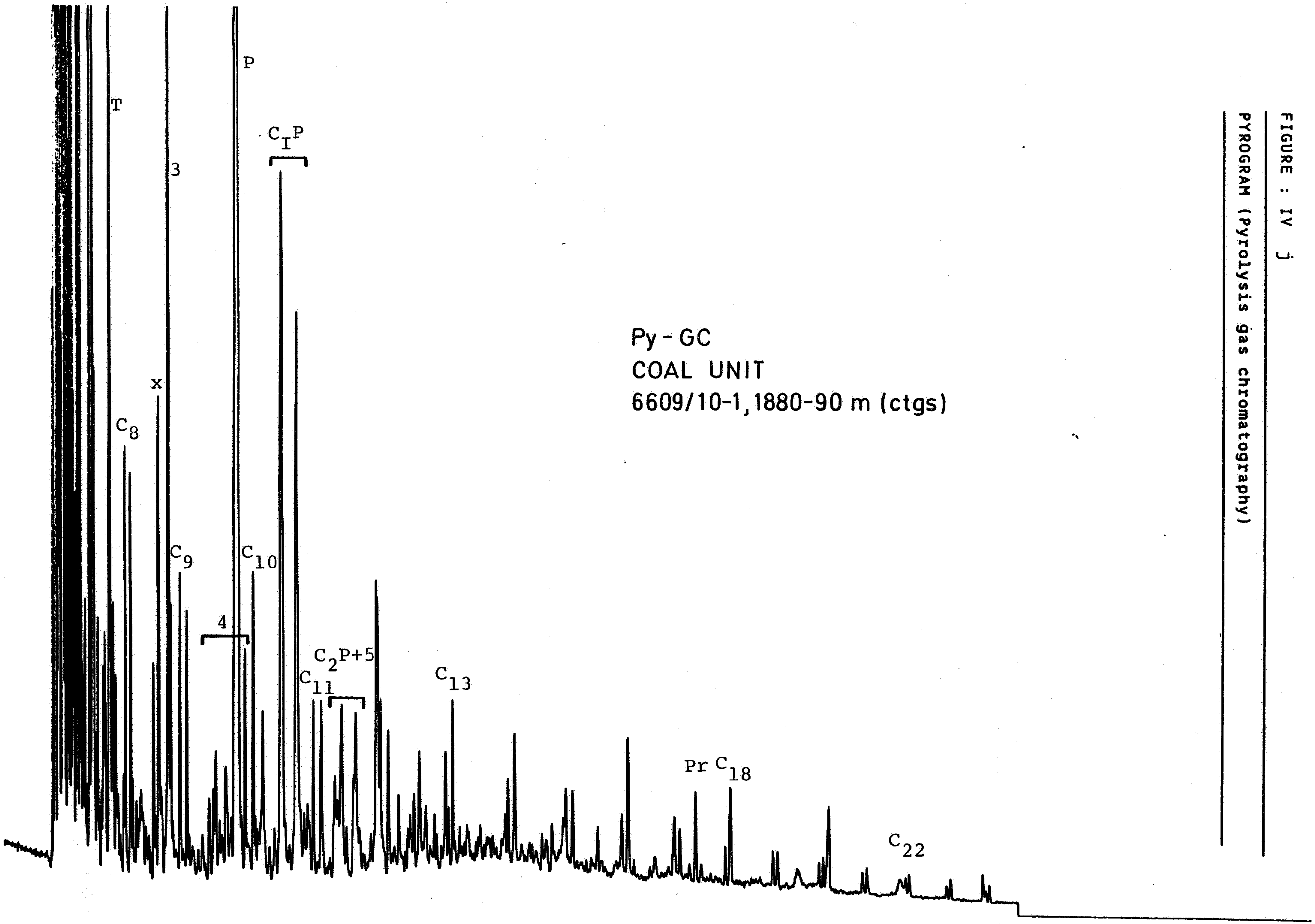


FIGURE : IV j

PYROGRAM (Pyrolysis gas chromatography)

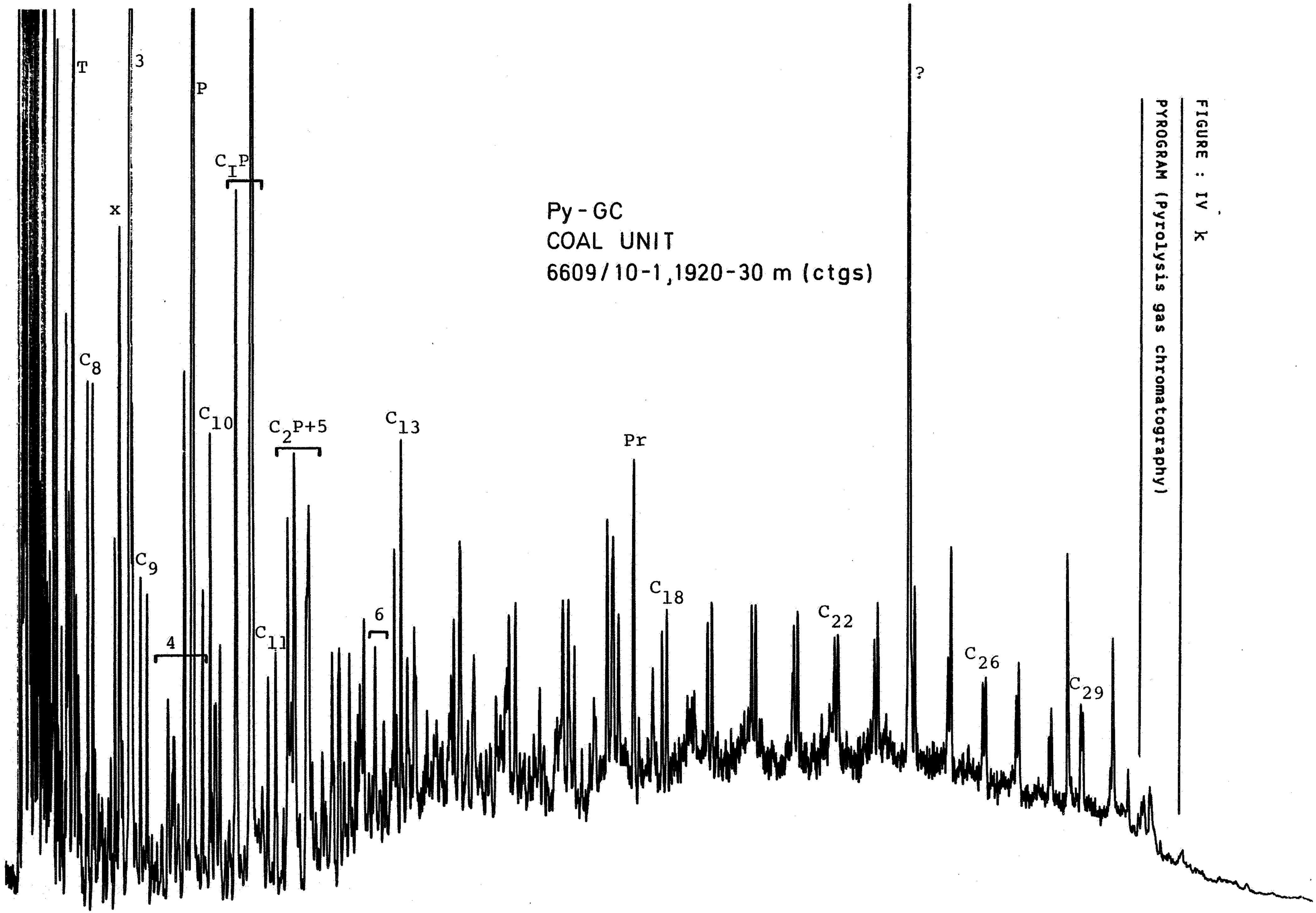
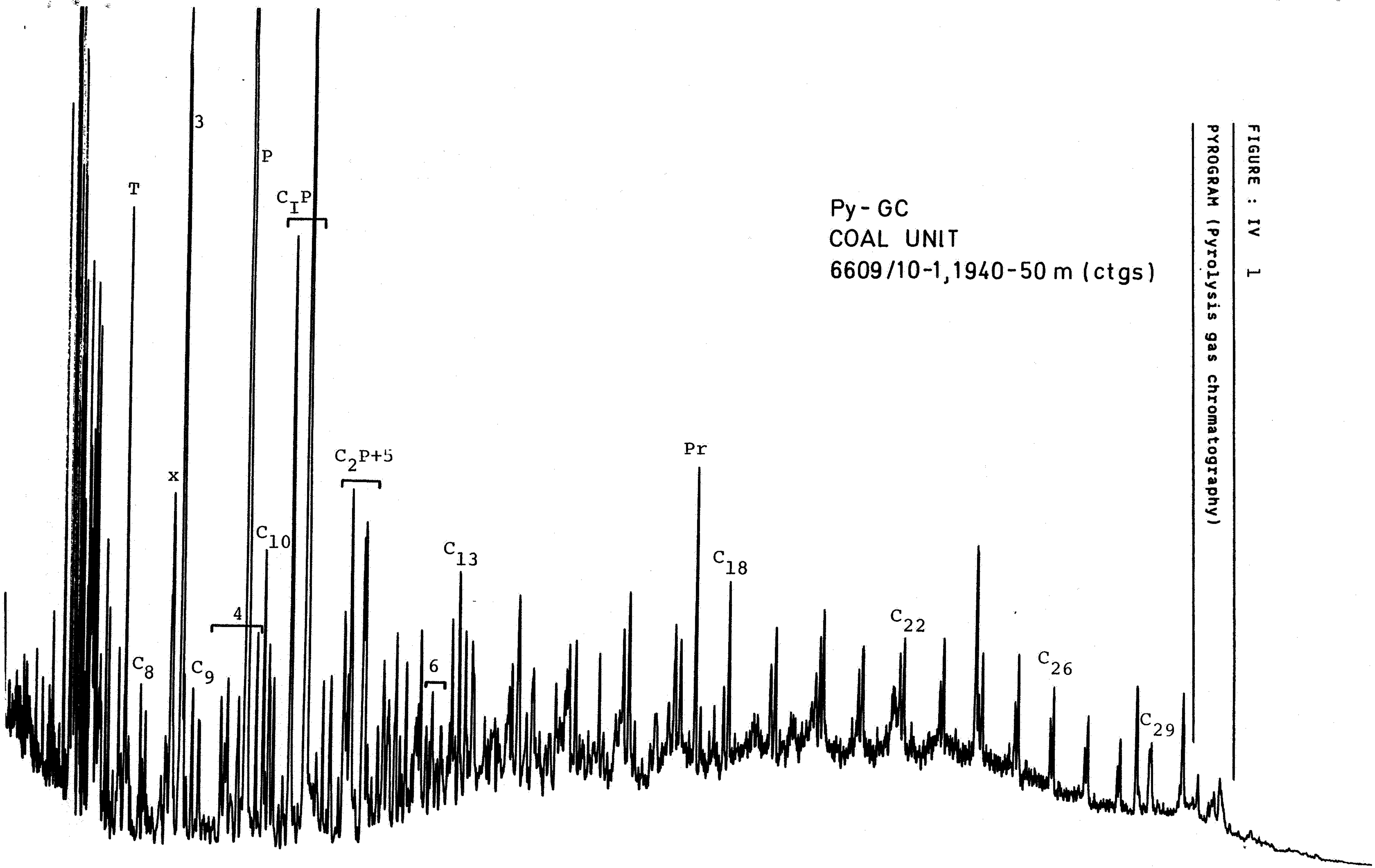


