GEOCHEMICAL EVALUATION OF SOURCE ROCKS

FROM

THE OTWAY BASIN

REPORT LQ2852

Report prepared for the Victorian Department of Energy and Minerals

by

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REPORT LQ2852

CLIENT REFERENCE:	PO 010722
WELL NAME:	Various Otway Basin Wells
MATERIAL:	Cuttings and Core
WORK REQUIRED:	Source Rock Geochemistry

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1. INTRODUCTION

Cuttings and core samples were received from various unspecified Otway Basin wells for organic geochemical analyses. These analyses were aimed at establishing the maturity, organic richness and source richness of the sedimentary section intersected in the various locations. Geochemical analyses performed on selected source rock extracts from the wells were aimed at determining more precisely their maturity and source affinity.

Preliminary results were reported to the Victorian Department of Energy and Minerals as work was completed on this study so that the results of initial screening analyses could be used to carefully select the most suitable samples for further, more detailed analyses. This report presents the data together with an interpretation of this data.

2. ANALYTICAL PROCEDURES

The analytical procedures used in this study are provided in Appendix 1.

3. RESULTS

Analytical data is presented in this report as follows:

Analysis	Table	Figure	Appendix
Vitrinite Reflectance	1	1	2
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4. INTERPRETATION

SOURCE ROCK GEOCHEMISTRY

4.1 Maturity

The measured vitrinite reflectance data is listed in Table 1 and Figure 1.

Oil generation from thermally labile liptinites (resinite, bituminite and suberinite) commences at vitrinite reflectance values of approximately 0.45% while the maturity threshold for significant gas generation from terrestrial woody herbaceous kerogen is at an approximate vitrinite reflectance value of 0.55%. The generation of liquid hydrocarbons from less thermally labile liptinites commences at a vitrinite reflectance level of approximately 0.7%.

Using a combination of vitrinite reflectance data measured in this study and data provided by the Victorian Department of Energy and Minerals an estimation of the approximate depths at which these maturity levels are reached in each of the wells has been made and is listed in the table below.

Well No.	Depth for early oil generation (0.45%)	Depth for gas generation (0.55%)	Depth for late oil generation (0.70%)
1	800m	1450m	2400m
2	1400m	2000m	2500m
4	1900m	2200m	2700m
5	900m	1700-2300m	Insufficient Data
6	Insufficient Data	Insufficient Data	Insufficient Data
7	Insufficient Data	500-700m	1500-2500m
8	Insufficient Data	Insufficient Data	Insufficient Data
9	1100m	2400-2900m	Insufficient Data
10	1450m	1800m	2350m
14	1400m	2000m	3000m
15	1200m	1650m	2300m
16	Insufficient Data	Insufficient Data	Insufficient Data
17	2100m	2300m	2600m
20	Insufficient Data	1500-2000m	Insufficient Data
21	1400m	1600-2300m	Insufficient Data
22	750m	1100m	1600m

Rock-Eval T_{max} and Hydrogen Index data (Table 5; Figure 2) generally shows very similar maturity ranges to those indicated by the measured vitrinite reflectance data. T_{max} values are depressed in several samples from different wells. This is likely to be due to small and ill-defined S_2 peaks for samples 2E, 5F, 9A, 10A, 14B and 17E. The possible presence of free hydrocarbons (Production Indices ≥approximately 0.20) may have depressed the T_{max} values for samples 4A, 6A, 7A and 8B. In consideration of these effects the Rock-Eval data shows excellent agreement with the measured vitrinite reflectance data.

Production Indices

Rock-Eval production indices are also maturity dependent and generally show an increase with depth. Reliable Production Indices of >0.2 are generally indicative of the possible presence of migrated hydrocarbons as they contain more hydrocarbons than can be generated from the amount of kerogen present. The following samples have reliable Production Indices greater than 0.20.

Sample	Production Index
1F	0.25
1H	0.26
4A	0.25
5C	0.29
5D	0.27
5E	0.25
7A	0.52
7B	0.28
7E	0.21
8A	0.30
8B	0.39
9B	0.41
10B	0.24
10D	0.23
14A	0.62
17D	0.21
21A	0.39
21B	0.35
21C	0.46
21D	0.28
21E	0.29
22A	0.28

A comparison of the aromatic maturity ratios (Table 18) with the measured vitrinite reflectance data (Table 1) indicates that several of the samples examined in this study are likely to contain a portion of hydrocarbons which were generated from a distant, more mature source. The remainder of the samples are likely to have been generated essentially in-situ. Based on this assessment the samples are listed below according to the influence on their aromatic fractions by migrated hydrocarbons.

In-Situ	Possibly Influenced by a Portion of Migrated Hydrocarbons
1H	1C
7C	4A
7E	5F
8B	9A
17E	14A
21C	15A
22B	
22C	
22E	

The maturity dependent saturated biomarker ratios generally show agreement with the maturities derived from the measured vitrinite reflectance values and the calculated aromatic data. However for several samples (1C, 5F, 9A, 14A and 15A) with calculated aromatic maturities higher than the measured vitrinite reflectance the saturated biomarker ratios indicate maturities similar to the measured vitrinite reflectance. Thus for these samples the extracted hydrocarbons appear to be largely source related with small components of migrated oil.

The saturated biomarker ratios for sample 4A are consistant with the calculated aromatic maturity suggesting that this sample may contain a more significant proportion of migrated hydrocarbons.

It is recommended that further geochemical analyses be performed on any nearby clean sands to more accurately characterise these migrated hydrocarbons free of source interferences. This would allow the extent to which the samples examined in this study have been influenced by the presence of migrated hydrocarbons to be determined.

Pristane/n-heptadecane and phytane/n-octadecane ratios (Table 16, Figure 29) are somewhat variable as they are influenced by organic facies variations. However an odd-over-even carbon preference of the C_{21}-C_{29} alkanes is observed in the less mature samples (Figures 13-28).

The C_{29} sterane maturity-migration plot (Figure 32) should be regarded with caution as these samples have probably not been derived from the same organic facies. However, it illustrates that most of the samples examined are likely to have undergone only limited if any migration.

4.2 Source Richness and Organic Richness

Organic richness ranges from poor to excellent in the extracted samples studied (TOC = 0.04-24.47%). However, the majority of the samples examined have TOC values indicative of poor to fair organic richness.

Source richness also ranges from poor to excellent in these samples ($S_1 + S_2$ = 0.29-47.56 kg of hydrocarbons/tonne). Samples with the best source richness also have the best organic richness in the interval studied. The majority of the samples examined have S_1+S_2 values indicative of poor to fair source richness.

4.3 Source Quality and Kerogen Type

Hydrogen Index and T_{max} values (Table 5; Figures 2a-2n) indicate that the samples examined contain organic matter which have bulk compositions ranging from that of Type II to Type IV kerogen.

Organic petrological analyses were performed on selected samples (Tables 2-4). These analyses give more detail on the composition of the organic matter present in these samples. The more hydrogen rich liptinite (exinite) macerals have greater liquids generative potential than the vitrinite and inertinite macerals. Generally, the samples which contain the better quality Type II-III organic matter, contain higher proportions of liptinite. Liptinite contents in these samples range from 10-20% of the indigenous organic matter present.

The most abundant indigenous liptinites present are variable but are typically dominated by the terrestrially derived macerals, sporinite, cutinite and resinite. Fragmented liptinites (liptodetrinite) are very common and are often the most abundant maceral present. The presence of lamalginite is indicative of lacustrine facies whereas phytoplankton may be indicative of either lacustrine or marginal marine environments of deposition. The presence of bituminite and resinite is significant as these macerals are thermally labile and will generate liquid hydrocarbons at lower maturities (VR ≥0.45%) than other macerals (VR ≥0.7%).

Pyrolysis gas-chromatography (Py-GC) analyses were performed on selected samples. These analyses may be used to indicate the amounts of both gaseous and liquid hydrocarbons which may be expected to be generated on maturity. The following calculations were made from the C_5-C_8 (condensate) and C_{9+} (oil) normal alkene + alkane yields as a percentage of total pyrolysate.

Sample	Pyrolysis Yield (kg hydrocarbons /tonne)	Normal Alkanes + Alkenes			
		C_5-C_8 Yield (kg hydrocarbons /tonne)	C_{9+} Yield (kg hydrocarbons /tonne)	mg C_{9+} per g TOC	C_{9+} % of S_2
1C	1.25	0.01	0.08	0.53	6.01
1F	6.99	0.15	0.36	14.48	5.14
1H	4.07	0.05	0.39	11.32	9.62
5D	1.80	0.03	0.10	0.82	5.50
7C	1.95	0.02	0.07	0.77	3.78
7E	0.80	0.01	0.03	0.11	3.24
10C	4.15	0.06	0.20	4.96	4.76

10D	0.96	0.02	0.11	0.64	11.22
22B	1.25	0.01	0.07	0.67	5.61
22C	44.75	0.29	1.54	377.79	3.45

The following calculations were made from the C_1-C_4 (gas yield) and C_{5+} (liquid yield) values from the pyrolysis GC and Rock-Eval data. It should be noted here that the figures in both of these data sets reflect generative yields only and that expulsion efficiencies have not been taken into account.

Sample	Pyrolysis Yield (kg hydrocarbons /tonne)	Gas Yield (kg hydrocarbons /tonne)	Liquid Yield (kg hydrocarbons /tonne)
1C	1.25	0.07	1.18
1F	6.99	1.15	5.84
1H	4.07	0.24	3.83
5D	1.80	0.18	1.62
7C	1.95	0.15	1.80
7E	0.80	0.07	0.73
10C	4.15	0.70	3.45
10D	0.96	0.13	0.83
22B	1.25	0.15	1.10
22C	44.75	2.36	42.39

The ratio of mg of C_9+ normal alkanes and alkenes per gram of TOC assesses the effective source quality of these intervals. In our opinion, values of greater than 10 are indicative of good effective source quality whilst values of greater than 20 are indicative of excellent effective source quality. This ratio indicates that samples 1F, 1H and particularly 22C have excellent effective source quality.

The proportion of C_{9+} normal alkanes and alkenes as a percentage of the total pyrolysate is also dependent on source quality. These values range from 3.24 to 11.22% in the samples examined in this study. In our experience, values of greater than 8% C_{9+} normal alkanes and alkenes as a percentage of the total pyrolysate are indicative of good source quality. Values of greater than 15% C_{9+} normal alkanes and alkenes as a percentage of the total pyrolysate are, in our opinion, indicative of excellent source quality. These values indicate that the organic matter in sample 10D has the best effective source quality of the intervals studied.

Effective source richness for the generation of oil and condensate may be gauged from the yields of C_{9+} (oil) and C_5-C_8 (condensate) alkenes and alkenes (kg of hydrocarbons/tonne). Gas yields may be gauged from C_1-C_4 yields (kg of hydrocarbons/tonne). The following values may be used as guidelines in the assessment of effective source richness. It is unrealistic however to use these values as specific cut-off values:

Oil source richness (C_{9+} alkanes + alkenes);

- good >0.5 kg hydrocarbons/tonne
- excellent >1.0 kg of hydrocarbons/tonne

Condensate source richness (C_5-C_8 alkanes + alkenes);

- good >0.25 kg hydrocarbons/tonne
- excellent >0.5 kg of hydrocarbons/tonne

Gas source richness (C_1-C_4 yields);

- good >3 kg hydrocarbons/tonne
- excellent >6 kg of hydrocarbons/tonne

These ratios indicate that almost all of the samples have poor effective source richness for the generation of oil, condensate and gas. However, sample 22C has poor effective source richness for the generation of gas but good effective source richness for the generation of condensate and excellent effective source richness for the generation of oil.

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4.4 Source Affinity and Bulk Composition

The sixteen extracts studied have C_{12+} bulk compositions ranging from aromatic-asphaltic to paraffinic-naphthenic and naphthenic (Table 16; Figure 30).

The alkane distributions of the saturated hydrocarbons of many of the extracts (Figures 13-28) suggests that many of the samples are mixtures containing a source component and an oil component. The oil component is most commonly represented by the n-alkanes ranging from C_{14} to C_{22-23} while the source component is represented by the C_{23+} alkanes and or corresponding branched and cyclic alkanes (naphthenic hump). The C_{23+} alkanes commonly show a distinct odd-over-even predominance. Thus the source affinity assessment of several of the samples is likely to be hampered by the presence of oil. The likely derivation of each sample based on alkane distributions is given below.

Sample	Derivation
1C	Oil + Source
1H	Source
4A	Oil + Source
5F	Oil + Source
7C	Oil + Source
7E	Source
8B	Oil + Source
9A	Oil + Source
10C	Source
14A	Oil + Source
15A	Oil + Source
17E	Source
21C	Source
22B	Oil + Source
22C	Source
22E	Oil + Source

The samples can be broadly catagorised into three major and somewhat overlapping groups based on various aspects of their molecular composition. It should be noted that for samples where a component of migrated oil is likely to be present that the source affinity of a sample will reflect both this component as well as the source component.

Group A comprises samples 1C, 7E, 10C, 22B, 22C and 22E. This group is characterised by moderately high to high pristane/phytane ratios (3.10 - 6.70, Table 16) to suggesting that the precursor organic matter is likely to have been exposed to oxic conditions prior to burial. The only exception to this is for sample 1C which has a pristane/phytane ratio of 1.76 implying that its precursor organic matter was exposed to anoxic conditions prior to burial. This pristane/phytane ratio however is probably influenced by the oil portion of the extract.

Saturated biomarker distributions (Table 17, Figures 31-33, Appendix 3) of the Group A samples are characterised by higher abundances of the higher plant derived C_{29} sterane and diasterane homologues (m/z 217, 218, 259) relative to algal/bacterial derived C_{27} homologues. Diterpanes and labdanes (m/z 123) are derived from higher plant resins and are generally abundent in the Group A samples. Their presence implies that the source contains a component of terrestrial kerogen. Algal/bacterial derived tri and tetraterpanes (m/z 191), although present in these samples, have low abundances relative to the hopanes when compared to the Group B samples. The C_{19} and C_{20} triterpanes which may be evidence of a higher plant source are abundent in samples 7E and 10C.

Organic petrology data confirms the predominantly higher plant derived nature of the dispersed organic matter in these samples. Coal and coal stringers are common and liptinites are predominantly terrestrially derived. Macerals are dominated by inertinite but vitrinite and liptinite macerals are common. Lamalginite in sample 10C suggests a possible lacustrine influence in this sample.

The samples in Group A are therefore likely to contain dominantly higher plant derived organic matter deposited in an oxic terrestrial or lacustrine environment.

Group B comprises samples 1H, 4A, 7C, 14A, 15A, 17E and 21C. This group has low to moderately high pristane/phytane ratios (1.97 - 4.10, Table 16) suggesting that the precursor organic matter is likely to have been exposed to slightly oxic to oxic conditions prior to burial. Slightly oxic conditions may occur in shallow marine (paralic) or lacustrine environments of deposition.

Saturated biomarker distributions (Table 17, Figures 31-33, Appendix 3) of the Group B samples are characterised by higher abundances of algal/bacterial derived C_{27} sterane and diasterane homologues (m/z 217, 218, 259) relative to the higher plant derived C_{29} homologues. Diterpanes and labdanes (m/z 123) derived from higher plant resins, are generally less abundent in the Group B samples than in the Group A samples. Algal/bacterial derived tri and tetraterpanes (m/z 191) are generally more abundant than the Group A samples.

Organic petrology data shows that these samples contain predominantlyterrestrially derived liptinites along with significant proportions of lamalginite. Lamalginite is generally indicative of a source deposited in a lacustrine environment. This maceral is probably responsible for the algal component of the source organic matter in these samples. Phytoplankton, noted in sample 14A, may be derived from either fresh water or salt water environments. However, in conjunction with lamalginite it is probably a fresh water species.

The samples in Group B are therefore likely to contain a greater proportion of algal/bacterial derived organic matter deposited in an slightly oxic lacustrine or possibly near shore marine environment.

Group C comprises samples 5F, 8B and possibly 9A. The major distinguishing feature of this group is the presence of the hypersaline marker gammacerane (m/z 191, 412). Gammacerane is highly abundent in sample 5F while less so in samples 8B and 9A.

Pristane/phytane ratios are low for samples 5F and 9A (1.97 and 1.67 respectively, Table 16) while moderately high for sample 8B (4.63, Table 16). This suggests exposure of the precursor organic matter to anoxic conditions prior to burial for samples 5F and 9A and exposure to oxic conditions prior to burial for sample 8B.

Saturated biomarker distributions (Table 17, Figures 31-33, Appendix 3) of the Group C samples are somewhat variable. All three samples have significant abundances of the higher plant derived C_{29} sterane and diasterane homologues (varying in the order 8B>9A>5F) relative to algal/bacterial derived C_{27}

homologues . Diterpanes and labdanes are more abundent in samples 9A and particularly 8B than in sample 5F. Algal/bacterial derived tri and tetraterpanes (m/z 191) are less abundant than sample 8B than in the other two samples.

It is unclear whether the gammacerane is related to the oil or source component of these extracts. There was no evidence found in the organic petrology of the highly reducing conditions expected in a hypersaline environment. Thin section petrology would be necessary to identify any hypersaline minerals present. Given the variability of the source input of these Group C samples as discussed above it is more likely that the gammacerane is derived from the oil portion of these samples. Well locations and geological units would be very beneficial to more accurately determine the source of the gammacerane rich oil or source.

Bacterial input in the precursor organic matter is evident in all of these samples from the abundance of C_{15} drimanes (m/z 123) and C_{27}-C_{32} hopanes (m/z 191). The n-alkylcyclohexanes are probably derived from bacteria and are abundant in all samples.

Saturated biomarkers present (in approximate order of increasing abundance) are generally: drimanes(m/z 123); C_{27}-C_{29} steranes and diasteranes (m/z 217,259); C_{29+} hopanes (m/z 191); acyclic isoprenoids (m/z 183); and n-alkylcyclohexanes (m/z 83).

5. CONCLUSIONS

5.1 The vitrinite reflectance versus depth profiles indicate that the sedimentary sections intersected in these wells are sufficiently mature for oil and gas generation as listed in the table below.

Well No.	Depth for early oil generation (0.45%)	Depth for gas generation (0.55%)	Depth for late oil generation (0.70%)
1	800m	1450m	2400m
2	1400m	2000m	2500m
4	1900m	2200m	2700m
5	900m	1700-2300m	Insufficient Data
6	Insufficient Data	Insufficient Data	Insufficient Data
7	Insufficient Data	500-700m	1500-2500m
8	Insufficient Data	Insufficient Data	Insufficient Data
9	1100m	2400-2900m	Insufficient Data
10	1450m	1800m	2350m
14	1400m	2000m	3000m

15	1200m	1650m	2300m
16	Insufficient Data	Insufficient Data	Insufficient Data
17	2100m	2300m	2600m
20	Insufficient Data	1500-2000m	Insufficient Data
21	1400m	1600-2300m	Insufficient Data
22	750m	1100m	1600m

5.2 Rock-Eval T_{max} and Hydrogen Index data generally shows very similar maturity ranges to those indicated by the measured vitrinite reflectance data.

5.3 Rock-Eval production indices are also maturity dependent and generally show an increase with increasing depth. Production indices of >0.2 are generally indicative of the possible presence of migrated hydrocarbons. The following samples have reliable production indices of >0.2.

Sample	Production Index
1F	0.25
1H	0.26
4A	0.25
5C	0.29
5D	0.27
5E	0.25
7A	0.52
7B	0.28
7E	0.21
8A	0.30
8B	0.39
9B	0.41
10B	0.24
10D	0.23
14A	0.62
17D	0.21
21A	0.39
21B	0.35
21C	0.46
21D	0.28
21E	0.29
22A	0.28

5.4 A comparison of the aromatic maturity ratios with the measured vitrinite reflectance data indicates that several of the samples examined in this study are likely to contain a portion of hydrocarbons which were generated from a distant, more mature source. The remainder of the samples are likely to have been generated essentially in-situ.

In-Situ	Possibly Influenced by a Portion of Migrated Hydrocarbons
1H	1C
7C	4A
7E	5F
8B	9A
17E	14A
21C	15A
22B	
22C	

5.5 The maturity dependent saturated biomarker ratios generally show agreement with the maturities derived from the measured vitrinite reflectance values and the calculated aromatic data. However for several samples (1C, 5F, 9A, 14A and 15A) the extracted hydrocarbons appear to be largely source related with small components of migrated oil. Sample 4A may contain a more significant proportion of migrated hydrocarbons.

It is recommended that further geochemical analyses be performed on any nearby clean sands to more accurately characterise these migrated hydrocarbons free of source interferences. This would allow the extent to which the samples examined in this study have been influenced by the presence of migrated hydrocarbons to be determined.

5.6 Organic richness ranges from poor to excellent in the extracted samples studied (TOC = 0.04-24.47%). However, the majority of the samples examined have TOC values indicative of poor to fair organic richness.

Source richness also ranges from poor to excellent in these samples ($S_1 + S_2$ = 0.29-47.56 kg of hydrocarbons/tonne). Samples with the best source richness also have the best organic richness in the interval studied. The majority of the samples examined have $S_1 + S_2$ values indicative of poor to fair source richness.

5.7 Hydrogen Index and T_{max} values indicate that the samples examined contain organic matter which have bulk compositions ranging from that of Type II to Type IV kerogen.

5.8 Organic petrological analyses were performed on selected samples. Generally, the samples which contain the better quality Type II-III organic matter, contain higher proportions of liptinite. Liptinite contents in these samples range from 10-20% of the indigenous organic matter present.

The most abundant indigenous liptinites present are variable but are typically dominated by the terrestrially derived macerals, sporinite, cutinite and resinite. Fragmented liptinites (liptodetrinite) are very common and are often the most abundant maceral present. The presence of lamalginite is indicative of lacustrine facies whereas phytoplankton may be indicative of either lacustrine or marginal marine environments of depositine. The presence of bituminite and resinite is significant as these macerals are thermally labile and will generate liquid hydrocarbons at lower maturities (VR ≥0.45%) than other macerals (VR ≥0.7%).

5.9 In pyrolysis-GC analysis the ratio of mg of C_9+ normal alkanes and alkenes per gram of TOC assesses the effective source quality of these intervals. The proportion of C_{9+} normal alkanes and alkenes as percentage of the total pyrolysate is also dependent on source quality. These values suggest that samples 1F, 1H, 10D and 22C have excellent effective source quality.

Effective source richness for the generation of oil and condensate may be gauged from the yields of C_{9+} (oil) and C_6-C_8 (condensate) alkenes and alkenes (kg of hydrocarbons/tonne). Gas yields may be gauged from C_1-C_5 yields (kg of hydrocarbons/tonne). These ratios indicate that almost all of the samples have poor effective source richness for the generation of oil, condensate and gas. However, sample 22C has poor effective source richness for the generation of gas but good effective source richness for the generation of condensate and excellent effective source richness for the generation of oil.

5.10 The sixteen extracts studied have C_{12+} bulk compositions ranging from aromatic-asphaltic to paraffinic-naphthenic and naphthenic (Table 16; Figure 30).

5.11 The alkane distributions of the saturated hydrocarbons of many of the extracts suggests that many of the samples are mixtures containing a source component and an oil component. The likely derivation of each sample is given below.

Sample	Derivation
1C	Oil + Source
1H	Source
4A	Oil + Source
5F	Oil + Source
7C	Oil + Source
7E	Source
8B	Oil + Source
9A	Oil + Source
10C	Source
14A	Oil + Source
15A	Oil + Source
17E	Source
21C	Source
22B	Oil + Source

22C	Source
22E	Oil + Source

5.12 The samples can be broadly catagorised into three major and somewhat overlapping groups. However for samples where a component of migrated oil is likely to be present that the source affinity will reflect both this component as well as the source component.

Group A comprises samples 1C, 7E, 10C, 22B, 22C and 22E. These samples are likely to contain dominantly higher plant derived organic matter deposited in an oxic terrestrial or lacustrine environment.

Group B comprises samples 1H, 4A, 7C, 14A, 15A, 17E and 21C. These samples are likely to contain a greater proportion of algal/bacterial derived organic matter deposited in an slightly oxic lacustrine or possibly near shore marine environment.

Group C comprises samples 5F, 8B and possibly 9A. The major distinguishing feature of this group is the presence of the hypersaline marker gammacerane however it is unclear whether the gammacerane is related to the oil or source component of these extracts. As there was no evidence found in the organic petrology of the highly reducing conditions thin section petrology would be necessary to identify any hypersaline minerals present. Given the variability of the source input of these Group C samples it is more likely that the gammacerane is derived from the oil portion of these samples. Well locations and geological units would be very beneficial to more accurately determine the source of the gammacerane rich oil or source.

TABLE 1
SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS, OTWAY BASIN

Sample	Mean Maximum Reflectace (%)	Standard Deviation	Range	Number of Determinations
1a 700m	0.44	0.04	0.37-0.51	22
1d 2000m	0.60	0.04	0.55-0.68	18
1f 2250-53m	0.67	0.07	0.55-0.80	22
1g 2300m	0.65	0.03	0.58-0.68	12
1h 2358-61m	0.81	0.06	0.68-0.91	22
2b 1902-07m	0.46	0.03	0.41-0.52	24
2d 2716-19m	0.73	0.07	0.65-0.88	16
2e 2977-78m	0.85	0.02	0.81-0.88	9
4a 1965m	0.50	0.03	0.45-0.54	13
4f 3197-3200m	0.78	0.07	0.66-0.85	8
5e 1395m	0.46	0.03	0.40-0.50	12
5f 2080m	0.49	0.04	0.44-0.58	14
6a 530m	0.41	0.03	0.36-0.46	19
7b 1100m	0.61	0.01	0.59-0.62	2
7c 1325m	0.70	0.06	0.60-0.82	12
7e 2525m	0.66	0.04	0.59-0.76	17
8a 505m	0.39	0.03	0.33-0.45	32
8b 853m	0.39	0.02	0.35-0.42	22
9a 600m	0.34	0.02	0.29-0.38	31
9b 1100m	0.45	0.01	0.43-0.48	7
10b 2250m	0.72	0.04	0.67-0.78	5
10c 2750m	0.81	0.07	0.71-0.96	38
10d 2975m	0.82	0.01	0.81-0.83	5
14a 1400m	0.45	0.03	0.41-0.50	9
14c 1800m	0.46	0.02	0.43-0.49	15
14d 1815m	0.54	0.04	0.45-0.60	15
14f 2550m	0.63	0.05	0.52-0.70	18

15b 1161-67m	0.42	0.02	0.40-0.44	5
15d 1645-52m	0.60*	0.02	0.57-0.62	2
15f 2194-98m	0.61	0.05	0.49-0.71	44
16b 1100m	2.32**	0.18	2.16-2.62	4
17c 2742m	0.85	0.05	0.75-0.93	31
17d 3001m	0.91	0.05	0.78-1.01	24
17e 3513m	1.27	0.03	1.21-1.31	15
20a 1880m	0.58	0.04	0.50-0.66	24
21b 1135m	0.39	0.03	0.35-0.45	14
21d 1795	0.43	0.03	0.36-0.48	26
21e 1840m	0.60	0.04	0.55-0.69	9
22a 731m	0.45	0.03	0.39-0.53	15
22c 1127m	0.60	0.05	0.48-0.68	36
22d 1280m	0.55	0.06	0.48-0.69	14
22f 1517m	0.64	0.06	0.57-0.73	4

* Possibly influenced by reworked vitrinite.
** Limited by paucity of vitrinite. Needs to be checked with other available maturity data.

TABLE 2

MACERAL GROUP PROPORTIONS

Sample/Depth (m)	Percentage of		
	Vitrinite	Inertinite	Liptinite
1a. 700	10	85	5
1d. 2000	5	90	5
1f. 2250-53	10-15	80-85	5
1g. 2300	5	90	<5
1h. 2358-61	5-10	90	<5
2b. 1902-07	20	65-70	10-15
2d. 2716-19	5	90	5
2e. 2977-78	<5	90	<5
4a. 1965	<5	90	<5
4f. 3197-00	5	90	<5
5e. 1395	<5	90	5
5f. 2080	5	90	5
6a. 530	5	90	<5
7b. 1100	10	85	5
7c. 1325	5	85-90	5-10
7e. 2525	5-10	85-90	5
8a. 505	10-15	80	5-10
8b. 853	5-10	80-85	10
9a. 600	10	75-80	10-15
9b. 1100	5	80-85	10-15
10b. 2250	5-10	80	10-15
10c. 2750	5-10	80	10-15
10d. 2975	5-10	80	10-15

14a. 1400	5-10	85	5-10
14c. 1800	10-15	80	5-10
14d. 1815	5-10	75	15-20
14f. 2550	5-10	80	10-15
15b. 1161-67	5-10	80	10-15
15d. 1645-52	<5	85	10-15
15f. 2194-98	25-30	65	5-10
16b. 1100	<5	90	5-10
17c. 2742	20-25	75	5-10
17d. 3001	5-10	85	5-10
17e. 3513	5	90	5
20a. 1880	5-10	80-85	<5
21b. 1135	5	90	5
21d. 1795	5-10	85-90	5
21e. 1840	10-15	80-85	5
22a. 731	5-10	85-90	5
22c. 1127	65	20-25	10-15
22d. 1280	<5	90	5-10
22f. 1517	5-10	80	10-15

TABLE 3

ORGANIC MATTER TYPE AND ABUNDANCE

Sample/Depth (m)	Relative Maceral Group Proportions	Estimated Volume of		Exinite Macerals
		DOM (%)	Liptinite	
1a. 700	I>V>L	0.5-1	Ra	Lipto, spo, cut, lama, bmite
1d. 2000	I>V=L	<0.5	Ra	Lipto, spo, cut
1f. 2250-53	I>V>L	3-5	Ra	Lipto, cut, res
1g. 2300	I>V>L	1-2	Ra	Lipto, cut
1h. 2358-61	I>V>L	2-3	Ra	Lipto, cut, bmite
2b. 1902-07	I>V>L	1-2	Ra	Cut, lipto, spo, res
2d. 2716-19	I>V=L	~1	Ra	Cut, lipto
2e. 2977-78	I>V=L	<0.5	Ra	Lipto, cut
4a. 1965	I>V=L	1-2	Ra-Vr	Lipto, spo, lama, cut
4f. 3197-00	I>V>L	0.5-1	Vr	Lipto
5e. 1395	I>L>V	0.5-1	Vr	Lama, lipto
5f. 2080	I>V=L	0.5-1	Ra	Spo, lipto, bmite
6a. 530	I>V>L	0.5-1	Ra-Vr	Lipto, spo, res
7b. 1100	I>V>L	0.5-1	Ra	Cut, lipto, spo, res
7c. 1325	I>L>V	~1	Ra	Spo, lama, cut
7e. 2525	I>V>L	<0.5	Ra-Vr	Lipto, bmite
8a. 505	I>V>L	~1	Ra	Spo, lama, lipto, cut, phyto
8b. 853	I>L>V	<0.5	Ra	Spo, lipto, cut, phyto
9a. 600	I>L>V	0.5-1	Ra	Cut, lipto, spo lama, phyto
9b. 1100	I>L>V	0.5-1	Ra	Lipto, cut, phyto,spo, lama, bmite
10b. 2250	I>L>V	~0.5	Ra	Lipto, spo, cut, lama

10c. 2750	I>L>V	2-3	Ra	Bmite, lipto, lama, spo, cut
10d. 2975	I>L>V	~0.5	Ra	Lama, lipto, spo, cut, bmite, phyto
14a. 1400	I>V=L	1-2	Ra	Phyto, lipto, spo, res lama, bmite
14c. 1800	I>V>L	1-2	Ra	Lipto, cut, phyto, spo, lama
14d. 1815	I>L>V	2-3	Ra	Bmite, lipto, cut, phyto, lama, res
14f. 2550	I>L>V	2-3	Sp-Ra	Cut, lipto, spo, lama, bmite, res, sub
15b. 1161-67	I>L>V	0.5-1	Ra	Cut, lama, lipto, spo, phyto
15d. 1645-52	I>L>V	<0.5	Ra	Lama, lipto, cut, phyto
15f. 2194-98	I>V>L	3-5	Ra	Cut, res, lipto, spo
16b. 1100	I>L>V	<0.5	Ra-Vr	Lipto, cut, lama
17c. 2742	I>V>L	2-3	Ra	Spo, bmite, lipto, cut
17d. 3001	I>V=L	1-2	Ra	Lipto, cut, phyto, spo res
17e. 3513	I>V=L	0.5-1	Ra	Lipto
20a. 1880	I>V>L	<0.5	Ra-Vr	Lipto, spo, res
21b. 1135	I>V=L	0.5-1	Ra-Vr	Phyto, lipto, spo
21d. 1795	I>V>L	0.5-1	Ra-Vr	Lipto, spo, phyto
21e. 1840	I>V>L	0.5-1	Ra	Lipto, phyto, lama, cut, res
22a. 731	I>V>L	0.5-1	Ra	Lipto, phyto, spo, cut
22c. 1127	V>I>L	20-30	Sp	Spo, cut, lipto, res, sub, bmite
22d. 1280	I>L>V	1-2	Ra	Spo, lipto, cut
22f. 1577	I>L>V	0.5-1	Ra	Lipto, spo, cut, res

TABLE 4

LIPTINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS

Sample/Depth (m)	**Liptinite Macerals**	**Lithology/Comments**
1a. 700	Lipto(Ra;miY-mO), spo(Ra;mY-mO), cut(Ra-Vr;mO-dO), lama(Vr;mO), bmite(Vr;mO-dO)	Shale; most liptinite is oxidised
1d. 2000	Lipto(Ra;mO-dO), spo(Ra-Vr;mO-dO), cut(Vr;mO-dO)	Chiefly sandstone, ~20% shale; most liptinite is oxidised
1f. 2250-53	Lipto(Ra;mO-dO), cut(Vr;dO), res(Vr;mO)	Silty shale; most liptinite is oxidised
1g. 2300	Lipto(Ra;dO-B), cut(Vr;dO-B)	Silty shale; most liptinite is oxidised
1h. 2358-61	Lipto(Ra-Vr;dO-B), cut(Vr;dO), bmite(Vr;dO-B)	Silty shale; most liptinite is oxidised
2b. 1902-07	Cut(Ra;mO-dO), lipto(Ra;mO-dO), spo,(Vr;mY-mO), res(Vr;mY-mO)	Chiefly sandstone, 10-20% siltstone; liptinite is oxidised
2d. 2716-19	Cut(Ra-Vr;mO-dO), lipto(Ra-Vr;dO)	Shale; most liptinite is oxidised
2e. 2977-78	Lipto(Ra;dO-B), cut(Vr;dO)	Siltstone; most liptinite is oxidised
4a. 1965	Lipto(Ra-Vr;mO), spo(Vr;mY-mO), lama(Vr;mO), cut(Vr;mO)	Shale
4f. 3197-00	Lipto(Vr;mO-dO)	Chiefly sandstone, ~10-20% siltstone
5e. 1395	Lama(Vr;mY-mO-dO), lipto(Vr;mO-dO)	Shale; some liptinite is oxidised
5f. 2080	Spo(Ra;mO-dO), lipto(Ra-Vr;dO), bmite(Vr;dO)	Shale; liptinite is oxidised

6a. 530	Lipto(Ra-Vr;mY-mO), spo(Vr;dO), res(Vr;dO)	Chiefly shale, ~20% sandstone; some liptinite is oxidised
7b. 1100	Cut(Ra;mO-dO), lipto(Ra;mO-dO), spo(Vr;mO-dO), res(Vr;mO-dO)	Chiefly shale, ~30% sandstone; a large portion of the DOM is present in caved shale cuttings
7c. 1325	Spo(Ra-Vr;mO), lama(Ra-Vr;mO), cut(Vr;mO)	Silty shale
7e. 2525	Lipto(Ra-Vr;mO-dO), bmite(Vr;dO)	Chiefly sandstone, ~20% siltstone + shale; most liptinite is oxidised
8a. 505	Spo(Ra-Vr;mO-dO), lama(Ra-Vr;mY-mO), lipto(Ra-Vr;mO-dO), cut(Vr;mO), phyto(Vr;mY)	Shale; some liptinite is oxidised
8b. 853	Spo(Ra;mY-mO), lipto(Ra;mY-mO), cut(Ra-Vr;mO), phyto(Ra-Vr;mO)	Siltstone
9a. 600	Cut(Ra;mO), lipto(Ra;mY-mO-dO), spo(Ra-Vr;mO), lama(Ra-Vr;mY-mO-dO), ?phyto(Vr;mO)	Siltstone; some liptinite is oxidised
9b. 1100	Lipto(Ra;mY-mO), cut(Ra-Vr;mY-mO), ?phyto(Ra-Vr;iY), spo(Vr;mO), lama(Vr;mO-dO), bmite(Vr;dO)	Chiefly siltstone, 10-20% sandstone; liptinite is oxidised
10b. 2250	Lipto(Ra;mO-dO), spo(Ra-Vr;mO-dO), cut(Ra-Vr;mO-dO), lama(Ra-Vr;dO)	Shale; liptinite is oxidised
10c. 2750	Bmite(Ra;mO-dO), lipto(Ra;mO-dO), lama(Ra-Vr;dO), spo(Vr;dO), cut(Vr;dO)	silty shale with coal stringers; liptinite is oxidised
10d. 2975	Lama(Ra;mO-dO), lipto(Ra;dO), spo(Ra-Vr;mO), cut(Ra-Vr;mO), bmite(Ra-Vr;dO), ?phyto(Vr;mO)	Siltstone; liptinite is oxidised
14a. 1400	Phyto(Ra-Vr;mY-mO), lipto(Ra-Vr;dO), spo(Vr;dO-dB), res(Vr;mO-dO), lama(Vr;mO), bmite(Vr;dO-dB)	Shale with minor glaucony; most liptinite is oxidised

14c. 1800	Lipto(Ra;mY-mO-dO), cut(Ra-Vr;mO-dO), phyto(Ra-Vr;mY), spo(Vr;mO), lama(Vr;mO)	Shale; some liptinite is oxidised
14d. 1815	Bmite(Ra;dO), lipto(Ra;mY-mO-dO), cut(Ra-Vr;mO-dO), ?phyto(Ra-Vr;mO), lama(Ra-Vr;mY-mO), res(Vr;mY-mO)	Shale; liptinite is oxidised
14f. 2550	Cut(Ra;mO-dO-B), lipto(Ra;mO-dO), spo(Ra-Vr;mO-dO), lama(Ra-Vr;dO-B), bmite(Ra-Vr;dO), res(Vr;iY), sub(Vr;B)	Chiefly shale, 5% sandstone, <5% coal; most liptinite is oxidised
15b. 1161-67	Cut(Ra;mO-dO), lama(Ra;mO-dO), lipto(Ra;mO), spo(Ra-Vr;mO-dO), ?phyto(Vr;mY)	Siltstone; some liptinite is oxidised
15d. 1645-52	Lama(Ra;mO-dO), lipto(Ra;mO-dO), cut(Ra-Vr;mO-dO), ?phyto(Ra-Vr;mY)	Chiefly shale, 10-20% sandstone; liptinite is oxidised
15f. 2194-98	Cut(Ra;mO-dO),res(Ra;mY-mO-dO), lipto(Ra;mO-dO),spo(Ra-Vr;mO-dO)	Siltstone with coal stringers; liptinite is oxidised
16b. 1100	Lipto(Ra-Vr; mO-dO), cut(Vr;dO), lama(Vr;dO)	Chiefly sandstone, 10-20% siltstone; liptinite is oxidised
17c. 2742	Spo(Ra;dO), bmite(Ra;dO-B), lipto(Ra;mO-dO), cut(Ra-Vr;mO-dO)	Chiefly siltstone, <5% coal; liptinite is oxidised
17d. 3001	Lipto(Ra;mY-mO), cut(Ra-Vr;dO), ?phyto(Ra-Vr;mY-mO), spo(Vr;dO), res(Tr;dO)	Silty shale; most liptinite is oxidised
17e. 3513	Lipto(Ra;mO-dO-B)	Silty shale; most liptinite is oxidised
20a. 1880	Lipto(Ra-Vr;mO), spo(Ra-Vr;mY-mO), res(Tr;mO)	Chiefly sandstone, 10-20% siltstone + shale
21b. 1135	Phyto(Ra-Vr;mY-mO), lipto(Ra-Vr;mY-mO-dO), spo(Vr;mO)	Shale; some liptinite is oxidised
21d. 1795	Lipto(Ra-Vr;mO-dO), spo(Vr;dO), ?phyto(Vr;mO-dO)	Silty shale; most liptinite is oxidised
21e. 1840	Lipto(Ra;mY-mO-dO), ?phyto(Ra-Vr;mO), ?lama(Ra-Vr;mO), cut(Vr;dO), res(Tr;mO)	shale with minor glaucony; some liptinite is oxidised

22a. 731	Lipto(Ra;mY-mO), phyto(Ra-Vr;iY-mO-dO), spo(Vr;mO-dO), cut(Vr;dO)	Shale; most liptinite is oxidised
22c. 1127	Spo(Sp;mO-dO), cut(Sp-Ra;mY-mO), lipto(Sp-Ra;mO), res(Ra-Vr;mY-mO), sub(Ra-Vr;dO-B), bmite(Ra-Vr;B)	Chiefly siltstone, 20-30% carbonaceous shale, 10-20% coal; some liptinite is oxidised
22d. 1280	Spo(Ra;mO-dO), lipto(Ra;mO-dO), cut(Vr;mO-dO)	Siltstone; most liptinite is oxidised
22f. 1577	Lipto(Ra;mY-mO-dO), spo(Ra-Vr;mY-mO), cut(Ra-Vr;mY-mO), res(Vr;mY)	Chiefly shale, 10-20% sandstone; most liptinite is oxidised

TABLE 5

Amdel Petroleum Services

Rock – Eval Pyrolysis

09/06/94

Client: *Victorian Department of Energy and Minerals*

Study Area: *Otway Basin*

Sample	T Max	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
1A	412	0.11	0.66	0.94	0.77	0.14	0.70	0.06	0.84	78	112
1B	421	0.13	0.47	0.53	0.60	0.22	0.88	0.05	0.64	73	83
1C	437	0.16	1.25	0.33	1.41	0.11	3.83	0.11	0.71	176	46
1D	441	0.16	0.54	0.21	0.70	0.23	2.56	0.05	0.44	122	48
1E									0.14		
1F	442	2.27	6.99	1.81	9.26	0.25	3.85	0.77	4.03	173	45
1G	441	0.26	1.33	0.58	1.59	0.16	2.28	0.13	1.08	123	54
1H	446	1.40	4.07	1.50	5.47	0.26	2.71	0.45	2.89	140	52
2A									0.28		
2B	436	0.10	0.72	0.76	0.82	0.12	0.94	0.06	1.09	66	70
2C	438	0.07	0.88	0.76	0.95	0.07	1.16	0.07	1.05	83	72
2D	445	0.16	1.07	0.43	1.23	0.13	2.47	0.10	0.92	116	47
2E	426	0.10	0.19	0.46	0.29	0.34	0.41	0.02	0.49	38	94
2F									0.14		
4A	422	0.35	1.07	1.32	1.42	0.25	0.81	0.11	1.48	72	89
4B									0.09		
4C									0.19		
4D									0.14		
4E									0.11		
4F	440	0.13	0.51	0.51	0.64	0.20	1.00	0.05	0.67	76	76
4G									0.19		
4H									0.32		
5A									0.19		
5B									0.19		
5C	365	0.62	1.52	0.60	2.14	0.29	2.55	0.17	0.84	180	71
5D	420	0.66	1.80	0.53	2.46	0.27	3.39	0.20	0.83	216	64
5E	418	0.28	0.82	0.72	1.10	0.25	1.14	0.09	0.87	94	83
5F	315	0.30	0.15	0.46	0.45	0.67	0.33	0.08	0.62	120	74
6A	278	0.18	0.22	0.67	0.40	0.45	0.33	0.06	0.74	83	91
7A	347	0.27	0.25	0.71	0.52	0.52	0.35	0.07	0.86	75	82
7B	418	0.36	0.94	0.48	1.30	0.28	1.98	0.10	0.66	142	72
7C	415	0.49	1.95	0.84	2.44	0.20	2.31	0.20	1.04	187	81
7D									0.11		
7E	429	0.21	0.80	0.30	1.01	0.21	2.68	0.08	0.42	190	71
8A	428	0.42	0.99	0.86	1.41	0.30	1.16	0.11	1.07	92	80
8B	385	0.34	0.54	0.28	0.88	0.39	1.94	0.07	0.41	131	68
8C									0.10		
8D									0.18		
9A	334	0.36	0.13	0.69	0.49	0.73	0.19	0.08	0.82	81	84
9B	418	0.32	0.46	0.58	0.78	0.41	0.80	0.09	0.79	102	73
10A	303	0.19	0.18	0.79	0.37	0.51	0.23	0.07	0.85	84	93
10B	420	0.25	0.78	0.48	1.03	0.24	1.64	0.08	0.58	134	82
10C	445	0.90	4.15	1.28	5.05	0.18	3.24	0.42	2.51	165	51
10D	449	0.29	0.96	0.24	1.25	0.23	4.07	0.10	0.59	162	40
10E									0.25		
14A	418	0.34	0.21	0.90	0.55	0.62	0.23	0.08	1.10	63	82
14B	335	0.14	0.11	1.03	0.25	0.56	0.11	0.07	1.31	54	79
14C	428	0.30	1.38	0.87	1.68	0.18	1.59	0.14	1.22	113	71
14D	419	0.39	2.78	1.65	3.17	0.12	1.68	0.26	2.50	111	66
14E	416	0.18	0.80	0.78	0.98	0.18	1.03	0.08	0.83	96	94
14F	437	0.37	3.15	2.10	3.52	0.11	1.50	0.29	2.44	129	86
15A	409	0.16	0.39	0.99	0.55	0.29	0.40	0.04	0.85	45	116
15B	415	0.09	0.42	0.59	0.51	0.18	0.71	0.04	0.58	72	102
15C	416	0.06	0.29	0.42	0.35	0.17	0.69	0.02	0.39	74	108
15D	426	0.08	0.36	0.29	0.44	0.18	1.23	0.03	0.40	90	73
15E									0.07		
15F	427	1.37	5.56	3.09	6.93	0.20	1.80	0.57	4.54	122	68
15G									0.04		
16A									0.12		
16B									0.14		
16C									0.16		
17A	397	0.09	0.24	0.37	0.33	0.27	0.64	0.02	0.39	61	96
17B	441	0.14	0.84	0.85	0.98	0.14	0.99	0.08	1.09	77	78
17C	445	0.39	2.40	1.26	2.79	0.14	1.90	0.23	2.43	98	52
17D	450	0.46	1.71	0.78	2.17	0.21	2.19	0.18	1.63	104	48
17E	401	0.24	0.05	0.20	0.29	0.83	0.26	0.02	0.70	7	28
20A									0.38		
21A	411	0.44	0.70	0.62	1.14	0.39	1.12	0.09	0.71	98	88
21B	415	0.45	0.82	0.59	1.27	0.35	1.38	0.10	0.76	107	78
21C	419	0.29	0.34	0.37	0.63	0.46	0.92	0.05	0.43	79	86
21D	428	0.28	0.71	0.44	0.99	0.28	1.63	0.08	0.67	105	65
21E	435	0.33	0.80	0.58	1.13	0.29	1.37	0.09	0.91	87	64
22A	422	0.35	0.89	0.73	1.24	0.28	1.22	0.10	0.96	92	76
22B	434	0.16	1.25	0.50	1.41	0.11	2.50	0.11	0.96	130	52
22C	431	2.81	44.75	13.95	47.56	0.06	3.21	3.96	24.47	182	57
22D	435	0.31	2.01	0.75	2.32	0.13	2.68	0.19	1.53	131	49
22E	445	0.13	0.33	0.27	0.46	0.28	1.21	0.03	0.57	57	48
22F	432	0.19	0.56	0.46	0.75	0.25	1.21	0.06	0.67	83	69

TABLE 6

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 1C
1650–1652m

Report # LQ2852

Component	Weight%	Mol%
C1–C4	5.26	20.89
C5	0.34	1.07
C–6	0.56	1.50
BENZENE	0.20	0.58
C–7	0.56	1.29
TOLUENE	0.37	0.93
C–8	0.90	1.81
ETHYLBZ+XYLENES	0.88	1.90
C–9	1.79	3.22
C–10	1.01	1.63
C–11	1.57	2.31
C–12	1.23	1.67
C–13	1.23	1.54
C–14	1.34	1.56
C–15	1.68	1.82
C–16	2.24	2.28
C–17	2.80	2.69
C–18	3.36	3.04
C–19	3.70	3.17
C–20	4.48	3.66
C–21	5.15	4.01
C–22	4.59	3.41
C–23	5.26	3.74
C–24	5.38	3.66
C–25	5.86	3.83
C–26	6.50	4.09
C–27	6.61	4.00
C–28+	25.15	14.69
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1–C4	5.26	20.89
BENZENE/HEXANES	0.35	0.39
TOLUENE/HEPTANES	0.67	0.72
BZ+TOL+EBZ+XYL	1.45	3.42
C25+(Waxes)	44.11	26.61

C5–C8 Alkanes + Alkenes / S2	0.95 %
C9+ Alkanes + Alkenes / S2	6.01 %
C15+ Alkanes + Alkenes / S2	3.80 %
Average molecular weight of whole oil (calc)	230.57 g/mol
Average molecular weight of C8+ fraction (calc)	287.42 g/mol