FIGURE : IV k

PYROGRAM (Pyrolysis gas chromatography)

FIGURE : IV 1

PYROGRAM (Pyrolysis gas chromatography)



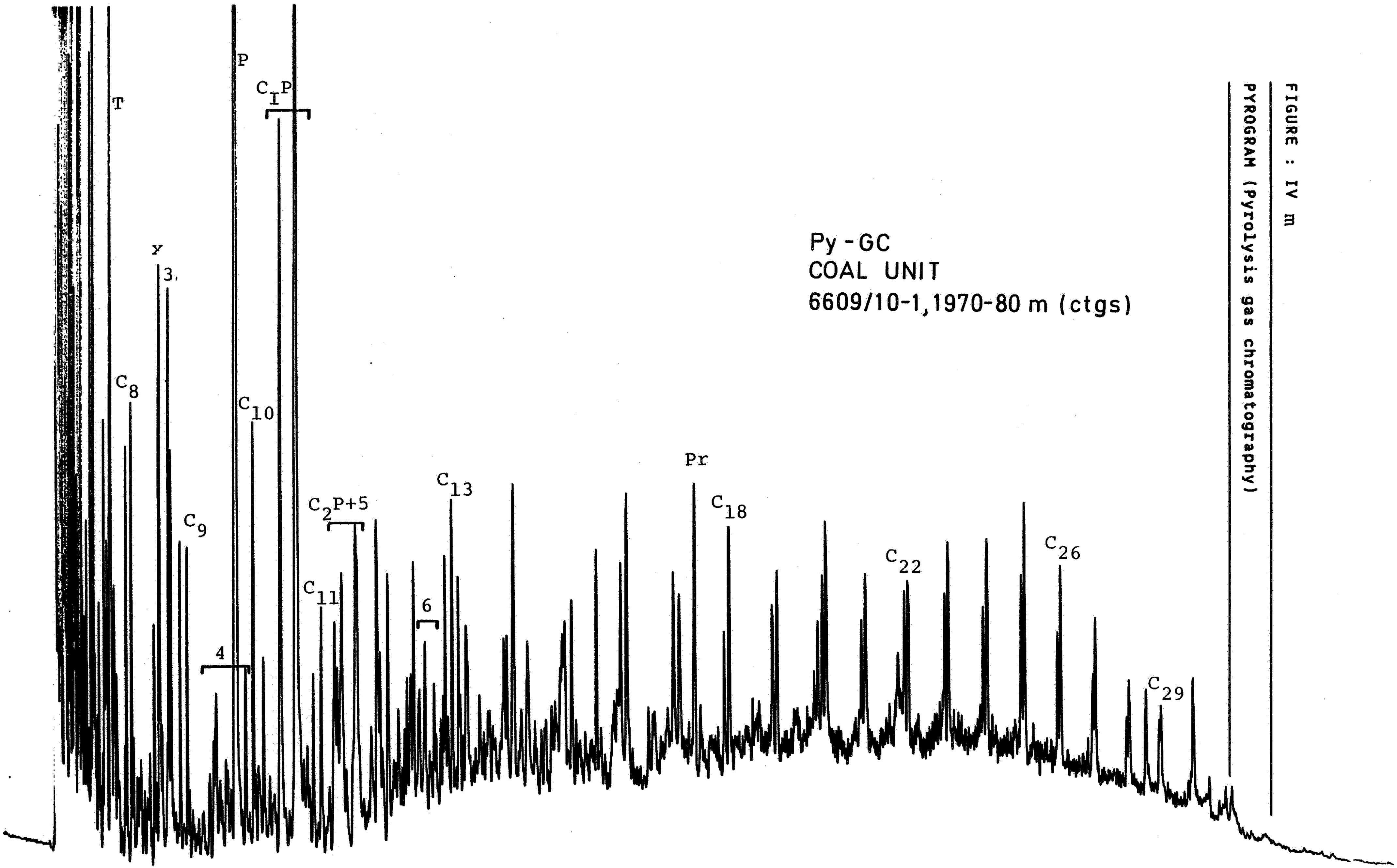


FIGURE : IV m

PYROGRAM (Pyrolysis gas chromatography)