TABLE 7

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 1F
2250–2253m

Report # LQ2852

Component	Weight%	Mol%
C1–C4	16.44	40.66
C5	7.96	15.86
C–6	1.47	2.45
BENZENE	0.19	0.35
C–7	1.26	1.80
TOLUENE	0.50	0.79
C–8	0.84	1.05
ETHYLBZ+XYLENES	0.58	0.78
C–9	1.05	1.17
C–10	1.05	1.06
C–11	1.99	1.83
C–12	1.99	1.68
C–13	2.09	1.63
C–14	2.09	1.52
C–15	2.41	1.63
C–16	2.20	1.40
C–17	2.30	1.38
C–18	2.72	1.54
C–19	3.25	1.74
C–20	4.08	2.08
C–21	3.66	1.78
C–22	4.19	1.94
C–23	3.66	1.62
C–24	4.29	1.82
C–25	3.66	1.49
C–26	4.82	1.89
C–27	3.66	1.38
C–28+	15.60	5.68
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1–C4	16.44	40.66
BENZENE/HEXANES	0.13	0.14
TOLUENE/HEPTANES	0.40	0.44
BZ+TOL+EBZ+XYL	1.27	1.92
C25+(Waxes)	27.74	10.45

C5–C8 Alkanes + Alkenes / S2	2.13 %
C9+ Alkanes + Alkenes / S2	5.14 %
C15+ Alkanes + Alkenes / S2	2.82 %
Average molecular weight of whole oil (calc)	143.79 g/mol
Average molecular weight of C8+ fraction (calc)	268.85 g/mol

TABLE 8

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 1H
2358–2361m

Report # LQ2852

Component	Weight%	Mol%
C1–C4	5.78	19.63
C5	0.31	0.85
C–6	0.72	1.66
BENZENE	0.08	0.20
C–7	1.03	2.03
TOLUENE	0.35	0.76
C–8	1.13	1.96
ETHYLBZ+XYLENES	0.74	1.38
C–9	1.03	1.59
C–10	3.09	4.30
C–11	3.92	4.95
C–12	4.33	5.02
C–13	4.23	4.53
C–14	4.23	4.21
C–15	4.85	4.51
C–16	5.26	4.59
C–17	4.85	3.98
C–18	5.36	4.16
C–19	5.16	3.79
C–20	5.67	3.97
C–21	5.47	3.64
C–22	4.95	3.15
C–23	4.85	2.95
C–24	4.85	2.83
C–25	4.23	2.37
C–26	4.33	2.33
C–27	2.89	1.50
C–28+	6.29	3.15
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1–C4	5.78	19.63
BENZENE/HEXANES	0.11	0.12
TOLUENE/HEPTANES	0.34	0.37
BZ+TOL+EBZ+XYL	1.17	2.33
C25+(Waxes)	17.74	9.35

C6–C8 Alkanes + Alkenes / S2	1.16 %
C9+ Alkanes + Alkenes / S2	9.62 %
C15+ Alkanes + Alkenes / S2	5.45 %
Average molecular weight of whole oil (calc)	197.54 g/mol
Average molecular weight of C8+ fraction (calc)	240.50 g/mol

TABLE 9

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 5D Report # LQ2852
1375m

Component	Weight%	Mol%
C1-C4	10.07	31.99
C5	1.05	2.70
C-6	1.64	3.51
BENZENE	0.27	0.63
C-7	1.17	2.16
TOLUENE	0.43	0.85
C-8	1.00	1.61
ETHYLBZ+XYLENES	0.61	1.06
C-9	1.05	1.52
C-10	1.99	2.58
C-11	2.81	3.32
C-12	2.22	2.41
C-13	2.11	2.11
C-14	2.34	2.18
C-15	2.69	2.34
C-16	2.93	2.39
C-17	2.81	2.16
C-18	3.28	2.38
C-19	3.40	2.34
C-20	4.22	2.75
C-21	4.57	2.84
C-22	3.98	2.37
C-23	4.92	2.80
C-24	4.57	2.49
C-25	6.33	3.32
C-26	5.74	2.89
C-27	6.21	3.01
C-28+	15.61	7.30
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	10.07	31.99
BENZENE/HEXANES	0.16	0.18
TOLUENE/HEPTANES	0.36	0.39
BZ+TOL+EBZ+XYL	1.30	2.54
C25+(Waxes)	33.89	16.52

C6-C8 Alkanes + Alkenes / S2	1.64 %
C9+ Alkanes + Alkenes / S2	5.50 %
C15+ Alkanes + Alkenes / S2	3.36 %
Average molecular weight of whole oil (calc)	184.65 g/mol
Average molecular weight of C8+ fraction (calc)	268.47 g/mol

TABLE 10

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 7C
1325m

Report # LQ2852

Component	Weight%	Mol%
C1-C4	7.55	25.58
C5	0.67	1.82
C-6	1.11	2.54
BENZENE	0.20	0.51
C-7	1.00	1.96
TOLUENE	0.36	0.78
C-8	0.83	1.44
ETHYLBZ+XYLENES	0.33	0.62
C-9	0.68	1.04
C-10	3.40	4.70
C-11	3.97	4.99
C-12	3.33	3.85
C-13	3.44	3.68
C-14	4.44	4.41
C-15	2.44	2.26
C-16	3.00	2.61
C-17	2.44	2.00
C-18	2.89	2.23
C-19	3.00	2.20
C-20	4.11	2.86
C-21	3.78	2.51
C-22	4.00	2.53
C-23	4.89	2.96
C-24	4.78	2.78
C-25	4.11	2.29
C-26	4.21	2.26
C-27	5.22	2.70
C-28+	19.82	9.88
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	7.55	25.58
BENZENE/HEXANES	0.18	0.20
TOLUENE/HEPTANES	0.36	0.40
BZ+TOL+EBZ+XYL	0.90	1.90
C25+(Waxes)	33.36	17.13

C6-C8 Alkanes + Alkenes / S2	0.99 %
C9+ Alkanes + Alkenes / S2	3.78 %
C15+ Alkanes + Alkenes / S2	1.97 %
Average molecular weight of whole oil (calc)	196.86 g/mol
Average molecular weight of C8+ fraction (calc)	260.59 g/mol

TABLE 11

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 7E
2525m

Report # LQ2852

Component	Weight%	Mol%
C1-C4	9.08	30.81
C5	0.71	1.95
C-6	1.22	2.80
BENZENE	0.17	0.44
C-7	1.07	2.11
TOLUENE	0.65	1.40
C-8	0.61	1.06
ETHYLBZ+XYLENES	0.57	1.06
C-9	0.71	1.10
C-10	1.73	2.40
C-11	1.94	2.45
C-12	2.04	2.36
C-13	2.14	2.29
C-14	3.98	3.95
C-15	2.35	2.18
C-16	2.55	2.22
C-17	2.14	1.76
C-18	2.75	2.13
C-19	2.86	2.10
C-20	3.78	2.63
C-21	3.78	2.51
C-22	3.78	2.40
C-23	3.78	2.29
C-24	4.08	2.38
C-25	2.96	1.65
C-26	5.20	2.80
C-27	6.12	3.17
C-28+	27.23	13.60
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	9.08	30.81
BENZENE/HEXANES	0.14	0.16
TOLUENE/HEPTANES	0.61	0.66
BZ+TOL+EBZ+XYL	1.40	2.90
C25+(Waxes)	41.52	21.22

C6-C8 Alkanes + Alkenes / S2	1.38 %
C9+ Alkanes + Alkenes / S2	3.24 %
C15+ Alkanes + Alkenes / S2	1.80 %
Average molecular weight of whole oil (calc)	197.18 g/mol
Average molecular weight of C8+ fraction (calc)	279.51 g/mol

TABLE 12

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 10C
2750m

Report # LQ2852

Component	Weight%	Mol%
C1-C4	16.91	42.76
C5	1.86	3.78
C-6	2.93	5.00
BENZENE	0.23	0.42
C-7	2.44	3.58
TOLUENE	0.46	0.73
C-8	1.95	2.52
ETHYLBZ+XYLENES	0.40	0.55
C-9	1.86	2.13
C-10	2.55	2.63
C-11	3.32	3.12
C-12	3.13	2.70
C-13	2.74	2.18
C-14	2.54	1.88
C-15	2.44	1.69
C-16	2.35	1.52
C-17	2.35	1.43
C-18	2.64	1.52
C-19	2.64	1.44
C-20	3.23	1.68
C-21	3.03	1.50
C-22	2.93	1.39
C-23	3.23	1.46
C-24	3.23	1.40
C-25	3.32	1.38
C-26	3.71	1.49
C-27	3.62	1.40
C-28+	17.98	6.70
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	16.91	42.76
BENZENE/HEXANES	0.08	0.08
TOLUENE/HEPTANES	0.19	0.20
BZ+TOL+EBZ+XYL	1.08	1.71
C25+(Waxes)	28.64	10.96

C6-C8 Alkanes + Alkenes / S2	1.53 %
C9+ Alkanes + Alkenes / S2	4.76 %
C15+ Alkanes + Alkenes / S2	2.69 %
Average molecular weight of whole oil (calc)	146.97 g/mol
Average molecular weight of C8+ fraction (calc)	250.07 g/mol

TABLE 13

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 10D 2975m Report # LQ2852

Component	Weight%	Mol%
C1-C4	13.97	38.06
C5	1.27	2.79
C-6	1.59	2.92
BENZENE	0.19	0.39
C-7	1.80	2.84
TOLUENE	0.50	0.86
C-8	1.34	1.86
ETHYLBZ+XYLENES	0.70	1.04
C-9	1.09	1.35
C-10	2.12	2.36
C-11	3.49	3.54
C-12	3.39	3.15
C-13	3.49	3.00
C-14	3.49	2.79
C-15	4.02	3.00
C-16	4.13	2.89
C-17	3.81	2.51
C-18	4.44	2.77
C-19	4.23	2.50
C-20	4.66	2.61
C-21	4.97	2.66
C-22	4.55	2.32
C-23	4.34	2.12
C-24	4.44	2.08
C-25	4.44	2.00
C-26	4.66	2.01
C-27	3.91	1.63
C-28+	4.97	2.00
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	13.97	38.06
BENZENE/HEXANES	0.12	0.13
TOLUENE/HEPTANES	0.28	0.30
BZ+TOL+EBZ+XYL	1.39	2.29
C25+(Waxes)	17.99	7.63

C6-C8 Alkanes + Alkenes / S2	2.17 %
C9+ Alkanes + Alkenes / S2	11.22 %
C15+ Alkanes + Alkenes / S2	6.72 %
Average molecular weight of whole oil (calc)	158.39 g/mol
Average molecular weight of C8+ fraction (calc)	242.62 g/mol

TABLE 14

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 22B
1066m

Report # LQ2852

Component	Weight%	Mol%
C1-C4	12.14	36.58
C5	1.06	2.57
C-6	1.53	3.11
BENZENE	0.22	0.48
C-7	0.94	1.65
TOLUENE	0.37	0.71
C-8	1.06	1.63
ETHYLBZ+XYLENES	0.41	0.68
C-9	0.57	0.77
C-10	2.12	2.61
C-11	3.06	3.43
C-12	2.24	2.30
C-13	2.59	2.46
C-14	2.48	2.19
C-15	2.95	2.43
C-16	3.42	2.64
C-17	3.18	2.32
C-18	3.65	2.51
C-19	4.01	2.61
C-20	4.24	2.63
C-21	4.48	2.64
C-22	4.24	2.39
C-23	4.48	2.42
C-24	4.72	2.44
C-25	5.19	2.58
C-26	5.30	2.53
C-27	5.66	2.60
C-28+	13.67	6.07
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	12.14	36.58
BENZENE/HEXANES	0.14	0.15
TOLUENE/HEPTANES	0.40	0.43
BZ+TOL+EBZ+XYL	1.00	1.87
C25+(Waxes)	29.82	13.78

C6-C8 Alkanes + Alkenes / S2	1.13 %
C9+ Alkanes + Alkenes / S2	5.61 %
C15+ Alkanes + Alkenes / S2	3.42 %
Average molecular weight of whole oil (calc)	175.11 g/mol
Average molecular weight of C8+ fraction (calc)	264.88 g/mol

TABLE 15

AMDEL PETROLEUM SERVICES PYROLYSIS GC ANALYSIS

Client: VICTORIAN DEPT OF ENERGY AND MINERALS

Sample: SAMPLE 22C
1127m

Report # LQ2852

Component	Weight%	Mol%
C1-C4	5.28	22.53
C5	0.46	1.58
C-6	0.54	1.54
BENZENE	0.06	0.18
C-7	0.42	1.04
TOLUENE	0.14	0.38
C-8	0.45	0.97
ETHYLBZ+XYLENES	0.23	0.53
C-9	0.33	0.64
C-10	0.92	1.60
C-11	1.53	2.43
C-12	1.57	2.28
C-13	1.26	1.70
C-14	1.38	1.72
C-15	1.30	1.52
C-16	1.91	2.10
C-17	1.53	1.58
C-18	1.99	1.94
C-19	1.91	1.77
C-20	3.14	2.75
C-21	2.98	2.50
C-22	5.05	4.03
C-23	3.44	2.63
C-24	3.52	2.58
C-25	3.75	2.64
C-26	5.05	3.42
C-27	3.29	2.14
C-28+	46.59	29.28
Total	100.00	100.00

(0.00 = LESS THAN 0.01%)

SOURCE DEPENDENT PARAMETERS

	Weight%	Mol%
C1-C4	5.28	22.53
BENZENE/HEXANES	0.10	0.11
TOLUENE/HEPTANES	0.34	0.37
BZ+TOL+EBZ+XYL	0.43	1.09
C25+(Waxes)	58.68	37.48

C6-C8 Alkanes + Alkenes / S2	0.65 %
C9+ Alkanes + Alkenes / S2	3.45 %
C15+ Alkanes + Alkenes / S2	2.47 %
Average molecular weight of whole oil (calc)	248.13 g/mol
Average molecular weight of C8+ fraction (calc)	316.39 g/mol

TABLE 16

C_{12+} BULK COMPOSITION AND ALKANE RATIOS, OTWAY BASIN

Sample	Extract Yield (ppm)	mgEOM/ gTOC	Composition				Alkane Ratios			
			n+iso	Napth	Arom	NSO	Np/Pr	Pr/Ph	Pr/n-C_{17}	Ph/n-C_{18}
1C, 1650-52m	228.1	32.13	18.5	25.0	25.5	31.0	0.39	1.76	0.83	0.43
1H, 2358-61m	358.9	12.42	16.0	35.1	6.5	42.4	0.55	2.94	0.96	0.37
4A, 1965m	193.1	13.05	6.4	44.7	4.0	44.9	0.51	2.80	0.82	0.45
5F, 2080m	401.0	64.68	8.2	19.1	2.6	70.1	0.48	1.97	0.56	0.45
7C, 1325m	1874	180.19	27.2	50.4	3.1	19.3	0.22	3.43	1.21	0.24
7E, 2525m	329.1	78.36	15.6	17.3	6.7	60.4	0.38	3.65	1.20	0.36
8B, 853m	280.9	68.51	30.0	17.6	5.5	46.9	0.35	4.63	0.71	0.31
9A 600m	321.3	39.18	4.3	33.6	2.8	59.3	0.75	1.67	0.42	0.31
10C 2750m	1725	68.73	27.6	17.4	5.4	49.6	0.35	5.44	1.09	0.19
14A, 1400m	146.8	13.35	11.1	36.1	1.7	51.1	0.34	3.23	0.72	0.25
15A, 825m	485.2	57.08	36.2	23.4	8.5	31.9	0.51	1.97	0.85	0.30
17E, 3513m	191.7	27.39	13.8	18.9	7.1	60.2	0.54	4.00	0.62	0.19
21C, 1255m	217.8	50.65	4.1	37.9	4.4	53.6	0.29	4.10	1.51	0.36
22B, 1066m	374.5	39.01	25.7	15.9	2.9	55.5	0.37	5.54	0.86	0.19
22C, 1127m	4323	17.67	21.9	21.8	5.4	50.9	0.22	6.70	3.69	0.42
22E, 1432m	231.6	40.63	19.0	17.8	13.2	50.0	0.75	3.10	0.68	0.29

n+iso = normal + isoalkanes
Napth = naphthenes (branched + cyclic alkanes)
Arom = aromatic hydrocarbons
NSO = compounds containing nitrogen, sulphur and oxygen

Np = norpristane
Pr = pristane
Ph = phytane
n-C_{17} = n-heptadecane
n-C_{18} = n-octadecane

TABLE 17

BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION, OTWAY BASIN WELLS

	Steranes							Terpanes				Acyclic Alkanes		
	Parameter													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1C	8:21:71	9.13	7.79	0.41	1.48	0.43	0.48	0.01	0.01	1.08	0.41	1.76	0.83	0.43
1H	39:20:41	1.00	1.09	1.11	1.59	1.39	1.19	1.17	0.27	1.38	0.11	2.94	0.96	0.37
4A	45:25:30	0.66	0.79	0.88	1.44	0.92	1.92	1.60	0.27	1.05	0.25	2.80	0.82	0.45
5F	33:19:48	1.44	1.16	0.44	1.94	0.72	0.74	3.11	0.15	0.73	1.06	1.97	0.56	0.45
7C	38:22:40	1.06	1.69	1.02	1.18	1.30	0.41	2.09	0.17	1.39	0.11	3.43	1.21	0.24
7E	28:19:53	1.92	3.57	0.88	1.41	0.75	0.91	7.99	0.07	1.40	0.32	3.65	1.20	0.36
8B	14:21:65	4.49	1.34	0.21	1.47	0.57	0.45	2.10	0.18	0.44	0.76	4.63	0.71	0.31
9A	29:19:52	1.80	1.25	0.58	1.15	0.82	0.43	2.43	0.23	1.24	0.56	1.67	0.42	0.31
10C	18:21:61	3.28	10.83	1.45	1.40	1.36	0.49	2.85	0.09	1.51	0.10	5.44	1.09	0.19
14A	31:27:42	1.36	1.31	0.42	1.56	0.72	0.83	1.41	0.26	0.81	0.54	3.23	0.72	0.25
15A	43:20:37	0.85	0.45	0.59	1.55	0.78	2.51	1.17	0.52	0.90	0.27	1.97	0.85	0.30
17E	39:22:39	1.02	1.56	1.28	1.65	1.26	0.87	1.06	0.43	1.39	0.13	4.00	0.62	0.19
21C	31:24:45	1.48	1.53	0.75	1.53	0.97	0.55	1.95	0.16	1.30	0.21	4.10	1.51	0.36
22B	8:21:71	9.48	9.88	0.15	1.37	0.44	0.35	10.67	0.03	0.51	0.37	5.54	0.86	0.19
22C	3:23:74	25.18	22.32	0.16	1.58	0.35	0.45	24.95	0.03	0.70	0.47	6.70	3.69	0.42
22E	9:19:72	7.54	4.13	0.25	1.16	0.37	0.23	38.27	0.02	1.03	0.50	3.10	0.68	0.29

KEY TO BIOMARKER PARAMETERS OF SOURCE, MIGRATION AND BIODEGRADATION

Parameter	Derivation*	Specificity
1	C_{27}:C_{28}:C_{29} 5α(H)14β(H)17β(H) 20S steranes	Source
2	C_{29} 5α(H)14β(H)17β(H) 20S sterane/C_{27} 5α(H)14β(H)17β(H) 20S sterane	Source
3	C_{29} 13β(H)17α(H) 20R diasterane/C_{27} 13β(H)17α(H) 20R diasterane	Source
4	C_{29} 5α(H)14α(H)17α(H) 20S sterane/C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Biodegradation
5	C_{27} 13β(H)17α(H) 20S diasterane/C_{27} 13β(H)17α(H) 20R diasterane	Maturity
6	C_{29} 5α(H)14β(H)17β(H) 20R sterane/C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Migration
7	C_{29} 13β(H)17α(H) 20R+20S diasteranes/C_{29} 5α(H) steranes	Migration, Source
8	C_{27} 18α(H)-22,29,30-trisnorhopane (Ts)/C_{27} 17α(H)-22,29,30-trisnorhopane (Tm)+ Ts	Maturity, Source
9	T_s/C_{30} 17α(H)21β(H) hopane	Maturity
10	C_{32} 17α(H)21β(H) 22S homohopane/C_{32} 17α(H)21β(H) 22R homohopane	Maturity
11	C_{30} 17β(H)21α(H) moretane/C_{30} 17α(H)21β(H) hopane	Maturity
12	pristane/phytane	Source
13	pristane/n-heptadecane	Source, Biodegradation, Maturity
14	phytane/n-octadecane	Source, Biodegradation, Maturity

* Ratios calculated from peak areas as follows:

Parameters	1-7	m/z = 217, 218, 259 mass fragmentograms
Parameters	8 - 11	m/z = 191 mass fragmentogram
Parameters	12 - 14	capillary gas chromatogram of alkanes or whole oil/extract

M = predominantly mud additive

TABLE 18

AROMATIC MATURITY DATA, OTWAY BASIN

Sample Depth (ft)	MPI	MPR	DNR	MPDF	VR CALC (%)					
					A	B	C	D	E	F
1C 1650-52m	0.767	1.159	4.596	0.495	0.89	1.84	1.00	3.00	0.76	0.94
1H 2358-61m	0.637	0.551	3.945	0.391	0.78	1.92	0.68	2.70	0.67	0.71
4A 1965m	0.748	1.735	4.346	0.539	0.85	1.85	1.18	2.89	0.74	1.04
5F 2080m	0.832	1.526	4.666	0.527	0.90	1.80	1.12	3.04	0.80	1.02
7C 1325m	0.667	0.984	3.028	0.449	0.81	1.89	0.93	2.28	0.69	0.84
7E 2525m	0.522	0.500	3.334	0.342	0.71	1.99	0.64	2.42	0.59	0.60
8B 853m	0.449	0.646	2.812	0.320	0.67	2.03	0.75	2.18	0.53	0.55
9A 600m	1.176	1.529	7.288	0.549	1.11	1.59	1.12	4.24	1.04	1.06
10C 2750m	nd	nd	5.727	nd	nd	nd	nd	3.52	nd	nd
14A 1400m	0.765	1.523	4.631	0.550	0.86	1.84	1.12	3.02	0.76	1.07
15A 825m	0.944	1.713	3.871	0.549	0.97	1.73	1.17	2.67	0.88	1.06
17E 3513m	1.170	1.756	7.942	0.612	1.10	1.60	1.18	4.54	1.04	1.21
21C 1255m	0.523	0.840	nd	0.383	0.71	1.99	0.87	nd	0.59	0.69
22B 1066m	0.482	0.614	1.024	0.365	0.69	2.01	0.73	1.36	0.56	0.65
22C 1127m	0.360	0.356	1.315	0.276	0.62	2.08	0.50	1.50	0.47	0.45
22E 1432m	0.477	0.683	nd	0.376	0.69	2.01	0.78	nd	0.55	0.68

KEY TO AROMATIC MATURITY INDICATORS

Methylphenanthrene index (MPI), methylphenanthrene ratio (MPR), dimethylnaphthalene ratio (DNR) and calculated vitrinite reflectance (VR_{calc}) are derived from the following equations (after Radke and Welte, 1983; Radke *et al*, (1984):

$$MPI = \frac{1.5(2\text{-}MP + 3\text{-}MP)}{P + 1\text{-}MP + 9\text{-}MP}$$

$$VR_{calc}\ (a) = 0.6\ MPI + 0.4\ (\text{for } VR < 1.35\%)$$

$$VR_{calc}\ (b) = -0.6\ MPI + 2.3\ (\text{for } VR > 1.35\%)$$

$$MPR = \frac{2\text{-}MP}{1\text{-}MP}$$

$$VR_{calc}\ (c) = 0.99\ \log_{10} MPR + 0.94 (VR = 0.5\text{-}1.7\%)$$

$$DNR = \frac{2,6\text{-}DMN + 2,7\text{-}DMN}{1,5\text{-}DMN}$$

$$VR_{calc}\ (d) \quad 0.46\ DNR + 0.89\ (\text{for } VR = 0.9\text{-}1.5\%)$$

Where
P = phenanthrene
1-MP = 1-methylphenanthrene
2-MP = 2-methylphenanthrene
3-MP = 3-methylphenanthrene
9-MP = 9-methylphenanthrene
1,5-DMN = 1,5-dimethylnaphthalene
2,6-DMN = 2,6-dimethylnaphthalene
2,7-DMN = 2,7-dimethylnaphthalene

Peak areas measured from m/z 156 (dimethylnaphthalene), m/z 178 (phenanthrene) and m/z 192 (methylphenanthrene) mass fragmentograms of diaromatic and triaromatic hydrocarbon fraction isolated by thin layer chromatography.

Recalibration of the methylphenanthrene index using data from a suite of Australian coals has given rise to another equation for calculated vitrinite reflectance (after Boreham *et al*, 1988):

$$VR_{calc}\ (e) = 0.7\ MPI + 0.22\ (\text{for } VR < 1.7\%)$$

The methylphenanthrene distribution ratio (MPDF) and calculated vitrinitc reflectance VR_{calc} (f) is derived from the following equation (after Kvalheim *et al*, 1987):

$$MPDF = \frac{(2\text{-}MP + 3\text{-}MP)}{(2\text{-}MP + 3\text{-}MP + 1\text{-}MP + 9\text{-}MP)}$$

$$VR_{calc}\ (f) = -0.166 + 2.242\ MPDF$$

FIGURE 1a

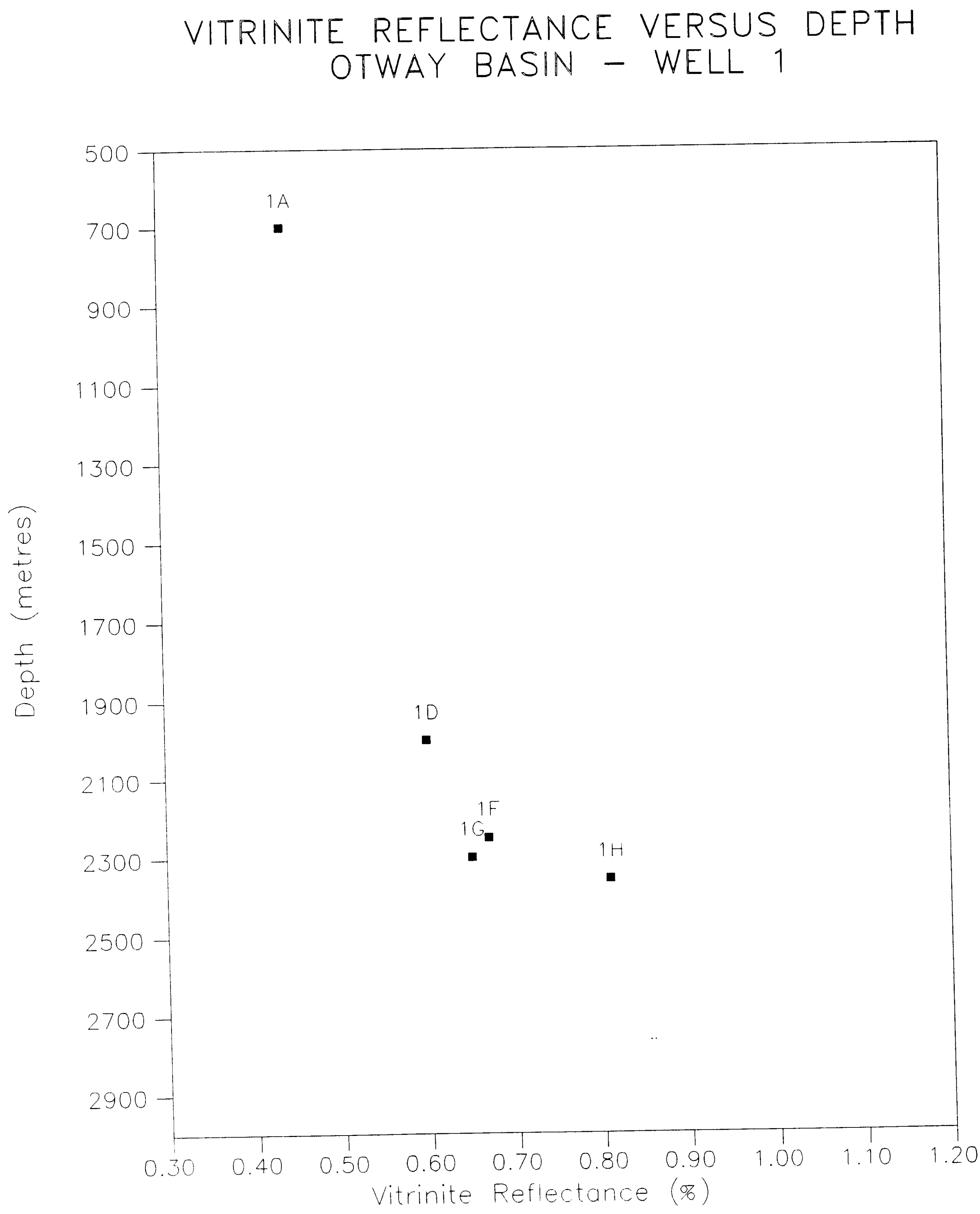

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 1
Depth (metres)
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
1A
1D
1F
1G
1H
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
Vitrinite Reflectance (%)

FIGURE 1b

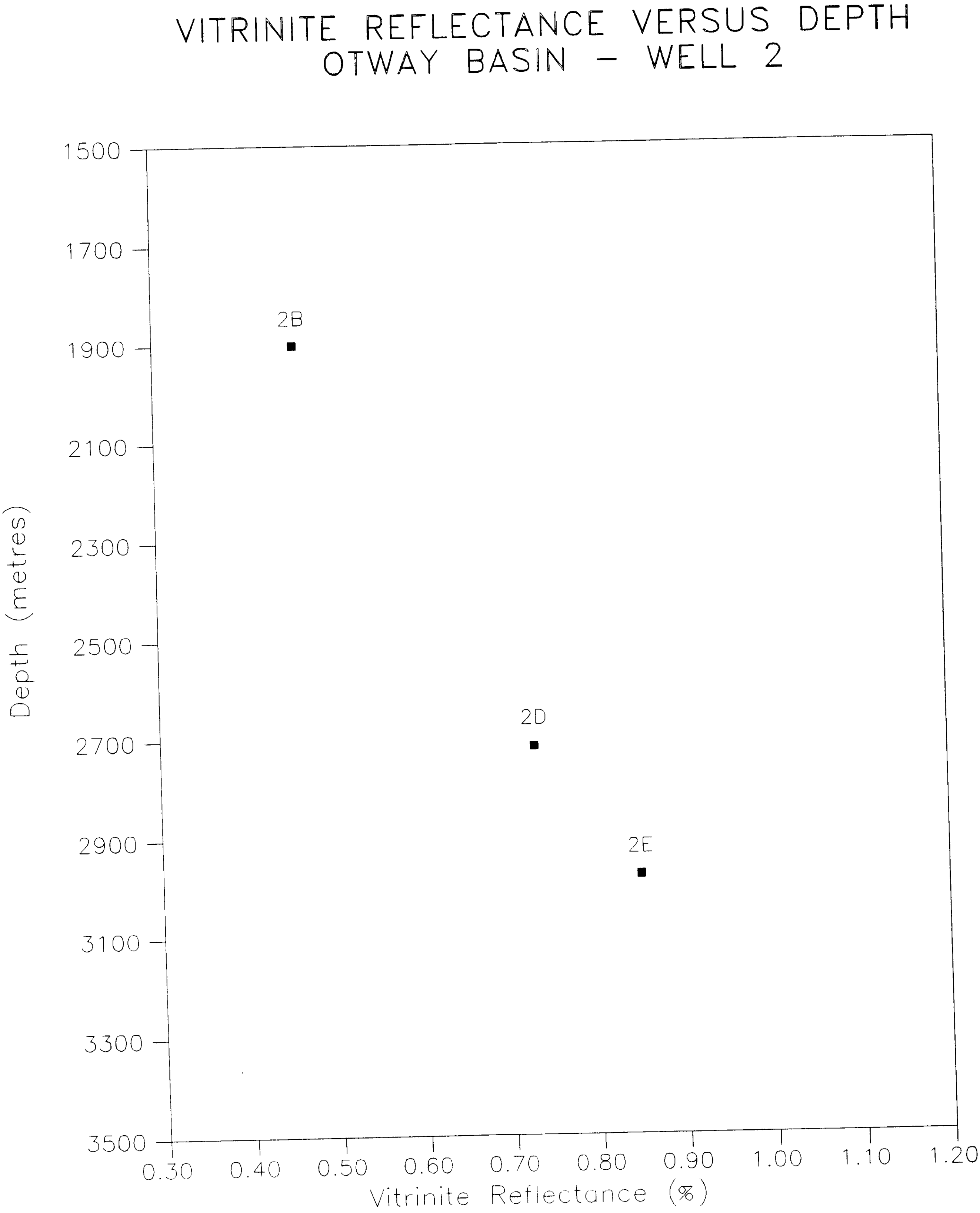

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 2
Depth (metres)
1500
1700
1900
2100
2300
2500
2700
2900
3100
3300
3500
2B
2D
2E
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
Vitrinite Reflectance (%)

FIGURE 1c

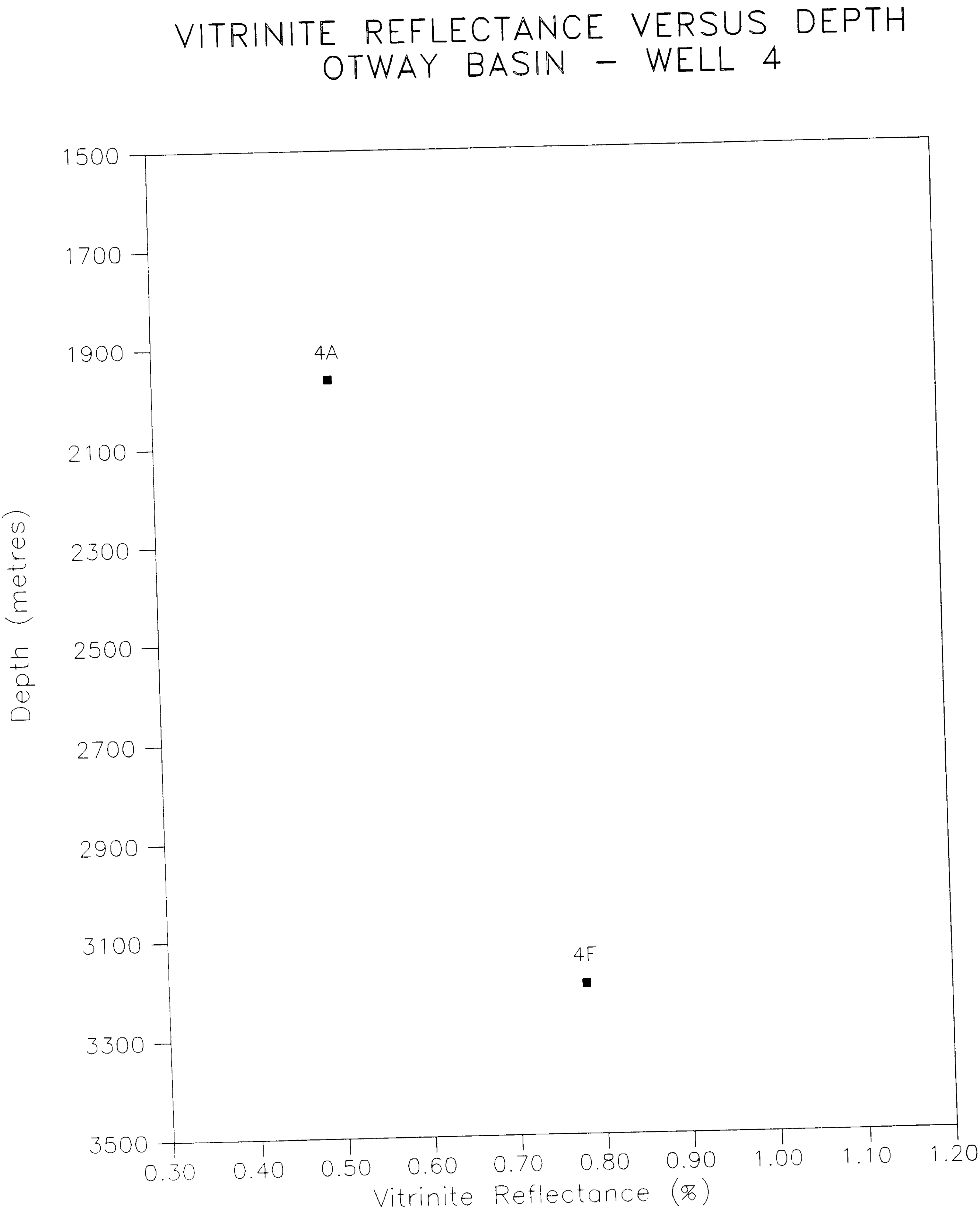

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 4
Depth (metres)
1500
1700
1900
2100
2300
2500
2700
2900
3100
3300
3500
4A
4F
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
Vitrinite Reflectance (%)

FIGURE 1d

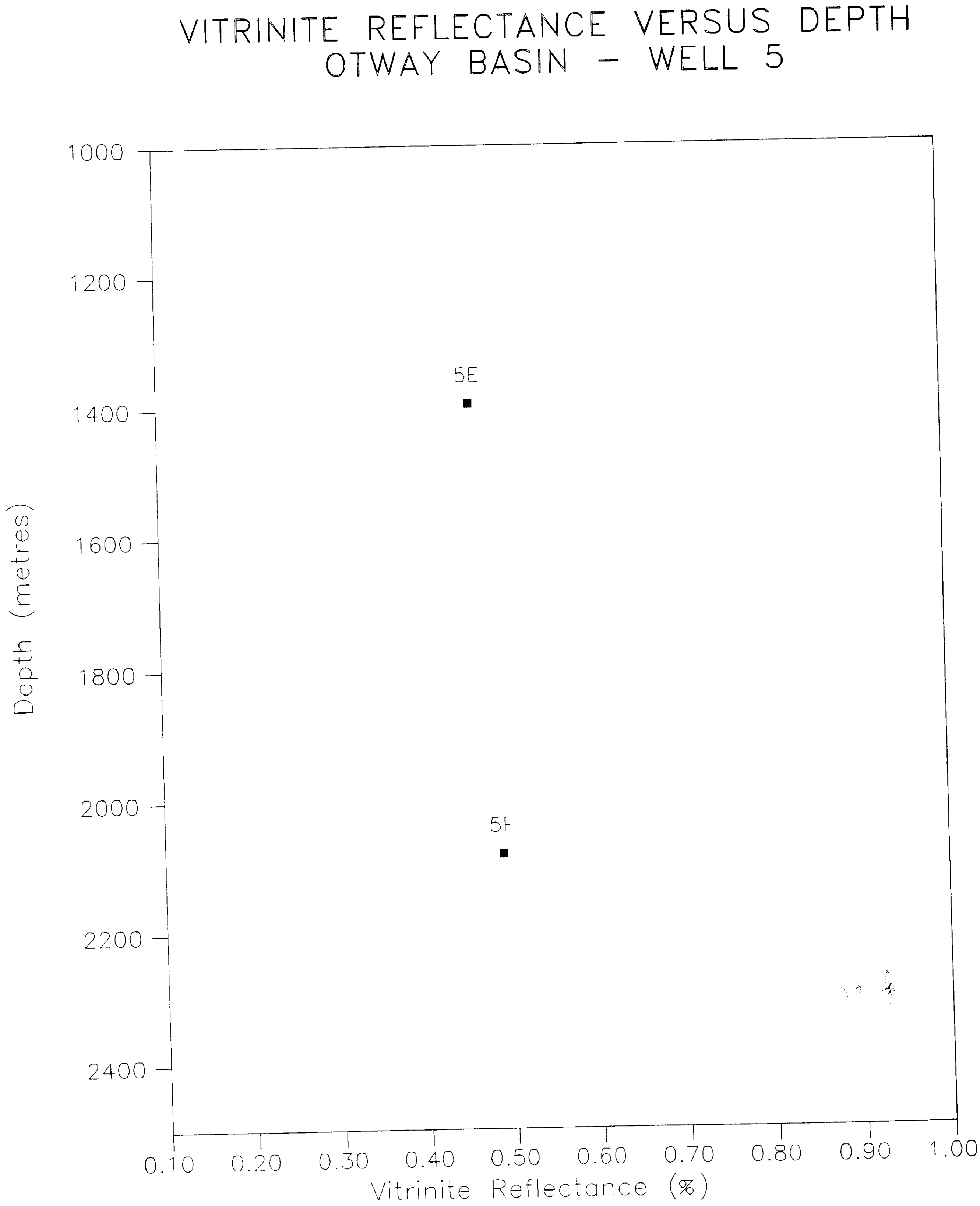
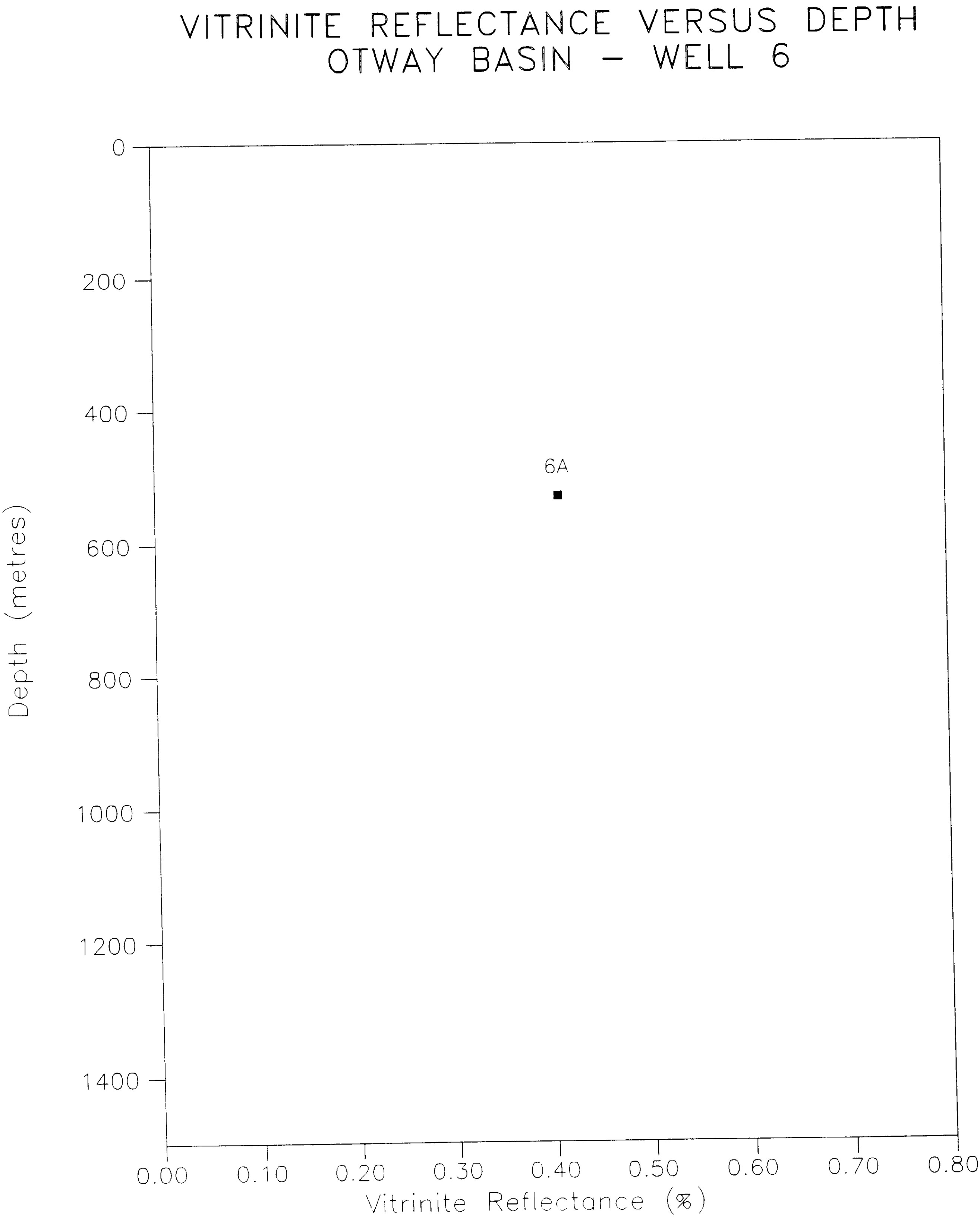
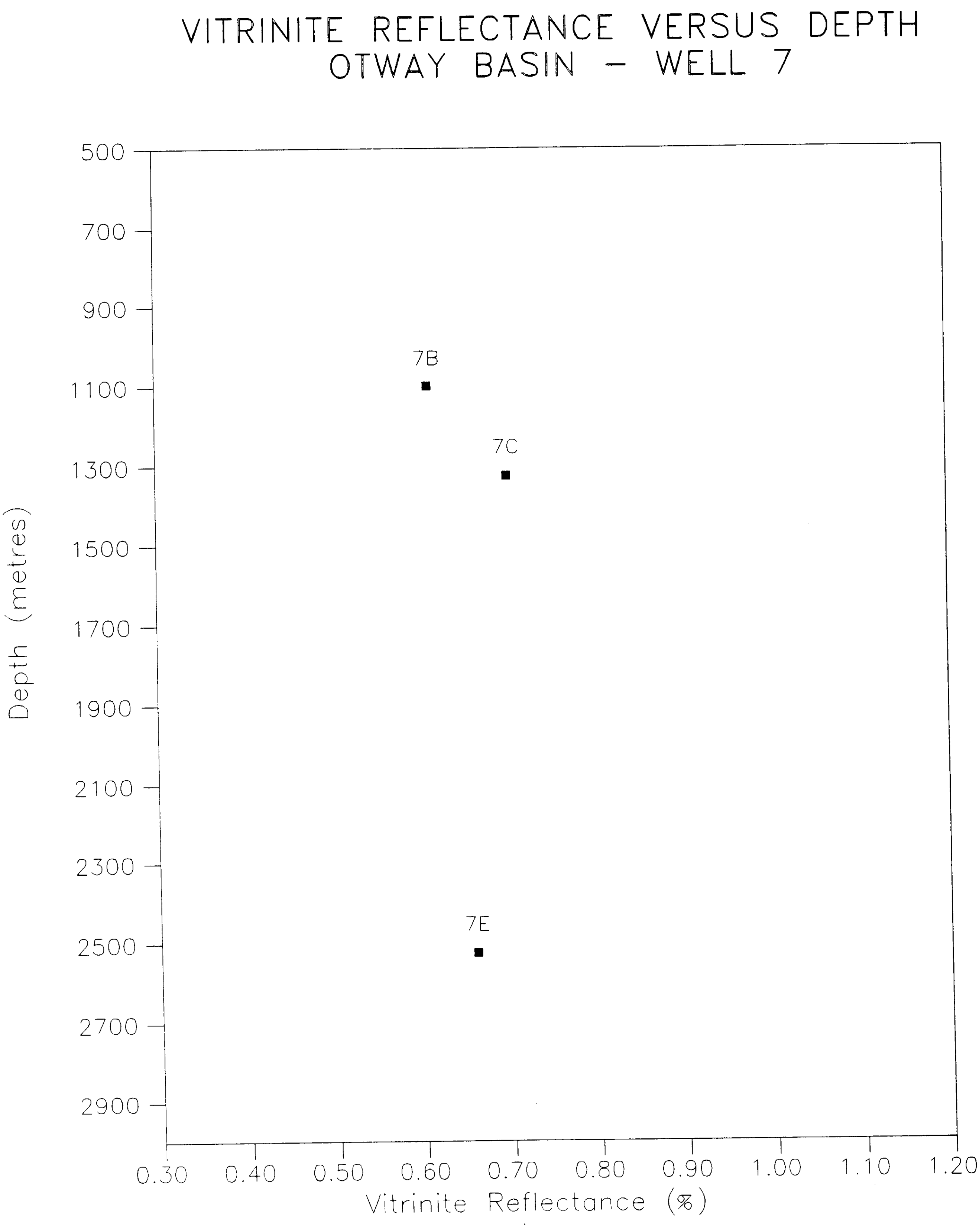

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 5
1000
1200
1400
1600
1800
2000
2200
2400
Depth (metres)
5E
5F
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Vitrinite Reflectance (%)

FIGURE 1e



VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 6
Depth (metres)
0
200
400
600
800
1000
1200
1400
6A
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Vitrinite Reflectance (%)

FIGURE 1f



VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 7
Depth (metres)
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
7B
7C
7E
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
Vitrinite Reflectance (%)