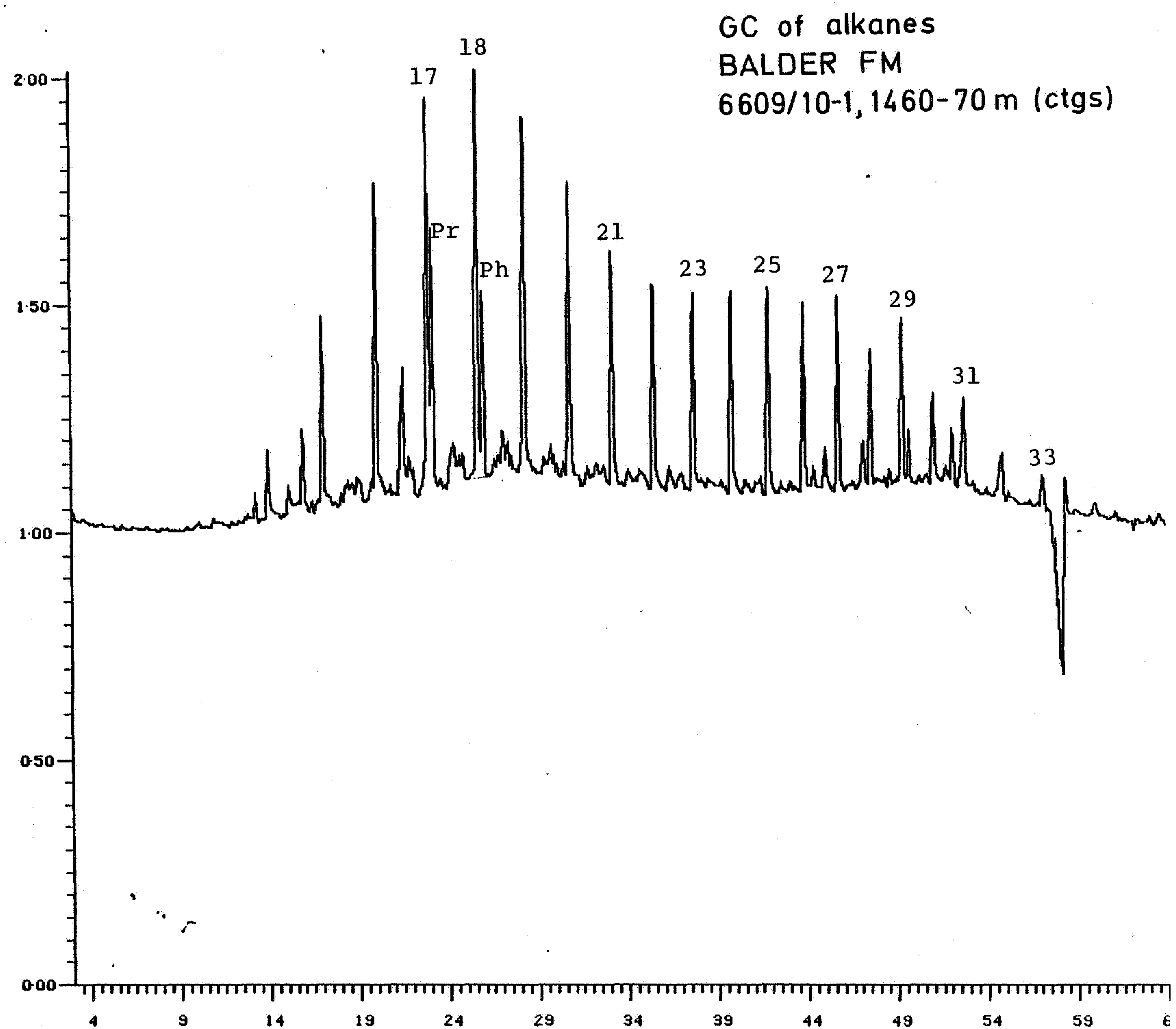


FIGURE : V a

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
LISTA/SELE FM
6609/10-1,1480-90 m (ctgs)

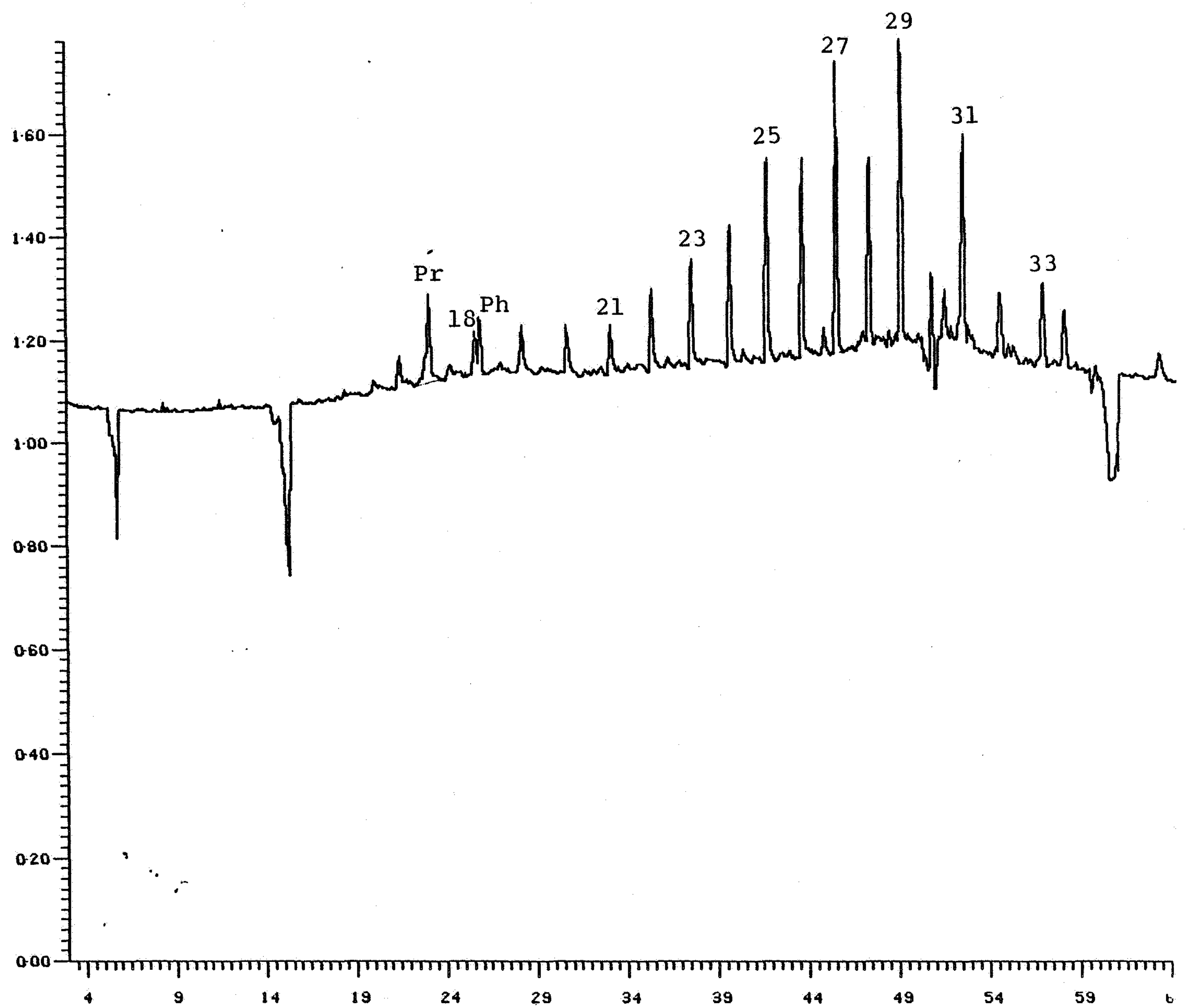


FIGURE : V b

GAS CHROMATOGRAM OF ALKANES

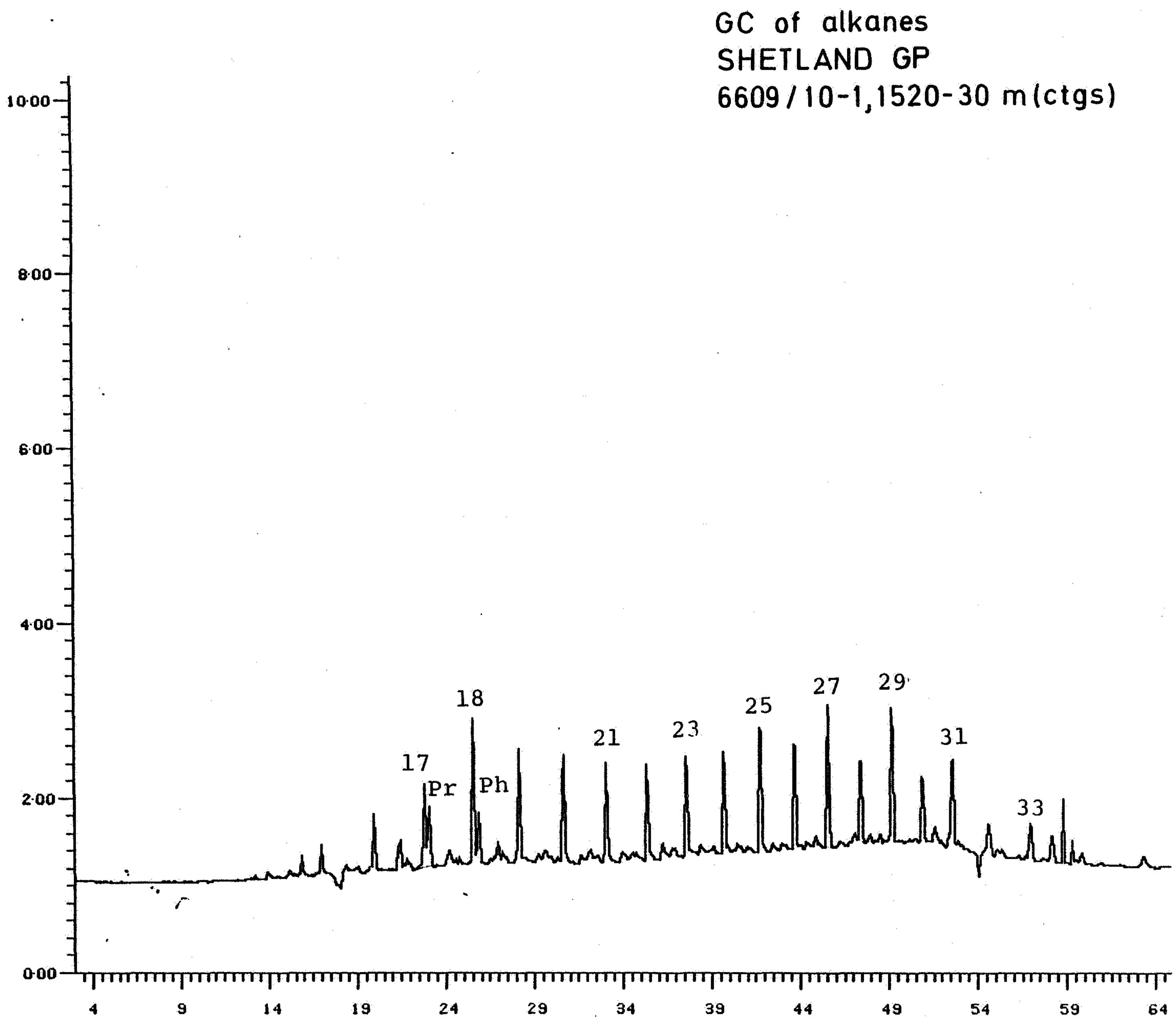


FIGURE : V C

GAS CHROMATOGRAM OF ALKANES

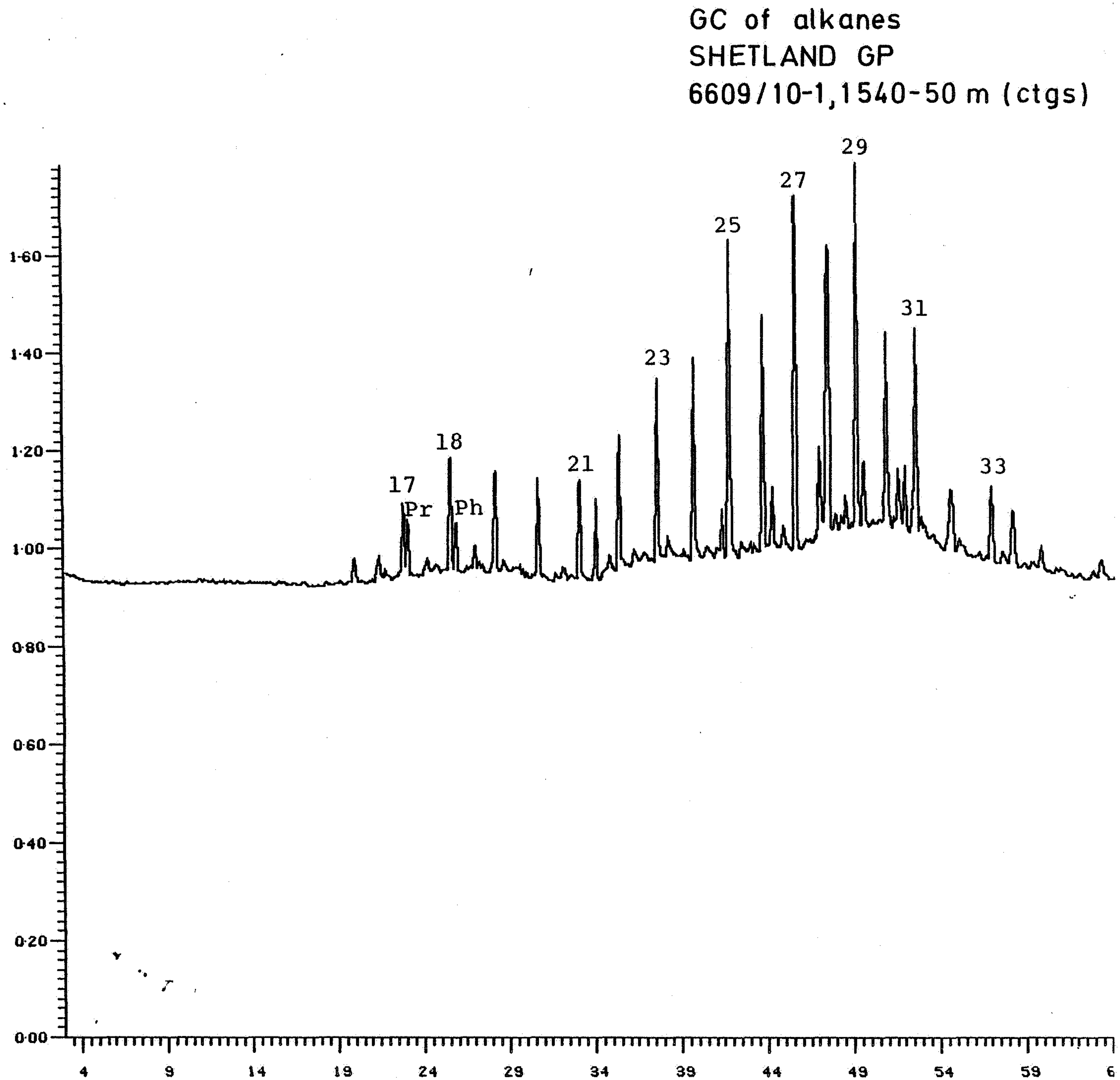


FIGURE : V d

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
SHETLAND GP
6609/10-1,1580-90 m (ctgs)