FIGURE 1g

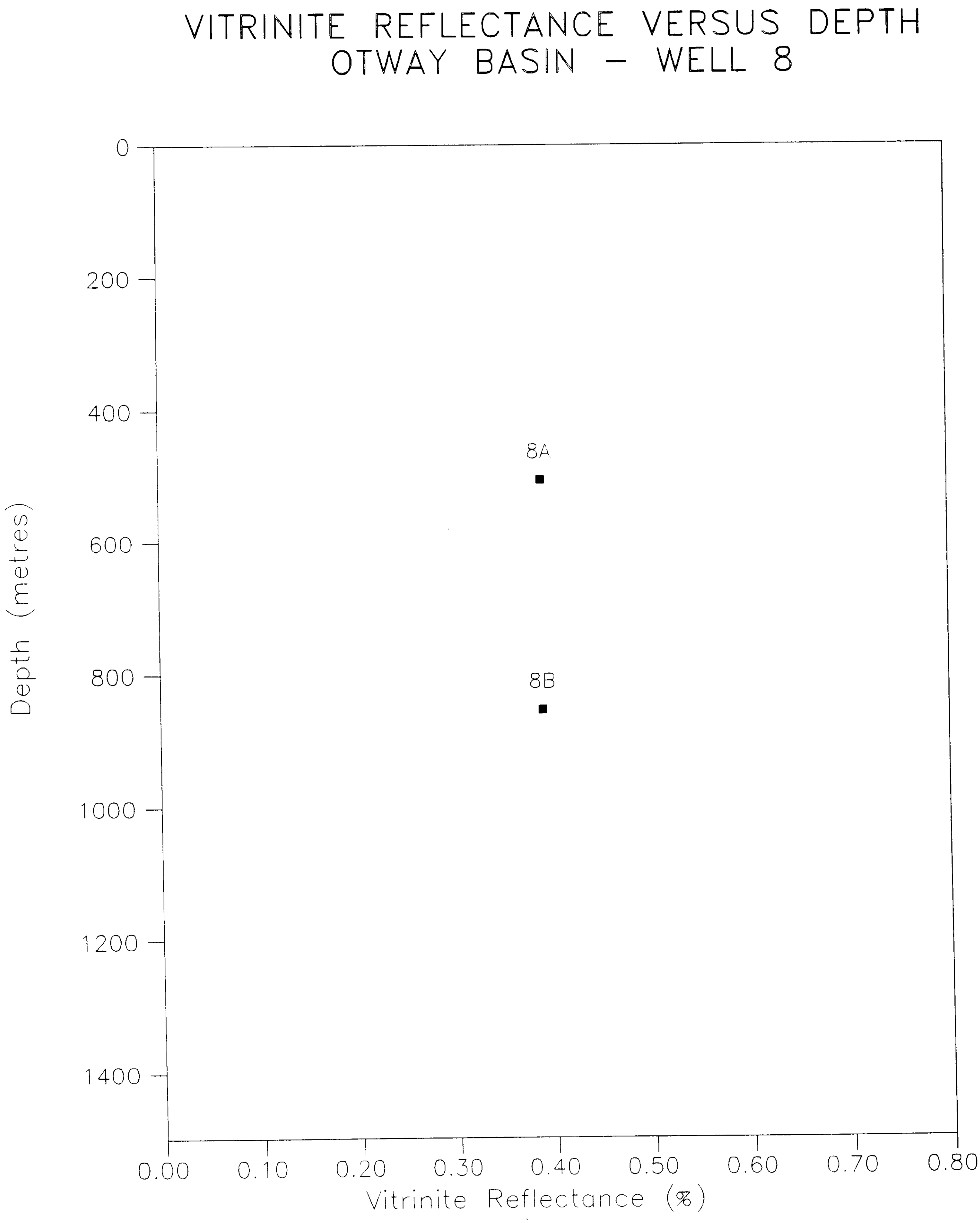
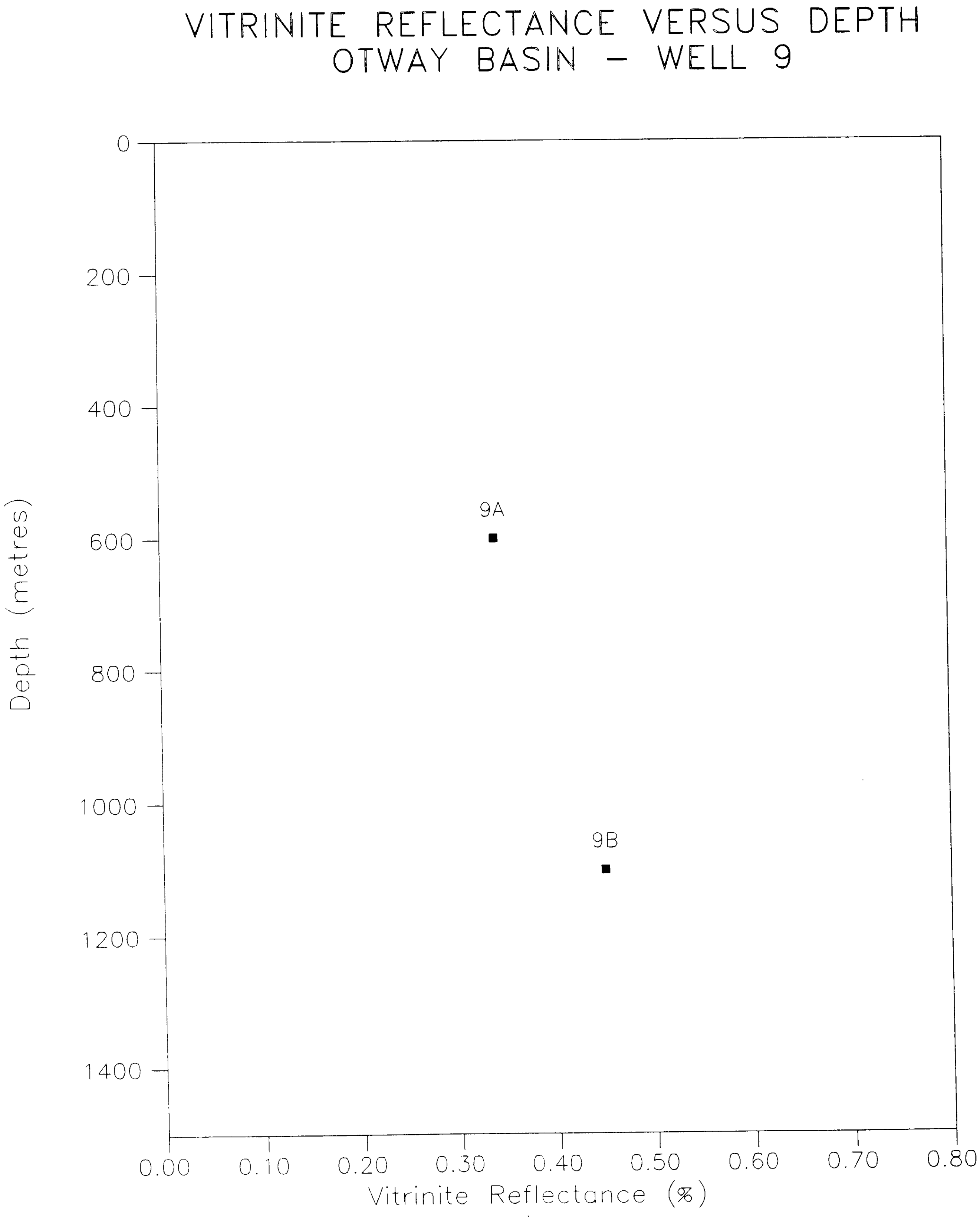

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 8
0
200
400
600
800
1000
1200
1400
Depth (metres)
8A
8B
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Vitrinite Reflectance (%)

FIGURE 1h



VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 9
0
200
400
600
800
1000
1200
1400
Depth (metres)
9A
9B
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Vitrinite Reflectance (%)

FIGURE 1i

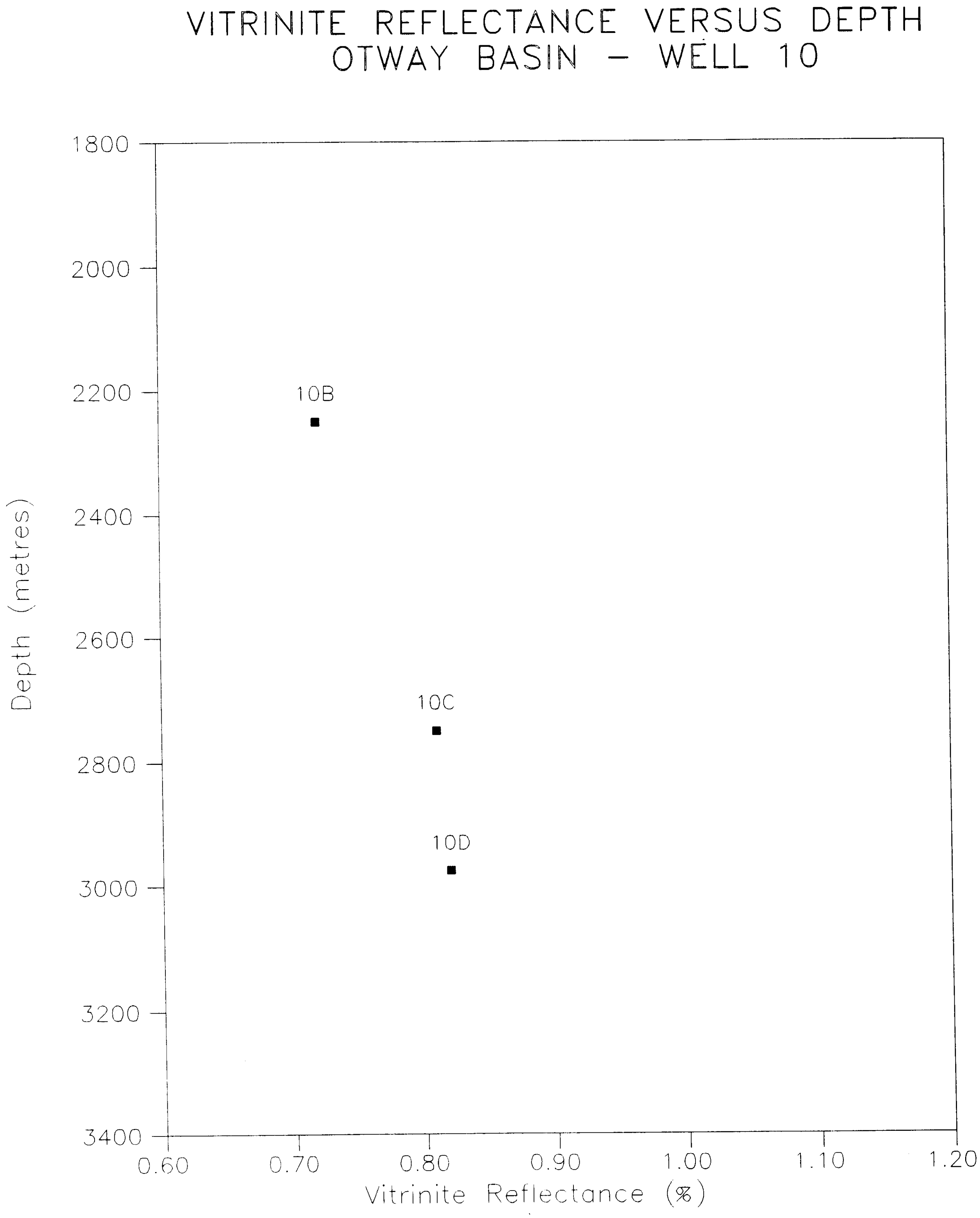

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 10
Depth (metres)
1800
2000
2200
2400
2600
2800
3000
3200
3400
10B
10C
10D
0.60
0.70
0.80
0.90
1.00
1.10
1.20
Vitrinite Reflectance (%)

FIGURE 1j

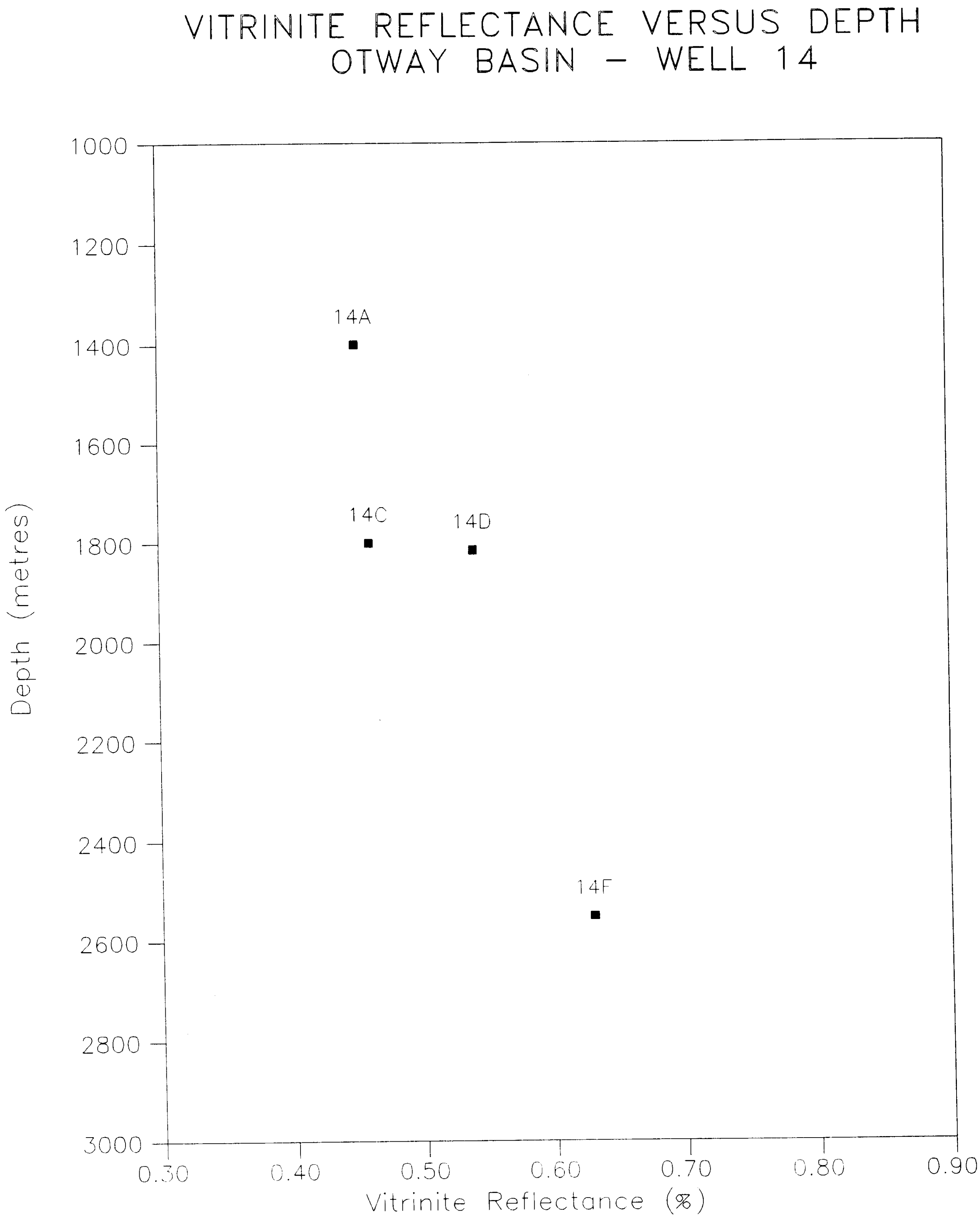

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 14
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Depth (metres)
14A
14C
14D
14F
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Vitrinite Reflectance (%)

FIGURE 1k

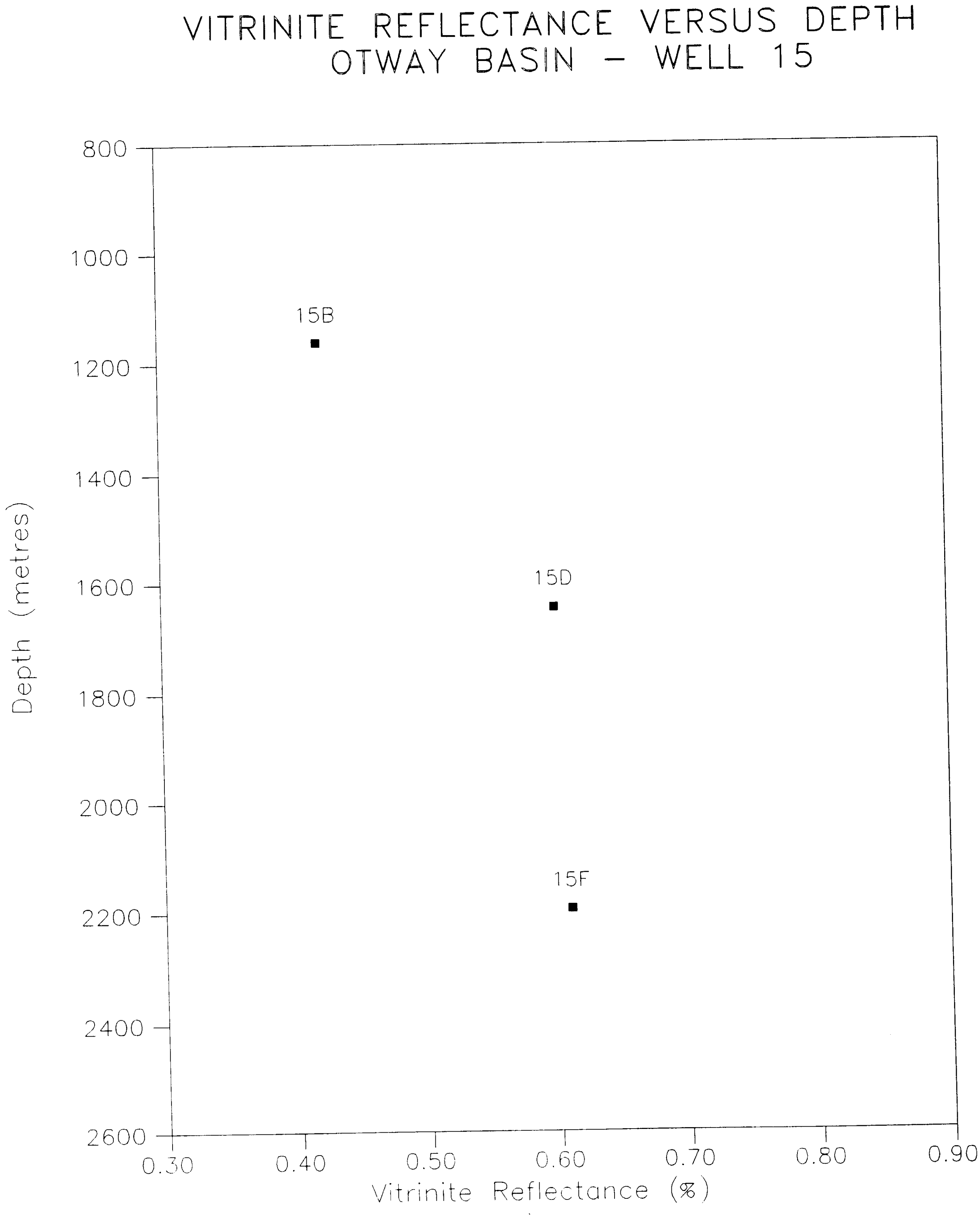
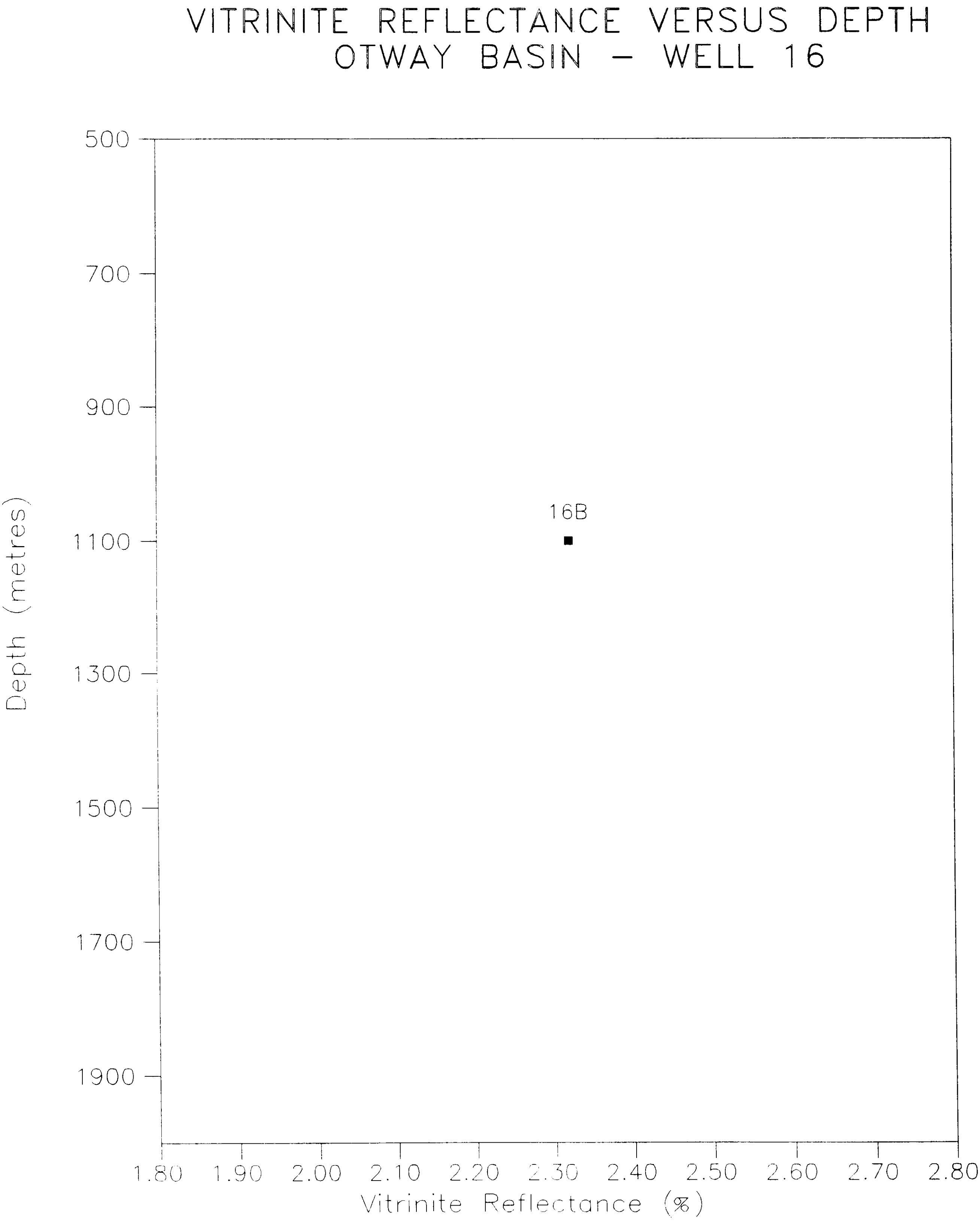
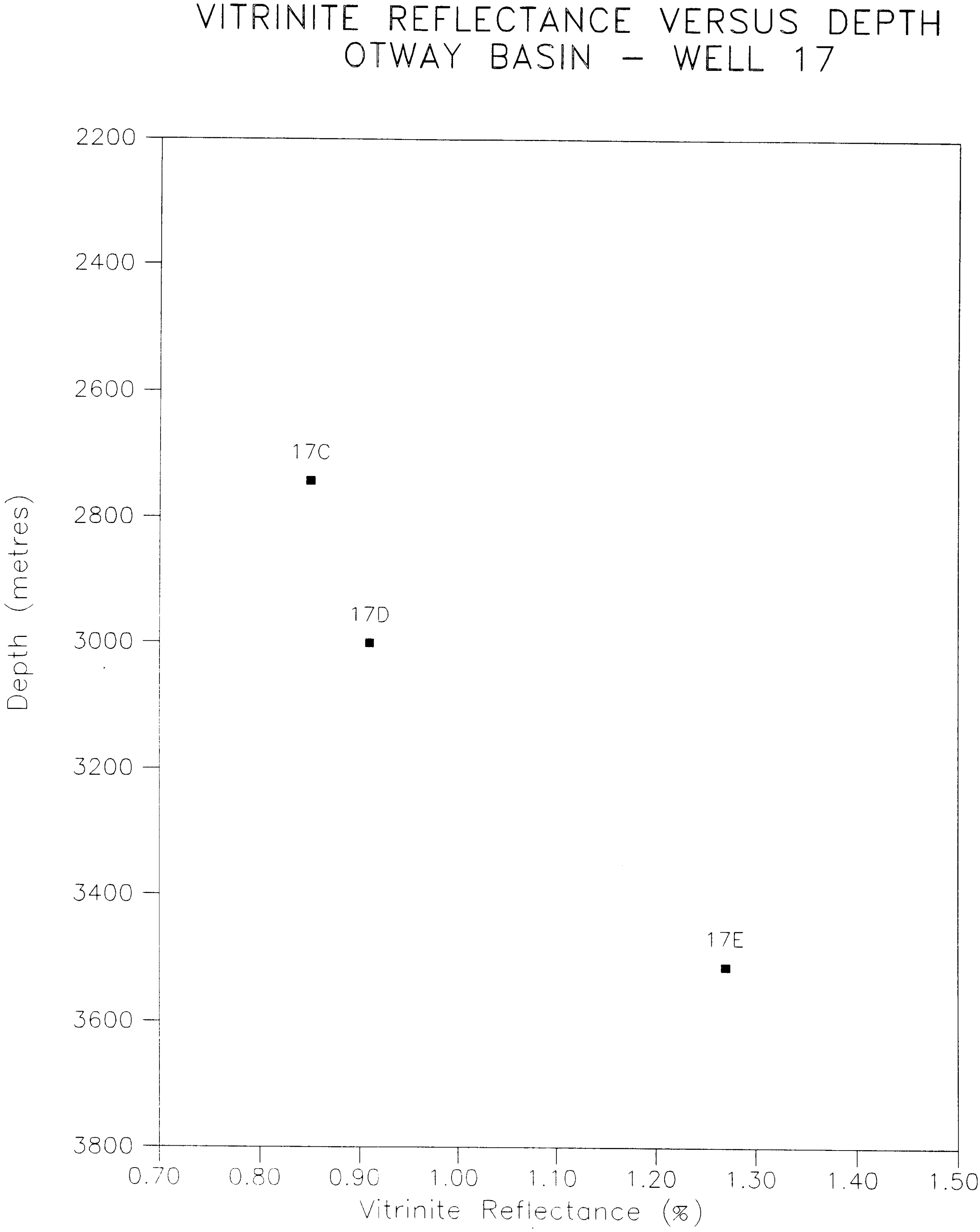

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 15
Depth (metres)
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
15B
15D
15F
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Vitrinite Reflectance (%)

FIGURE 1l



VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 16
500
700
900
1100
1300
1500
1700
1900
Depth (metres)
16B
1.80
1.90
2.00
2.10
2.20
2.30
2.40
2.50
2.60
2.70
2.80
Vitrinite Reflectance (%)

FIGURE 1m



VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 17
Depth (metres)
2200
2400
2600
2800
3000
3200
3400
3600
3800
17C
17D
17E
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
Vitrinite Reflectance (%)

FIGURE 1n

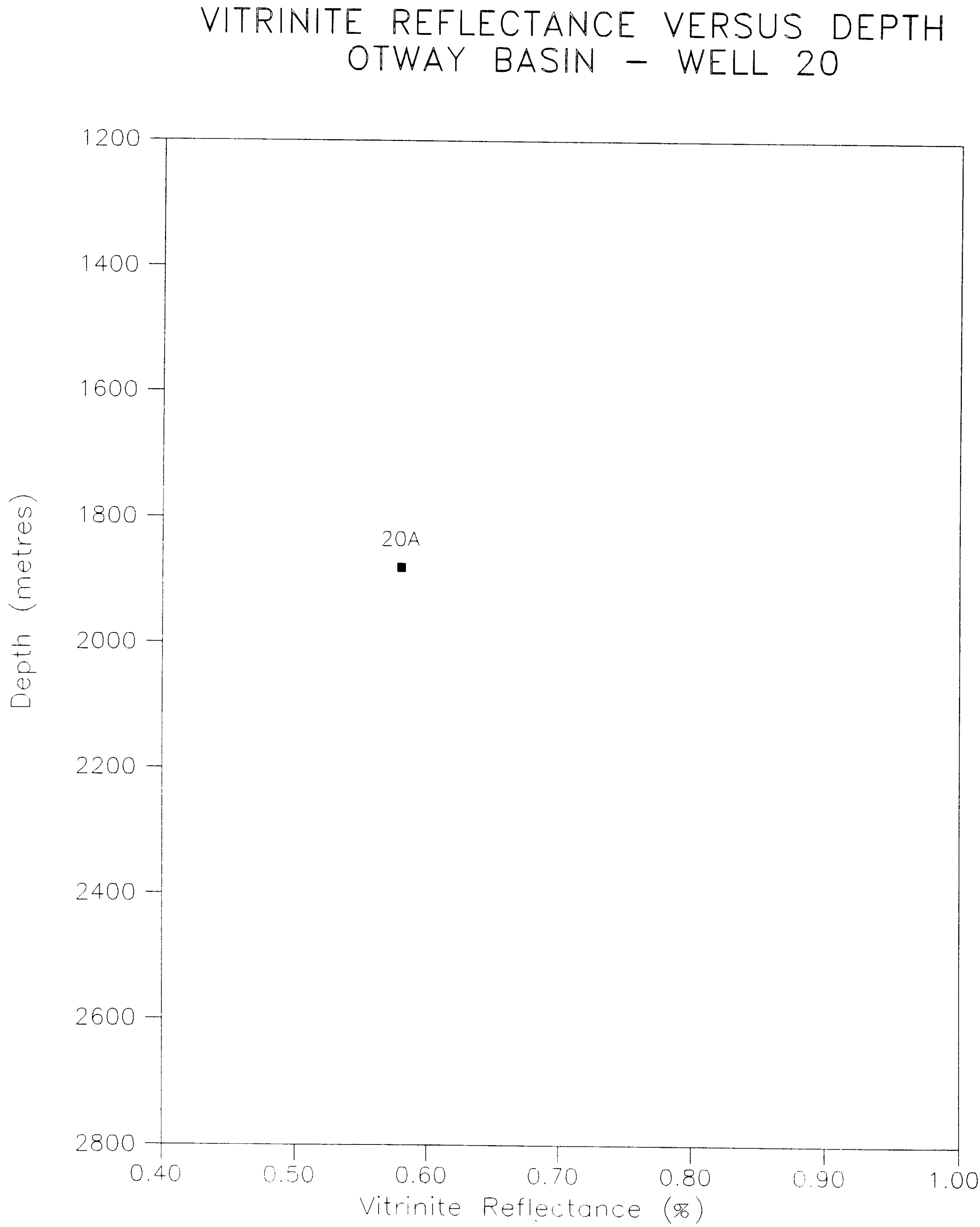

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 20
1200
1400
1600
1800
2000
2200
2400
2600
2800
Depth (metres)
20A
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Vitrinite Reflectance (%)

FIGURE 1o

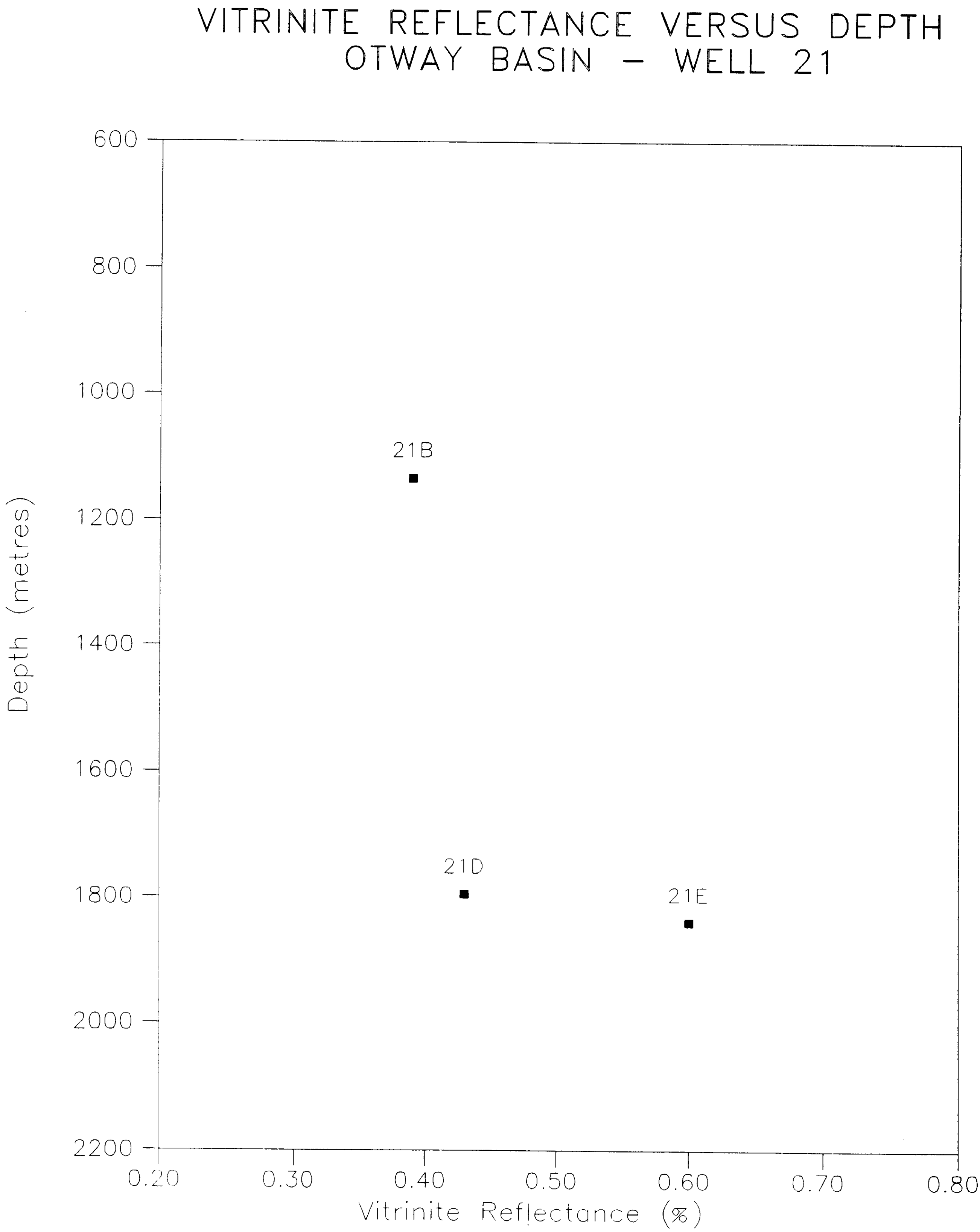

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 21
Depth (metres)
600
800
1000
1200
1400
1600
1800
2000
2200
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Vitrinite Reflectance (%)
21B
21D
21E

FIGURE 1p

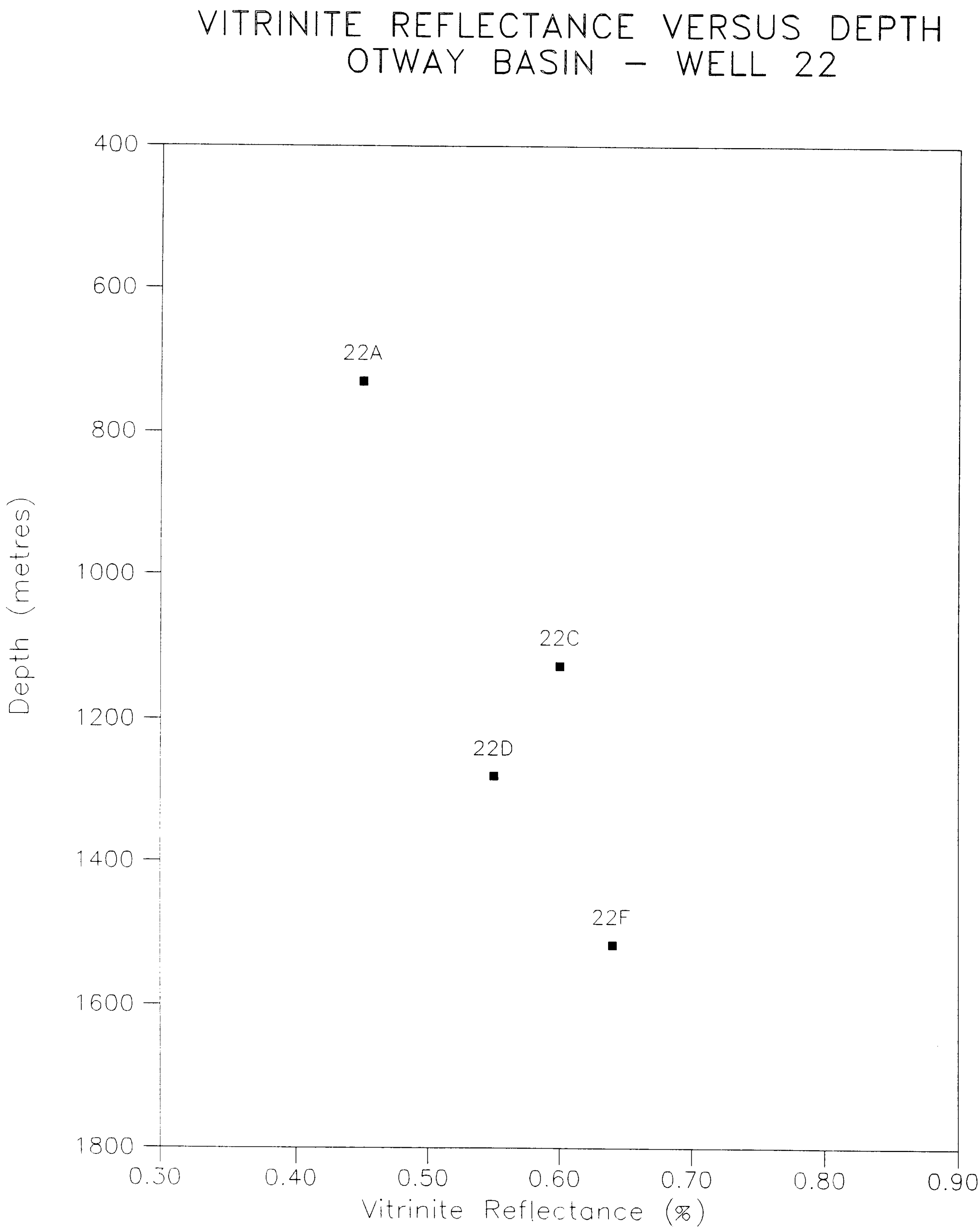

VITRINITE REFLECTANCE VERSUS DEPTH
OTWAY BASIN - WELL 22
Depth (metres)
400
600
800
1000
1200
1400
1600
1800
22A
22C
22D
22F
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Vitrinite Reflectance (%)

FIGURE 2a

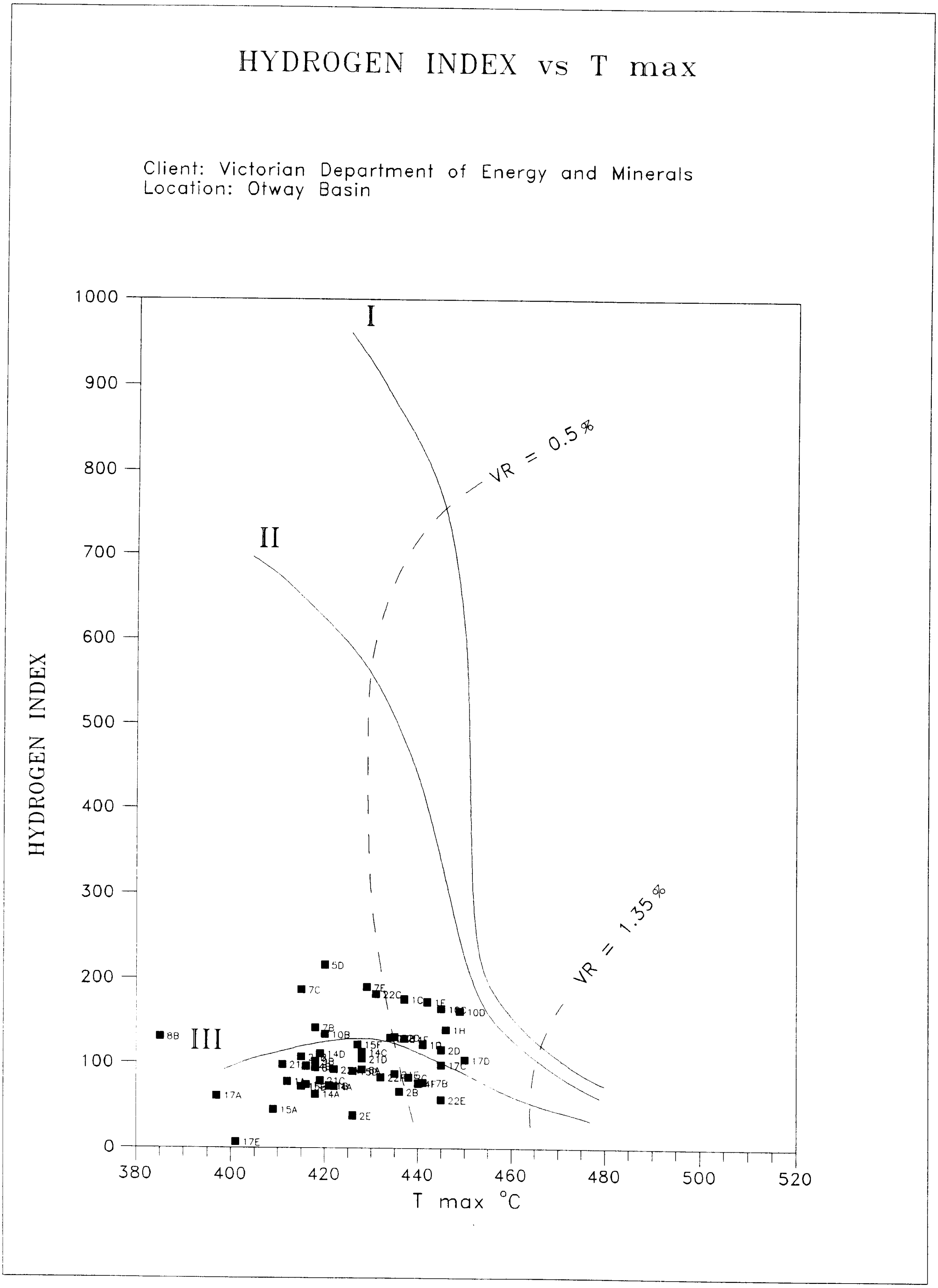
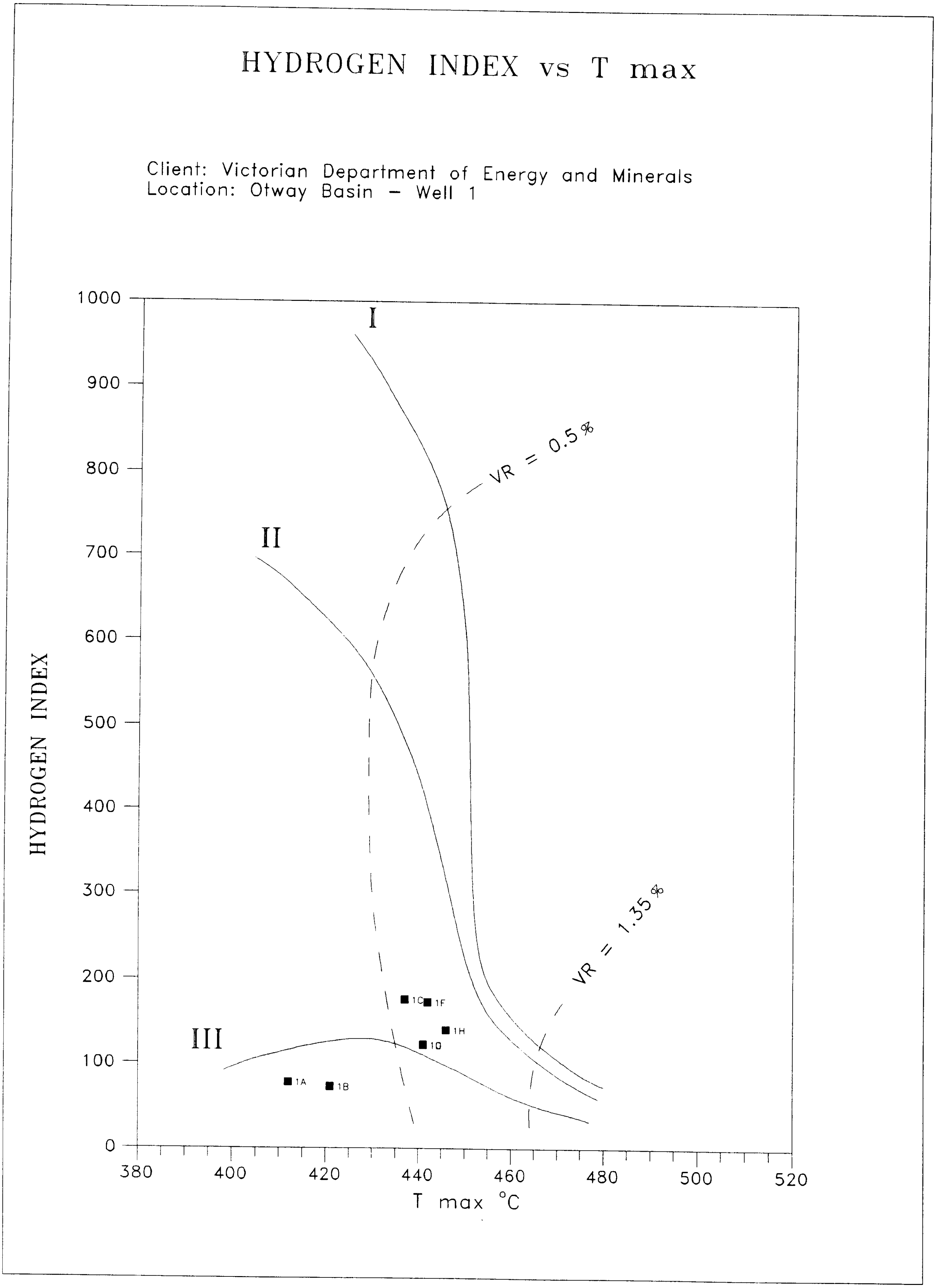
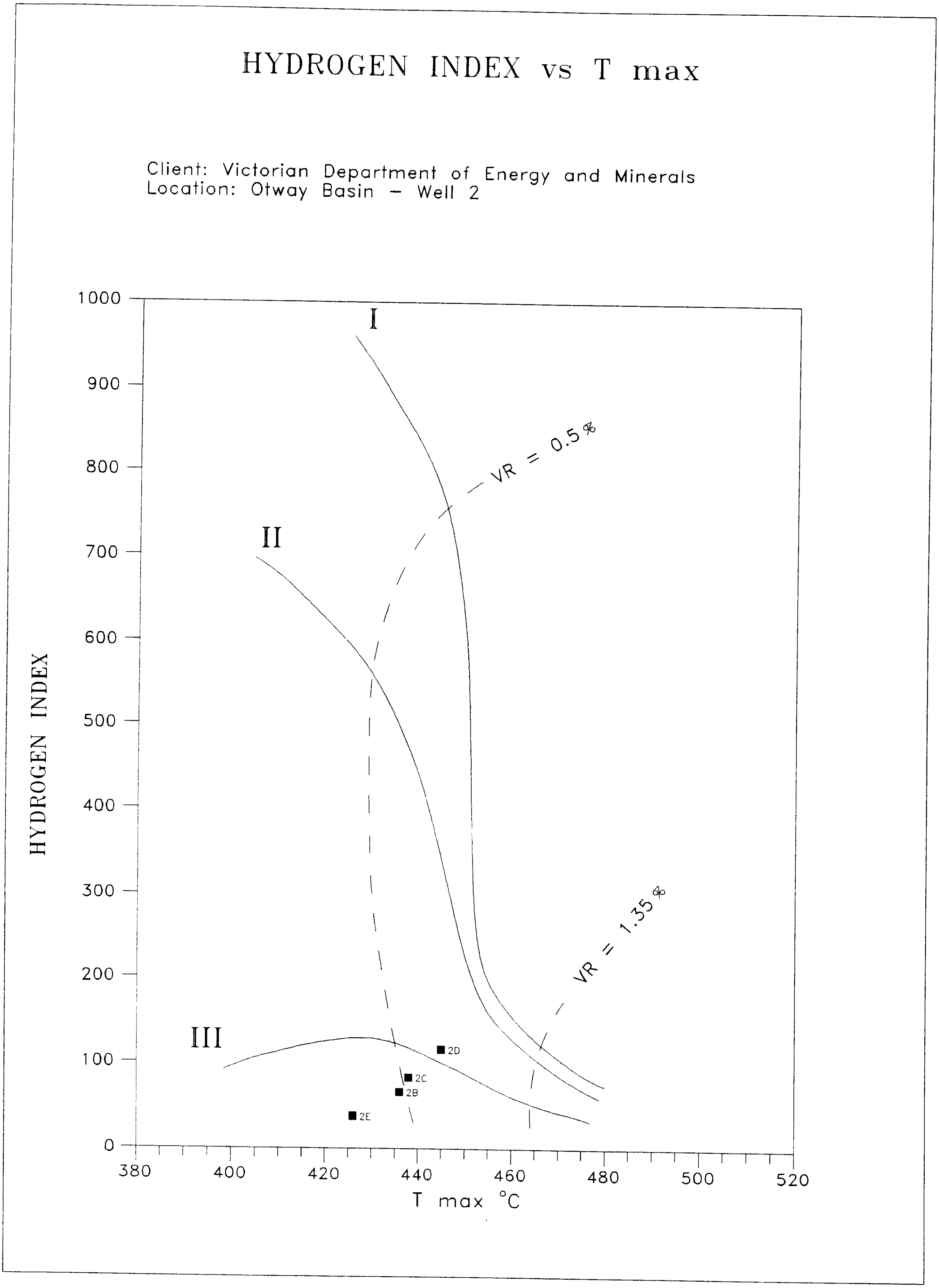

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2b



HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 1
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
1A
1B
1C
1D
1F
1H
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2c



HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 2
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
2D
2C
2B
2E
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2d