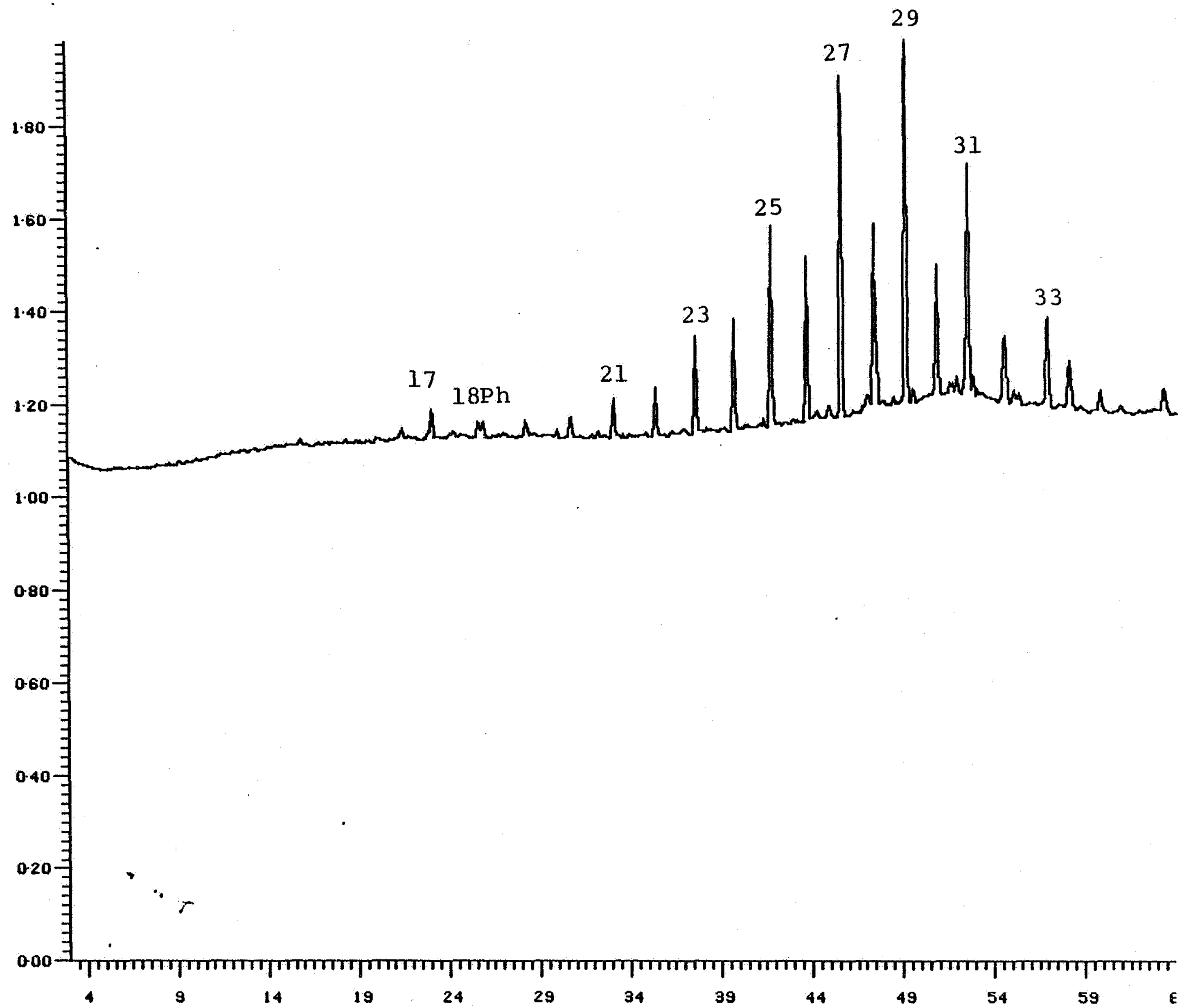


FIGURE : V e

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
MIDDLE JURASSIC CLAYSTONE
6609/10-1,1610-20 m (ctgs)

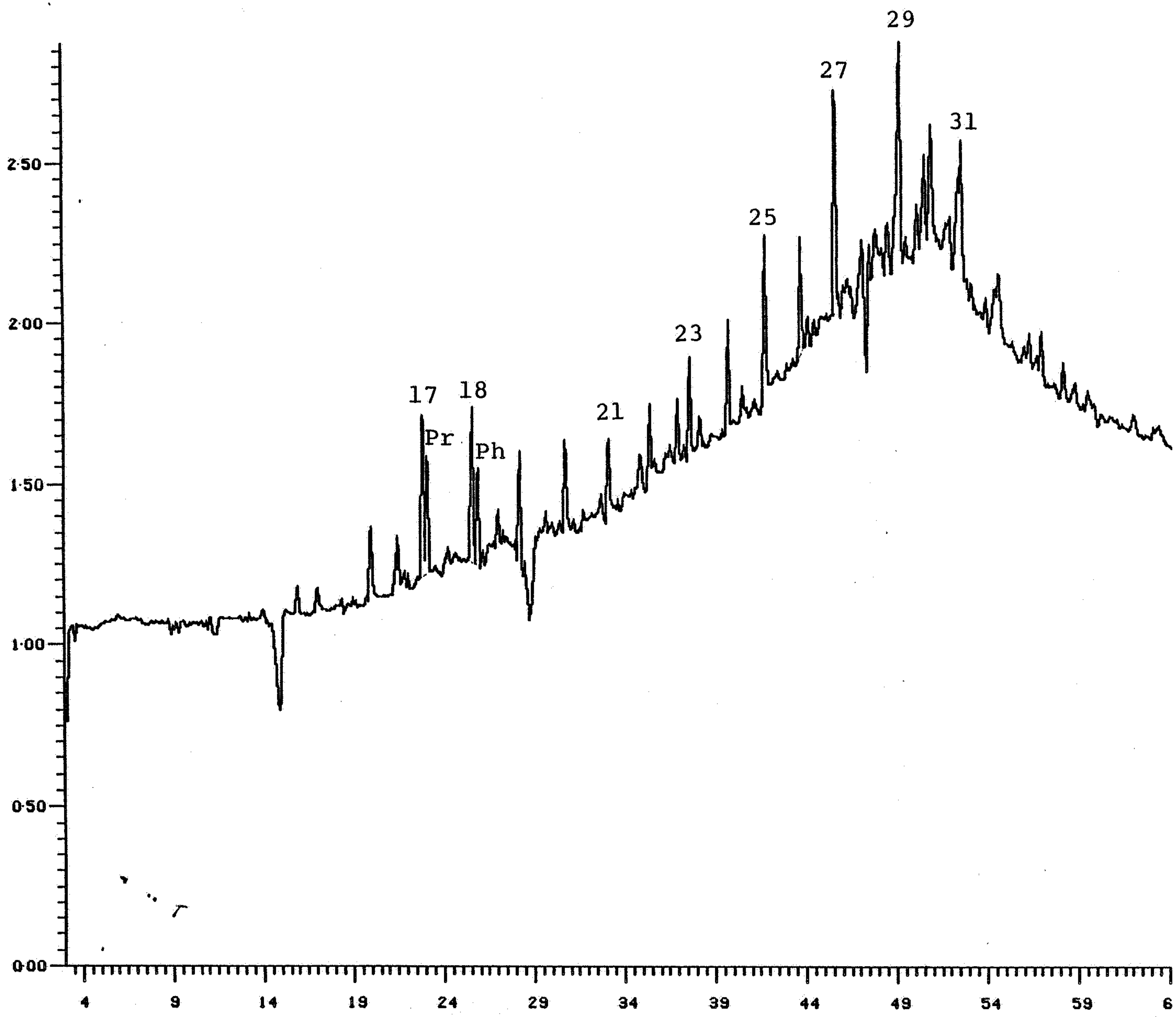


FIGURE : V E

GAS CHROMATOGRAM OF ALKANES

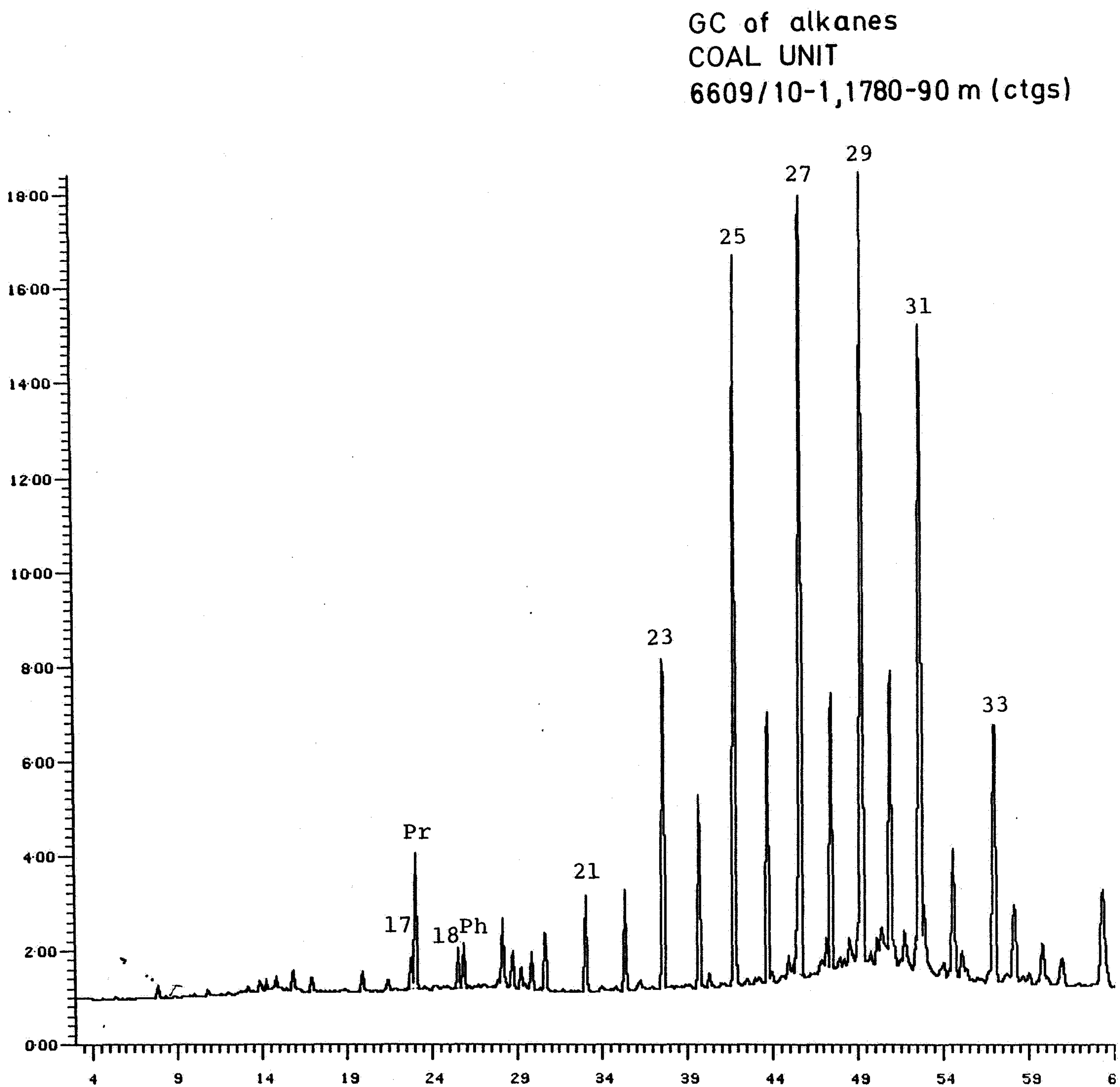


FIGURE : V g

GAS CHROMATOGRAM OF ALKANES

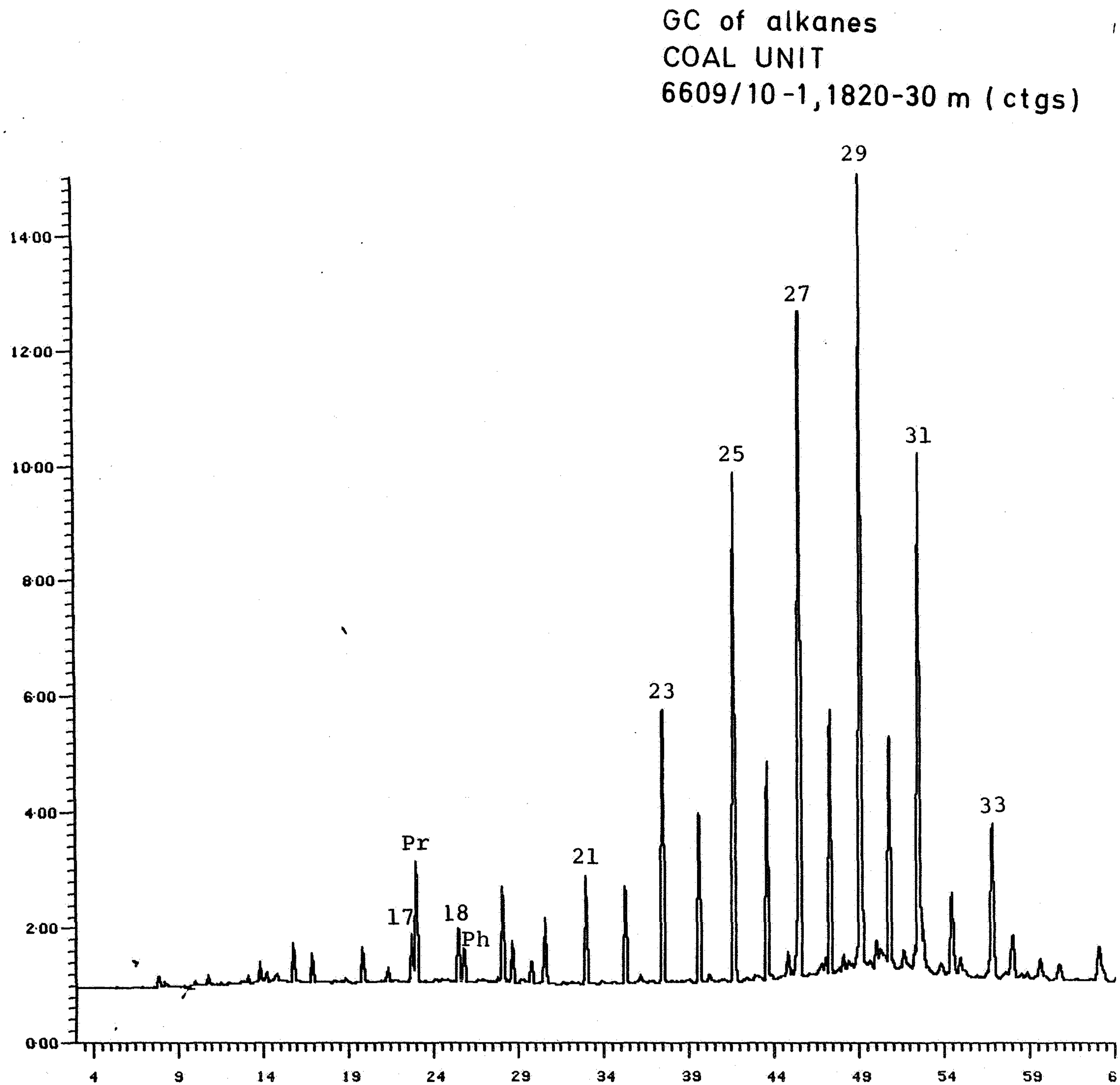


FIGURE : V h

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
COAL UNIT
6609/10-1,1830-40 m (ctgs)