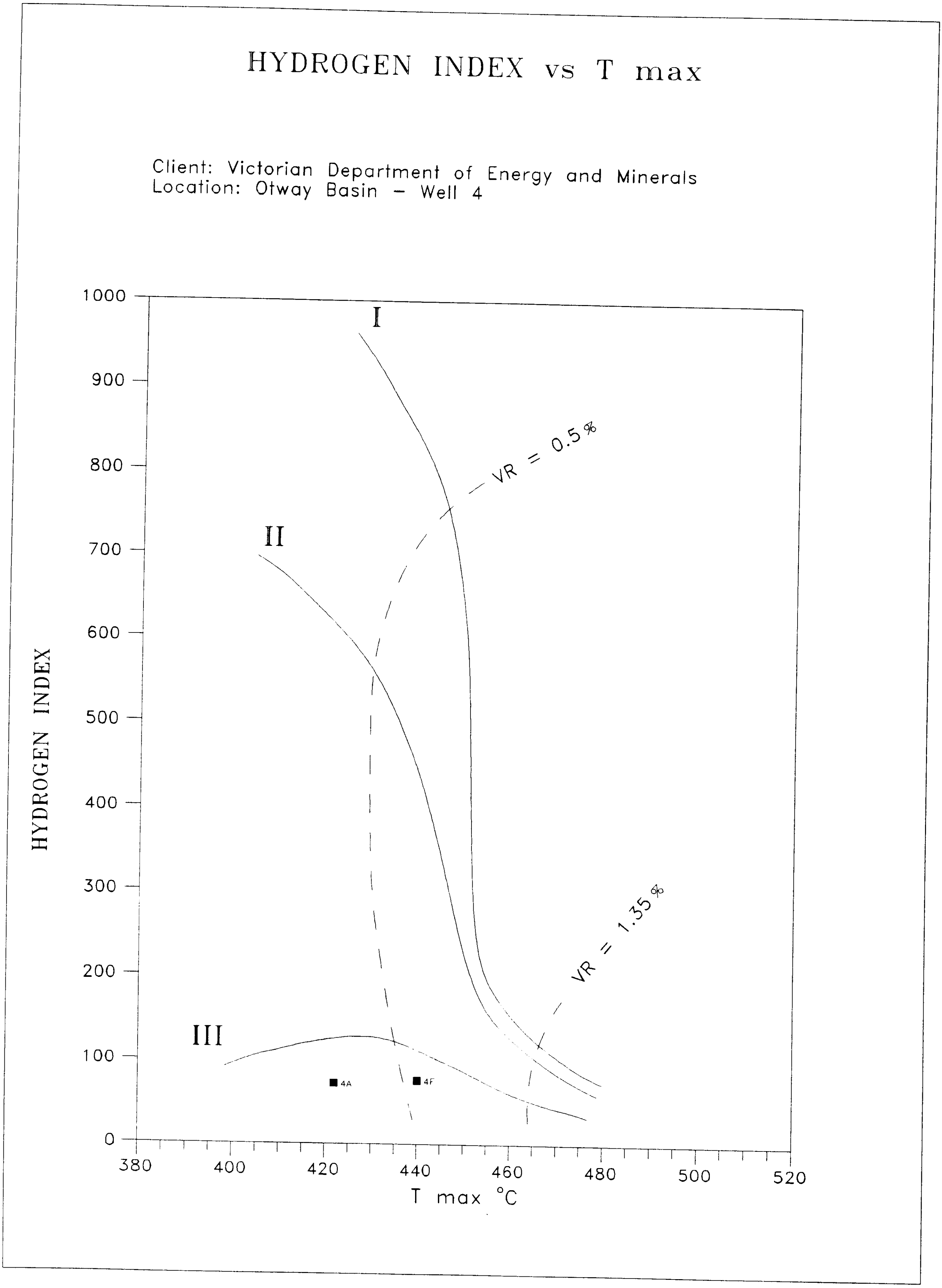

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 4
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
4A
4F
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2e

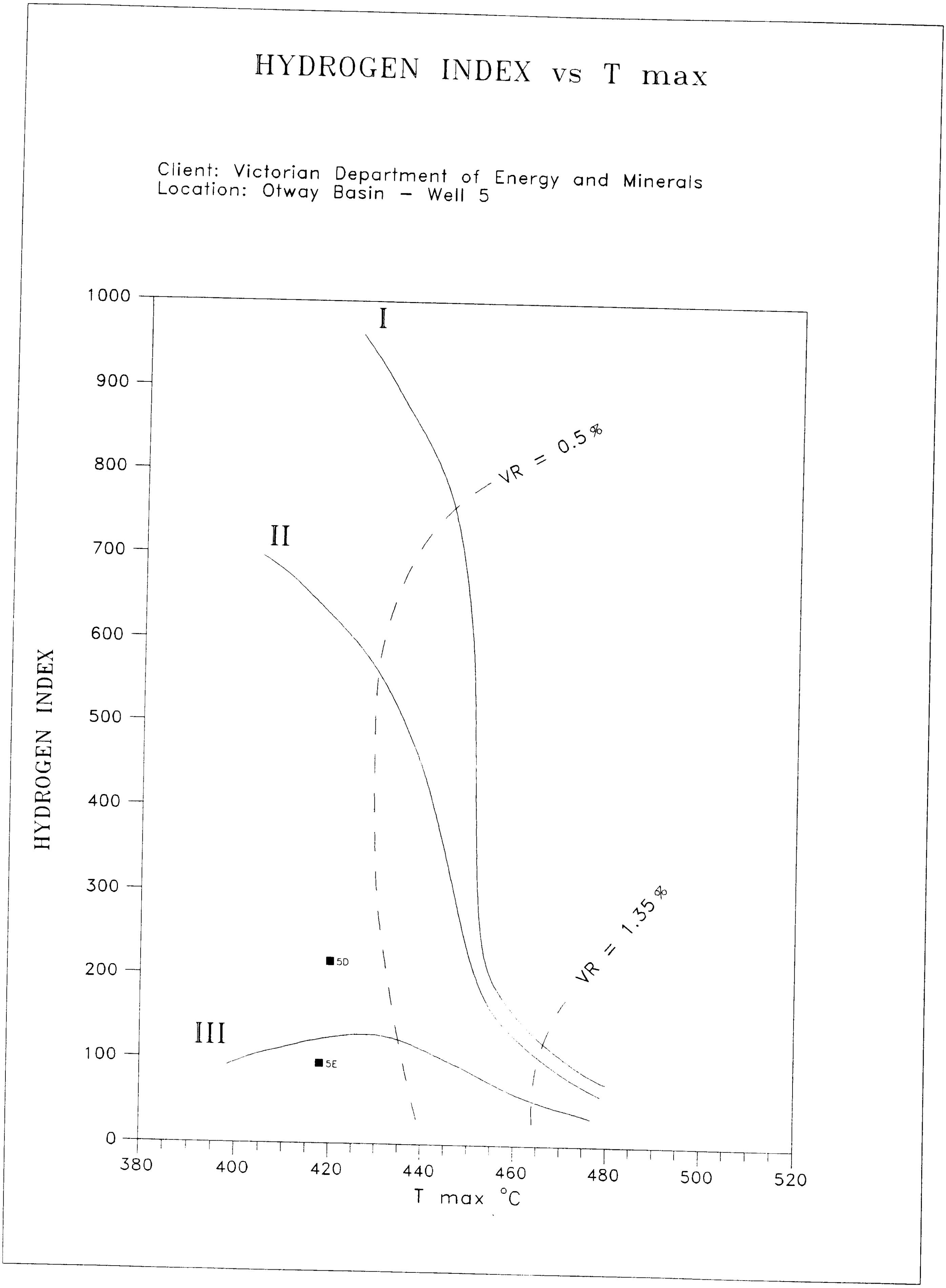

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 5
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
5D
5E
1000
900
800
700
600
500
400
300
200
100
0
380
400
420
440
460
480
500
520

FIGURE 2f

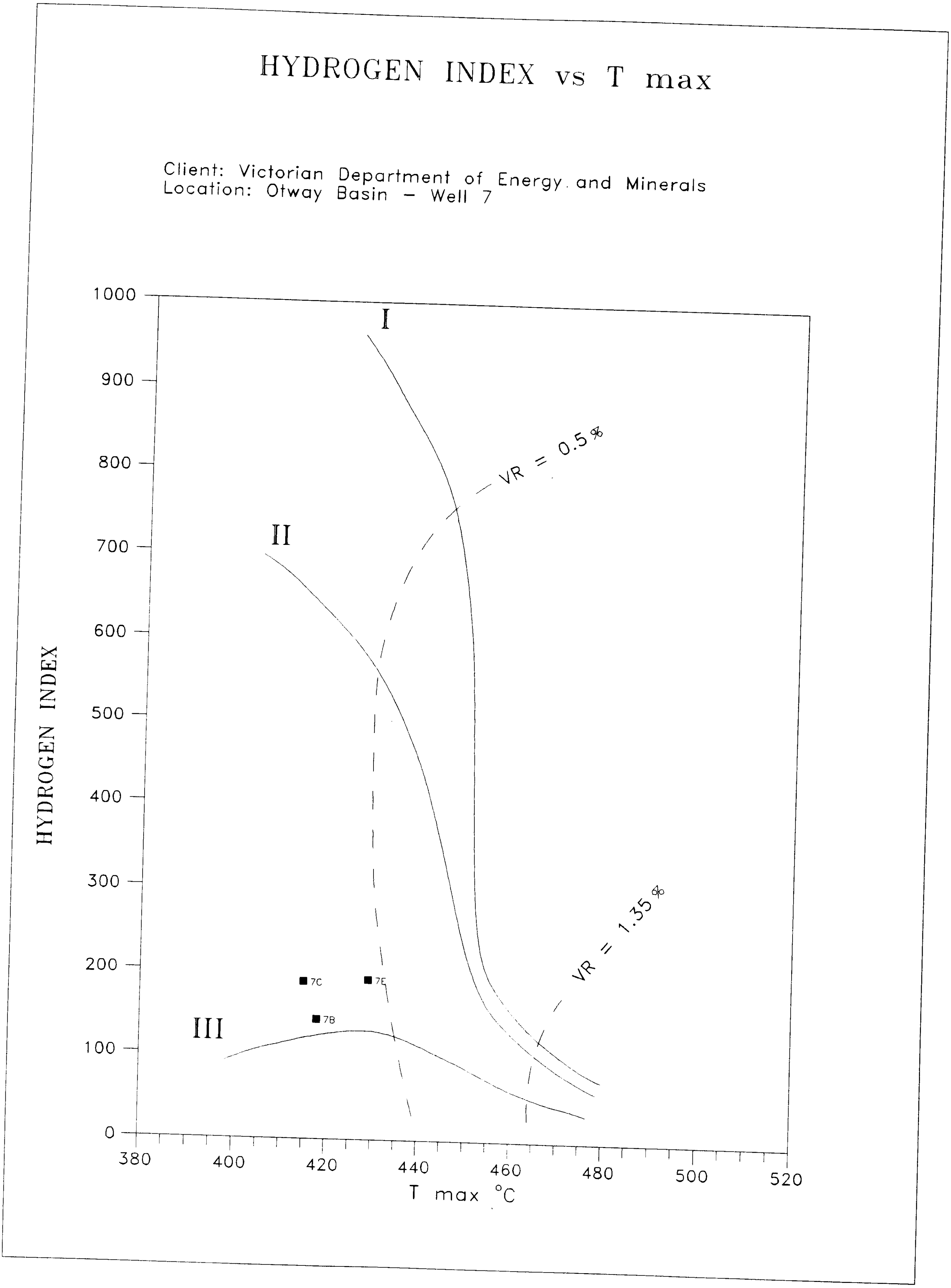

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 7
HYDROGEN INDEX
1000
900
800
700
600
500
400
300
200
100
0
380
400
420
440
460
480
500
520
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
7C
7E
7B

FIGURE 2g

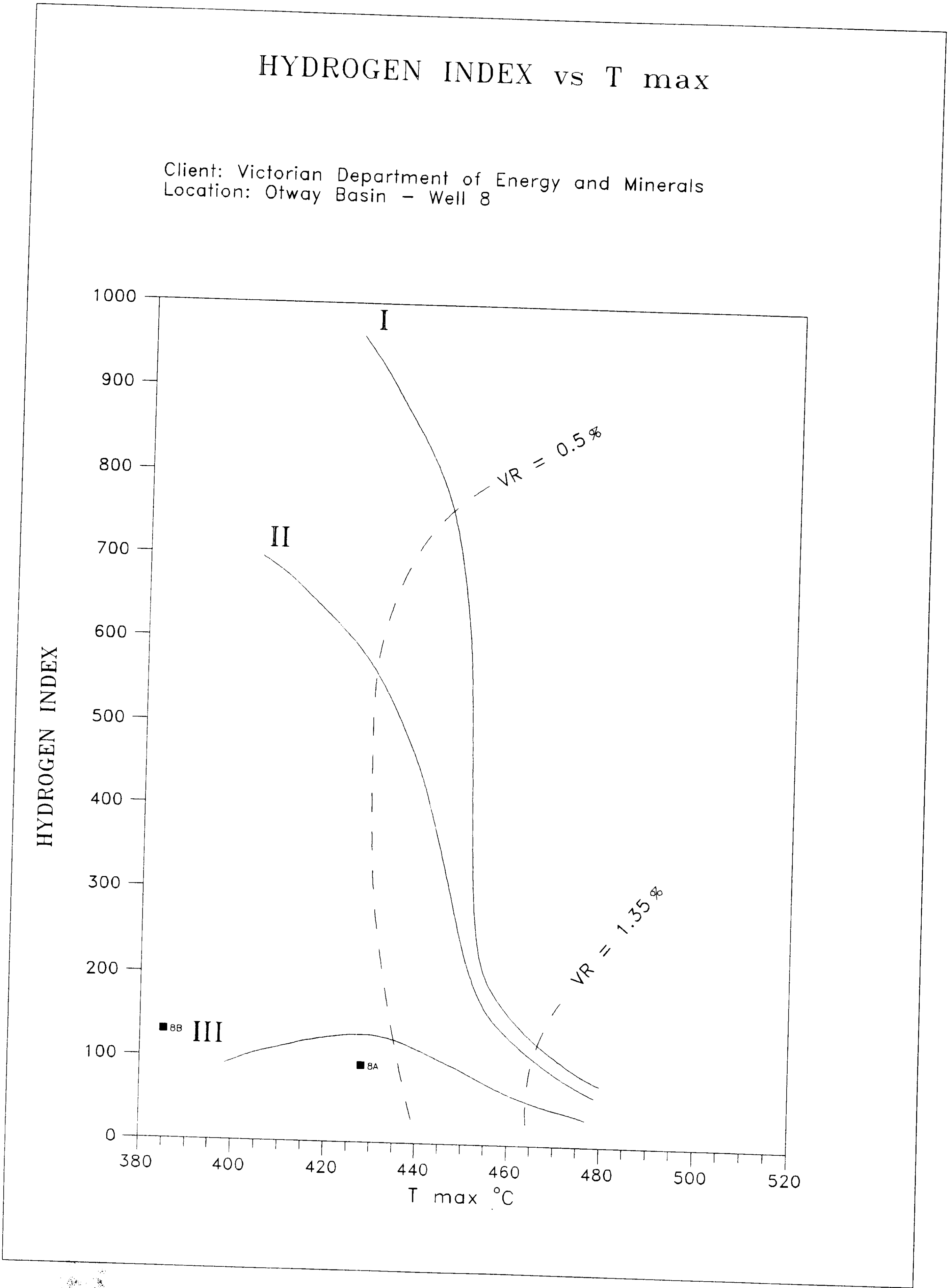

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 8
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
8B
8A
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2h

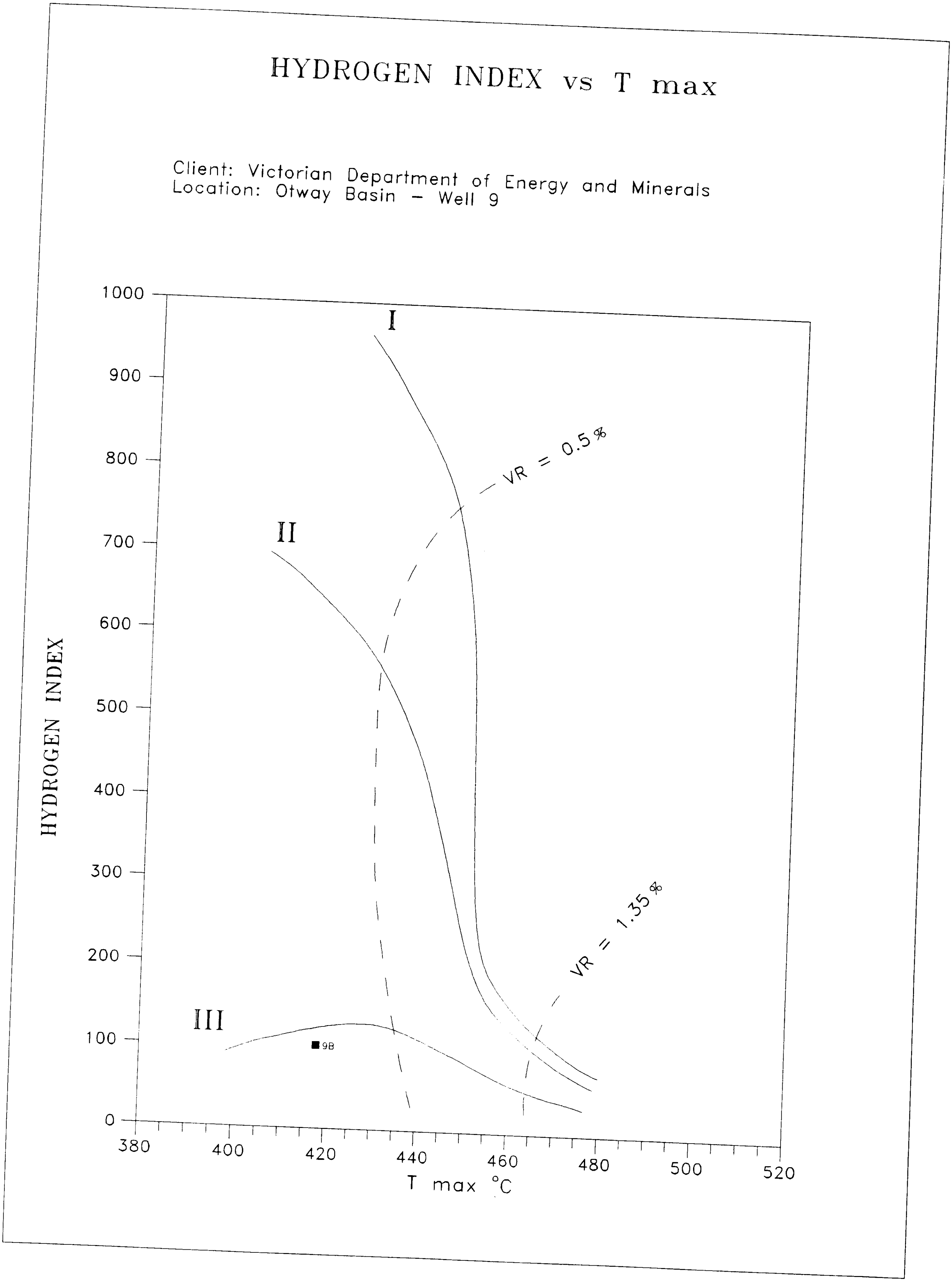

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 9
HYDROGEN INDEX
1000
900
800
700
600
500
400
300
200
100
0
380
400
420
440
460
480
500
520
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
9B

FIGURE 2i

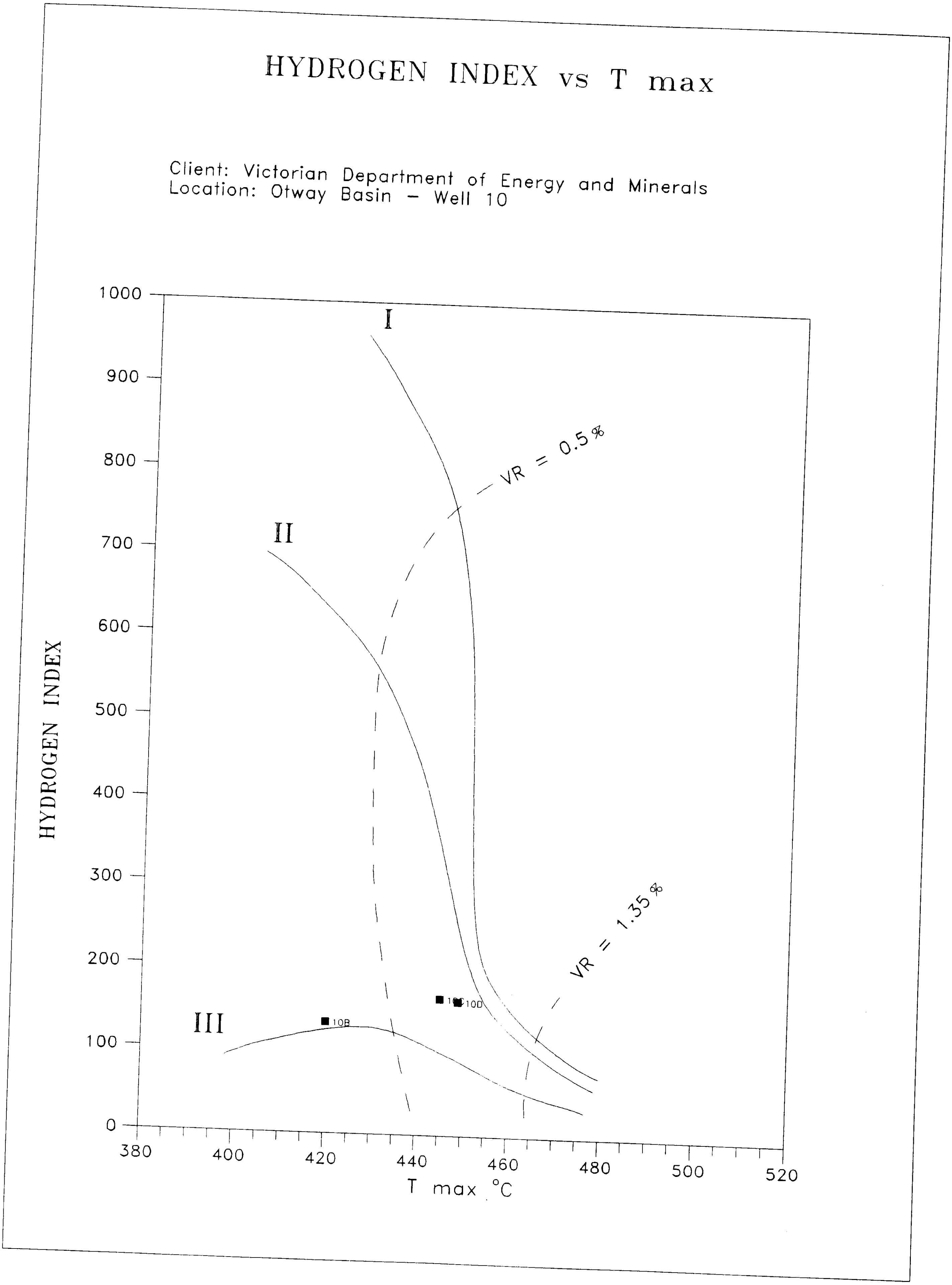

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 10
HYDROGEN INDEX
1000
900
800
700
600
500
400
300
200
100
0
I
II
III
VR = 0.5 %
VR = 1.35 %
10B
10C
10D
380
400
420
440
460
480
500
520
T max °C