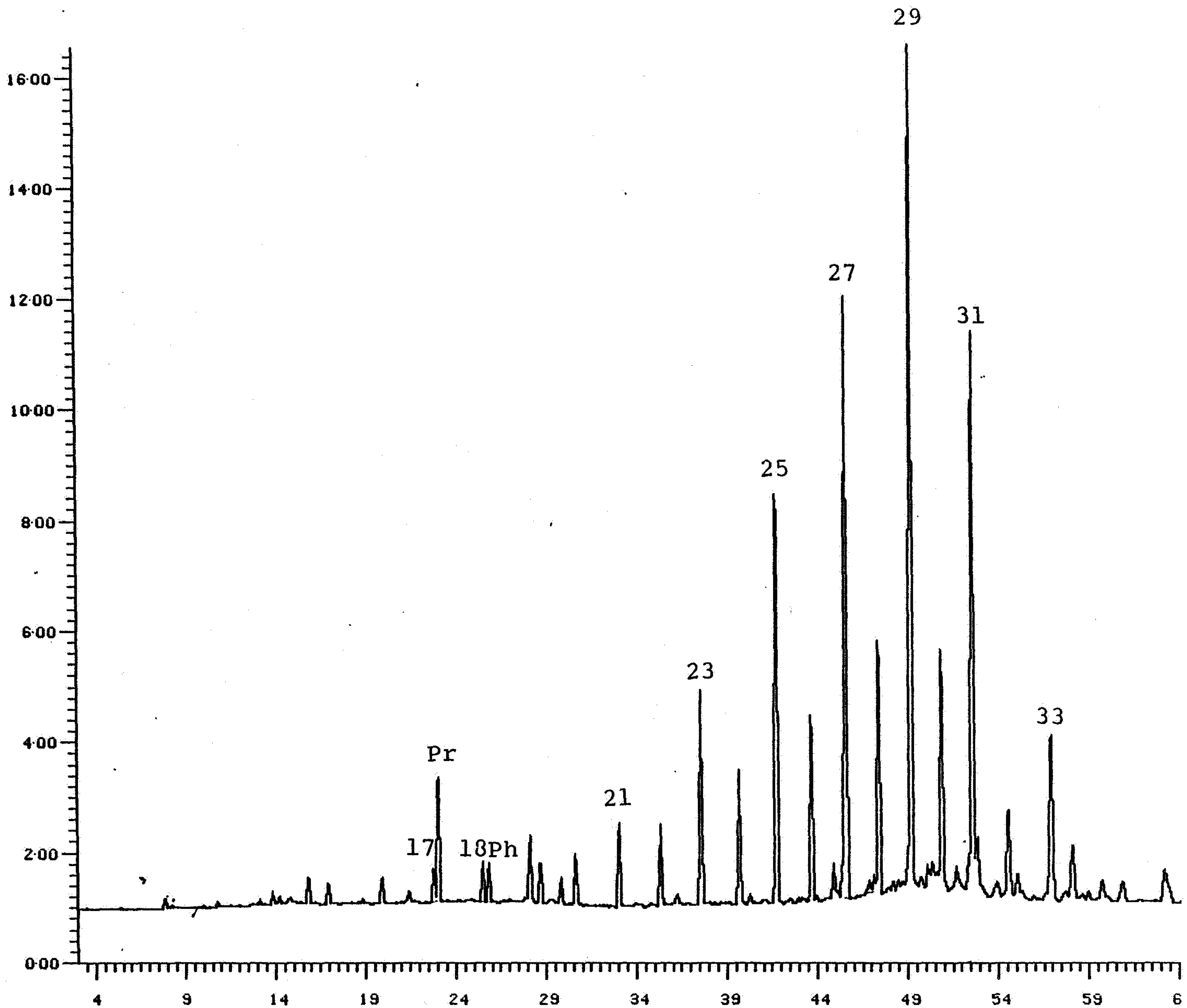


FIGURE : V i

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
COAL UNIT
6609 / 10 - 1 , 1880 - 90m (ctgs)

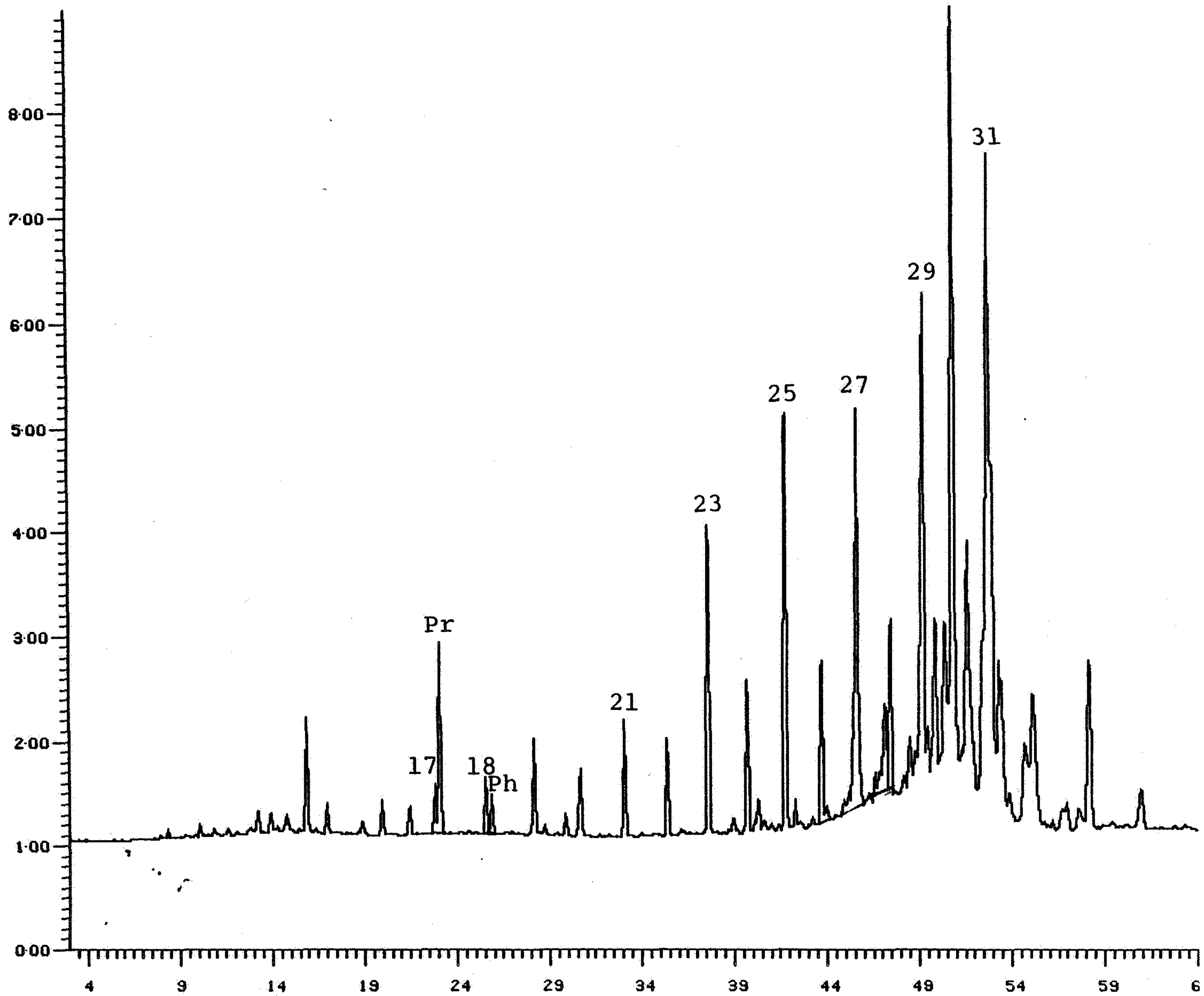


FIGURE : V j
GAS CHROMATOGRAM OF ALKANES

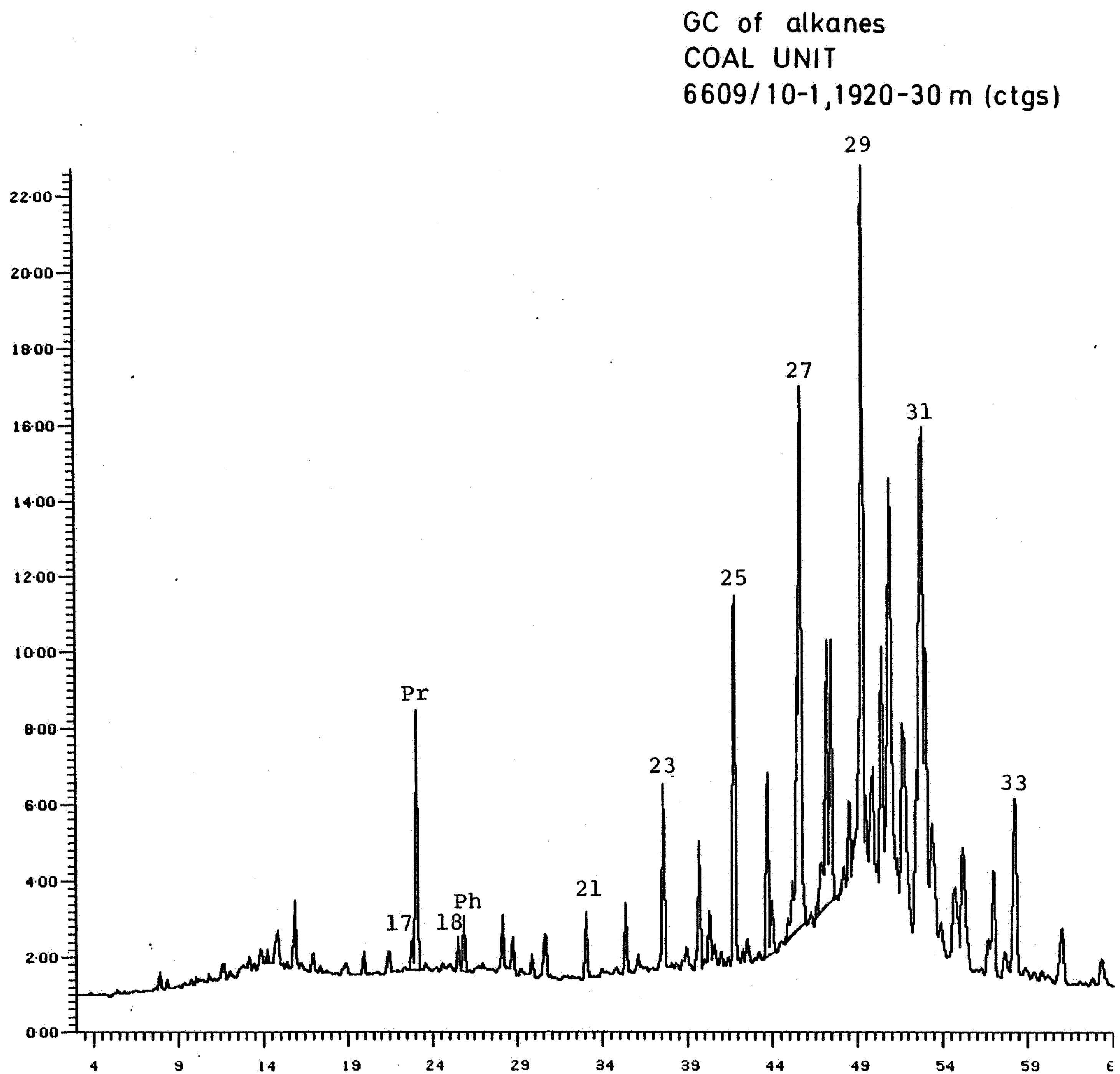


FIGURE : V k

GAS CHROMATOGRAM OF ALKANES

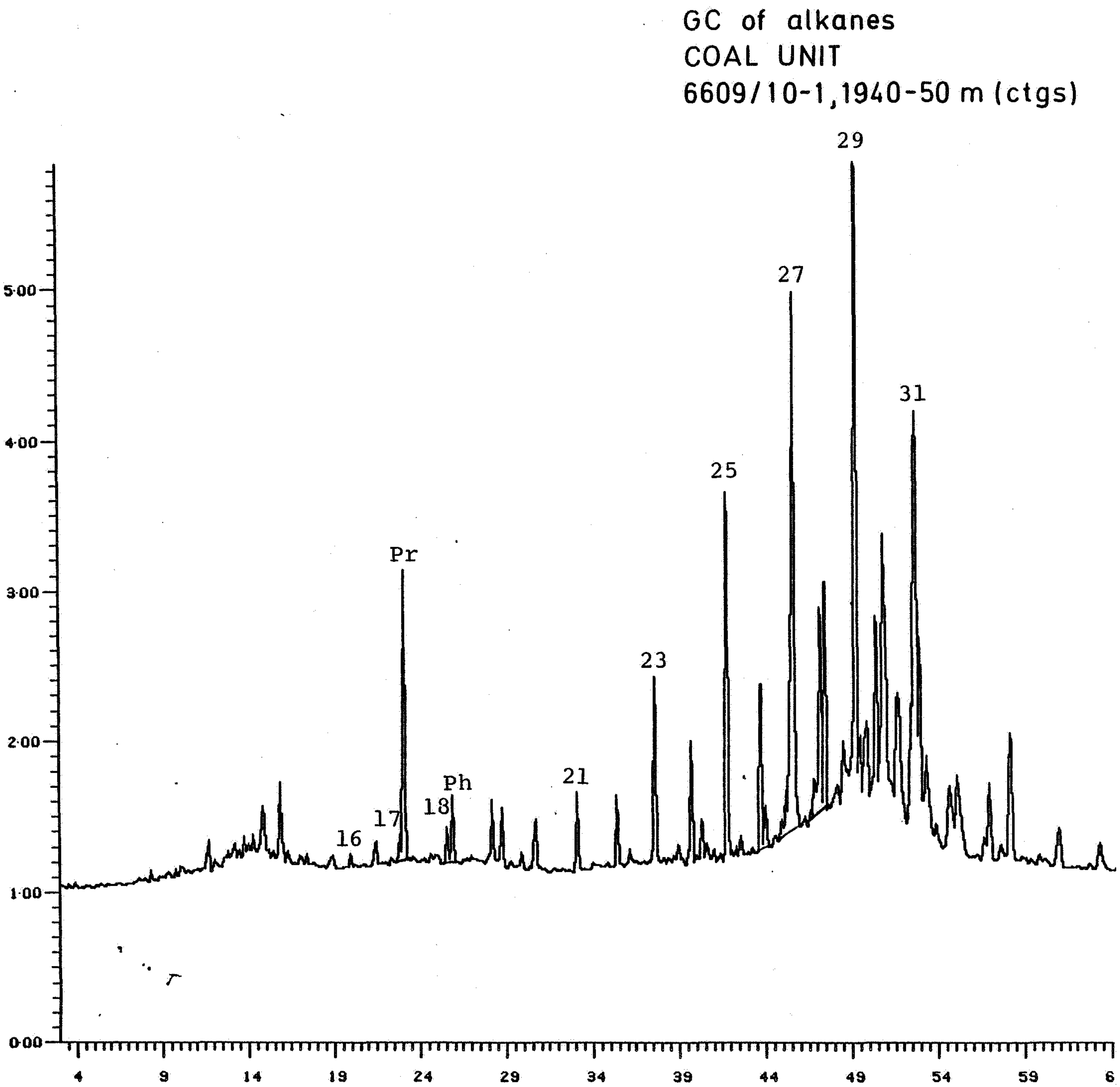


FIGURE : V 1

GAS CHROMATOGRAM OF ALKANES

FIGURE : V m

GAS CHROMATOGRAM OF ALKANES

GC of alkanes
COAL UNIT
6609/10-1, 1970-80 m (ctgs)