FIGURE 2j

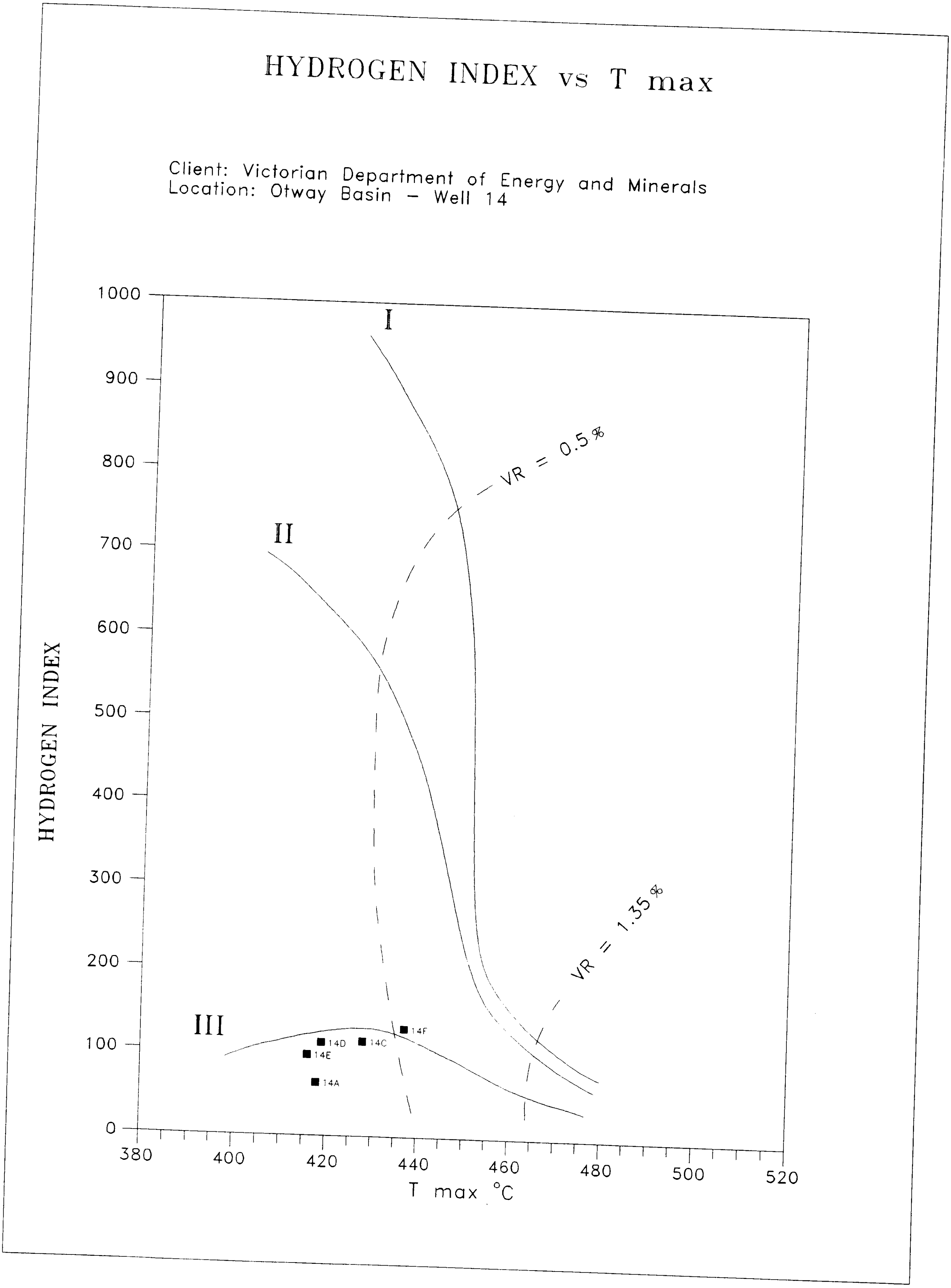
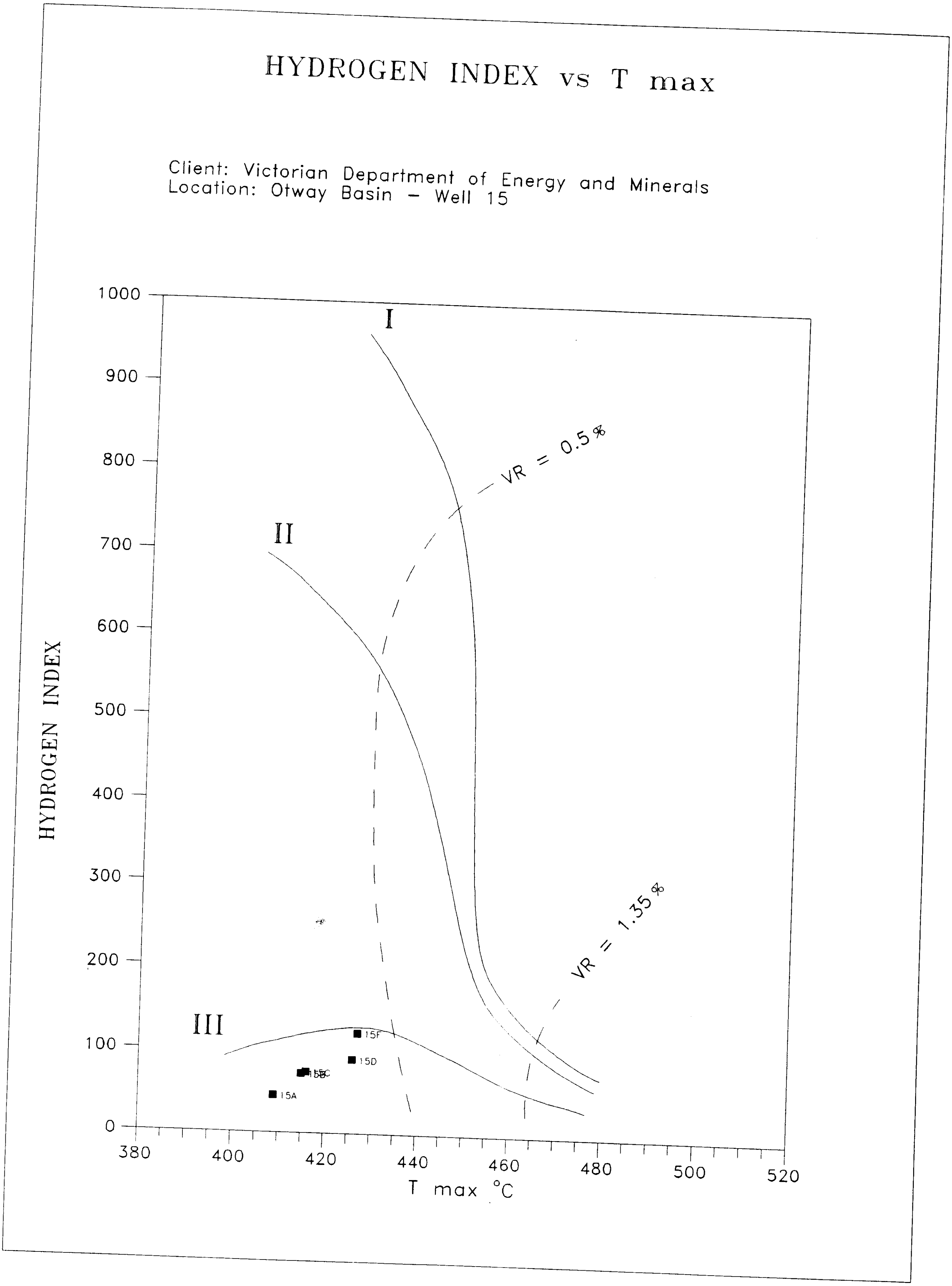

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 14
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
14A
14C
14D
14E
14F
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2k



HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 15
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
15A
15B
15C
15D
15F
1000
900
800
700
600
500
400
300
200
100
0
380
400
420
440
460
480
500
520

FIGURE 21

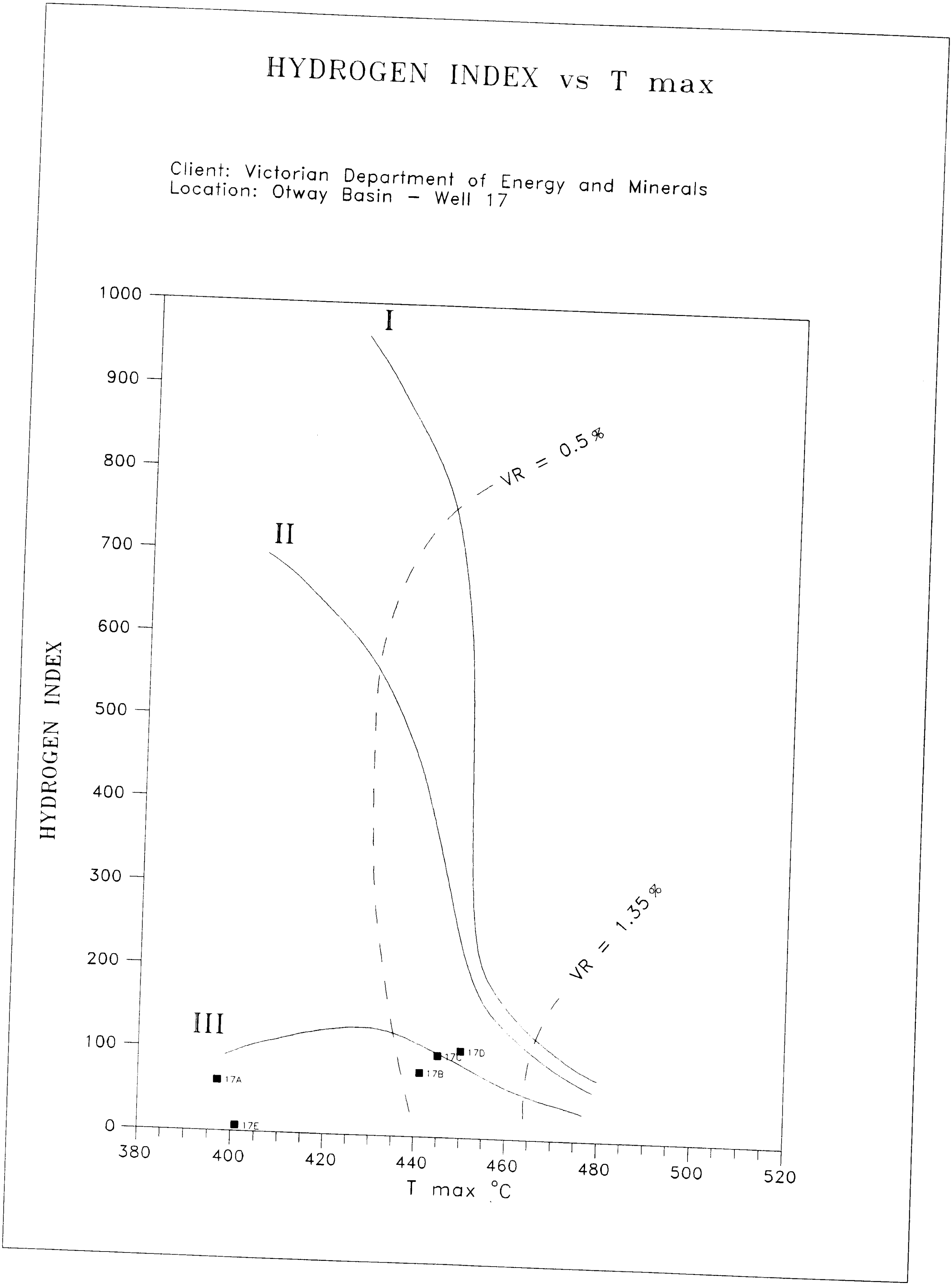
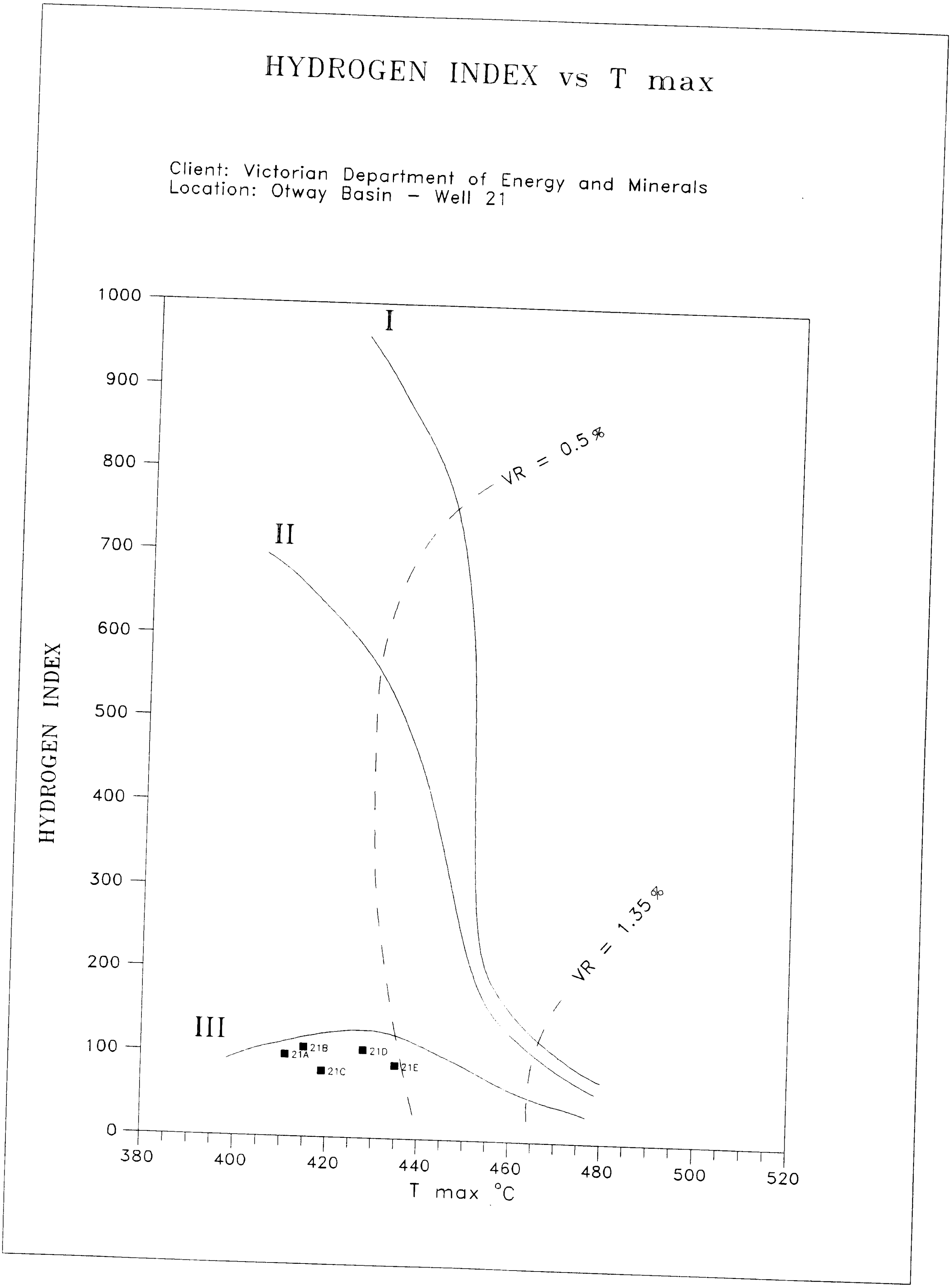
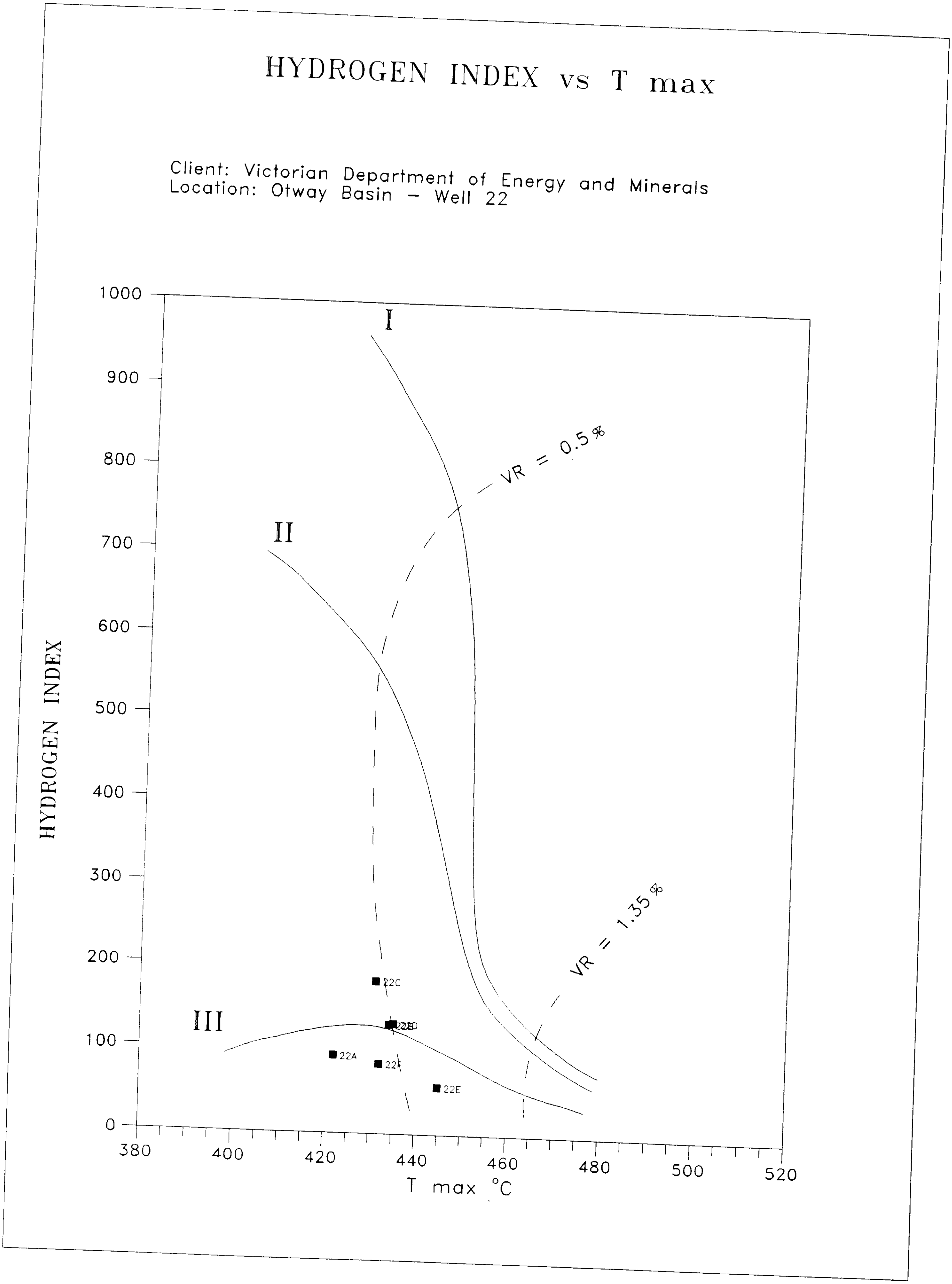

HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 17
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
17A
17B
17C
17D
17E
1000
900
800
700
600
500
400
300
200
100
0
380
400
420
440
460
480
500
520

FIGURE 2m



HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 21
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5%
VR = 1.35%
21A
21B
21C
21D
21E
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 2n



HYDROGEN INDEX vs T max
Client: Victorian Department of Energy and Minerals
Location: Otway Basin - Well 22
HYDROGEN INDEX
T max °C
I
II
III
VR = 0.5 %
VR = 1.35 %
22C
22A
22F
22E
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520

FIGURE 3

Victorian Department of Energy & Minerals
Otway Basin
Sample 1C, 1650-1652 metres
Pyrolysis GC

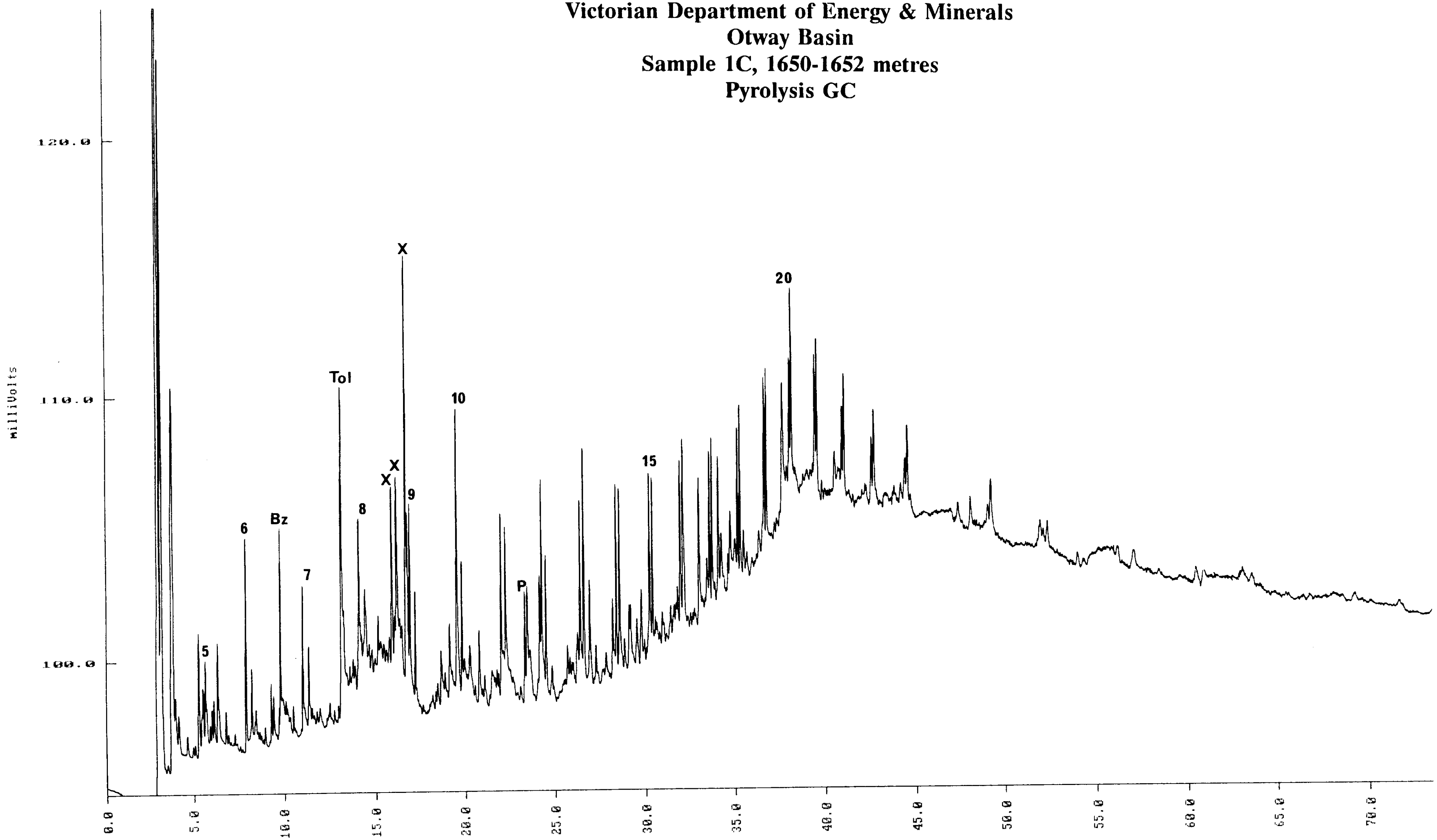


FIGURE 4

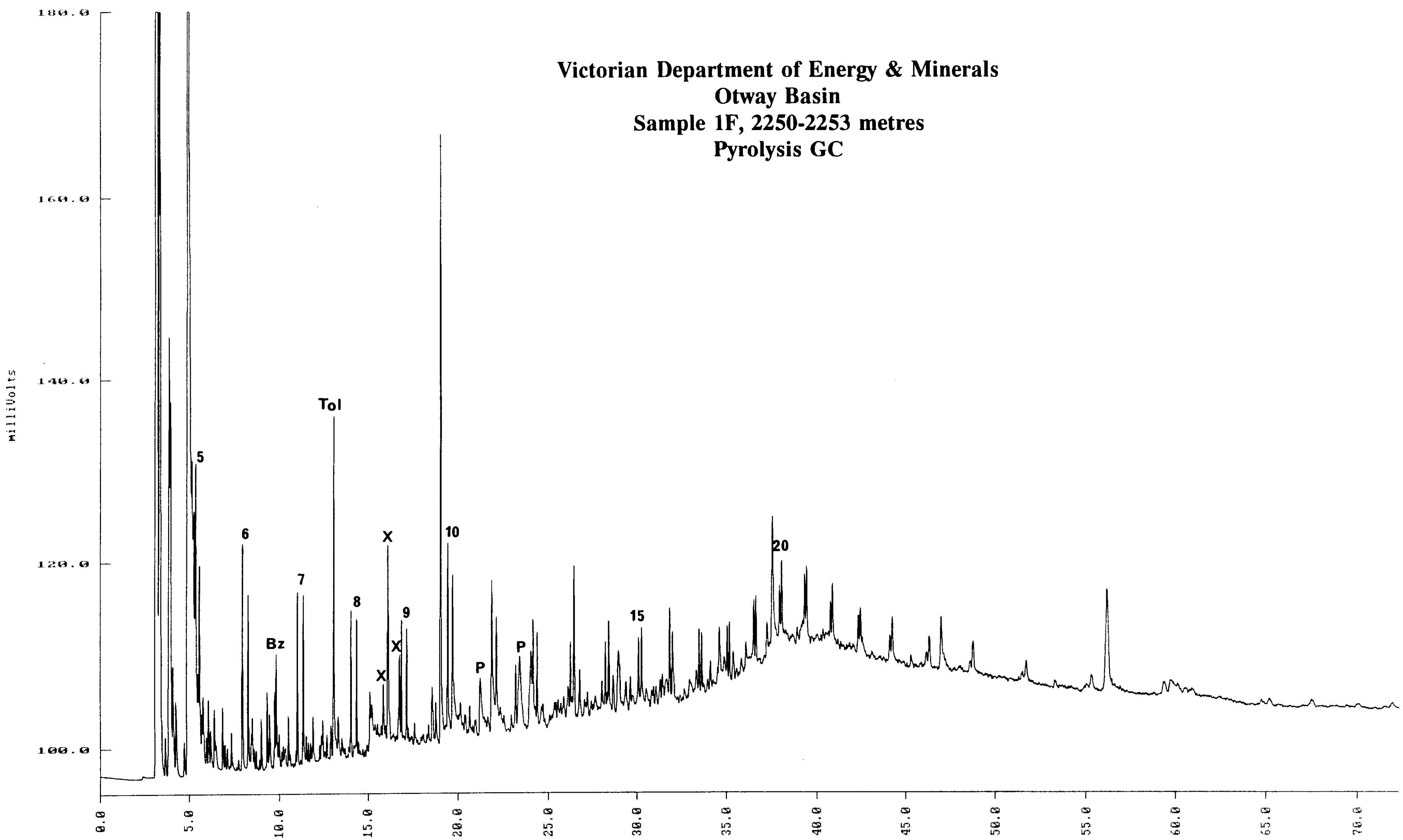
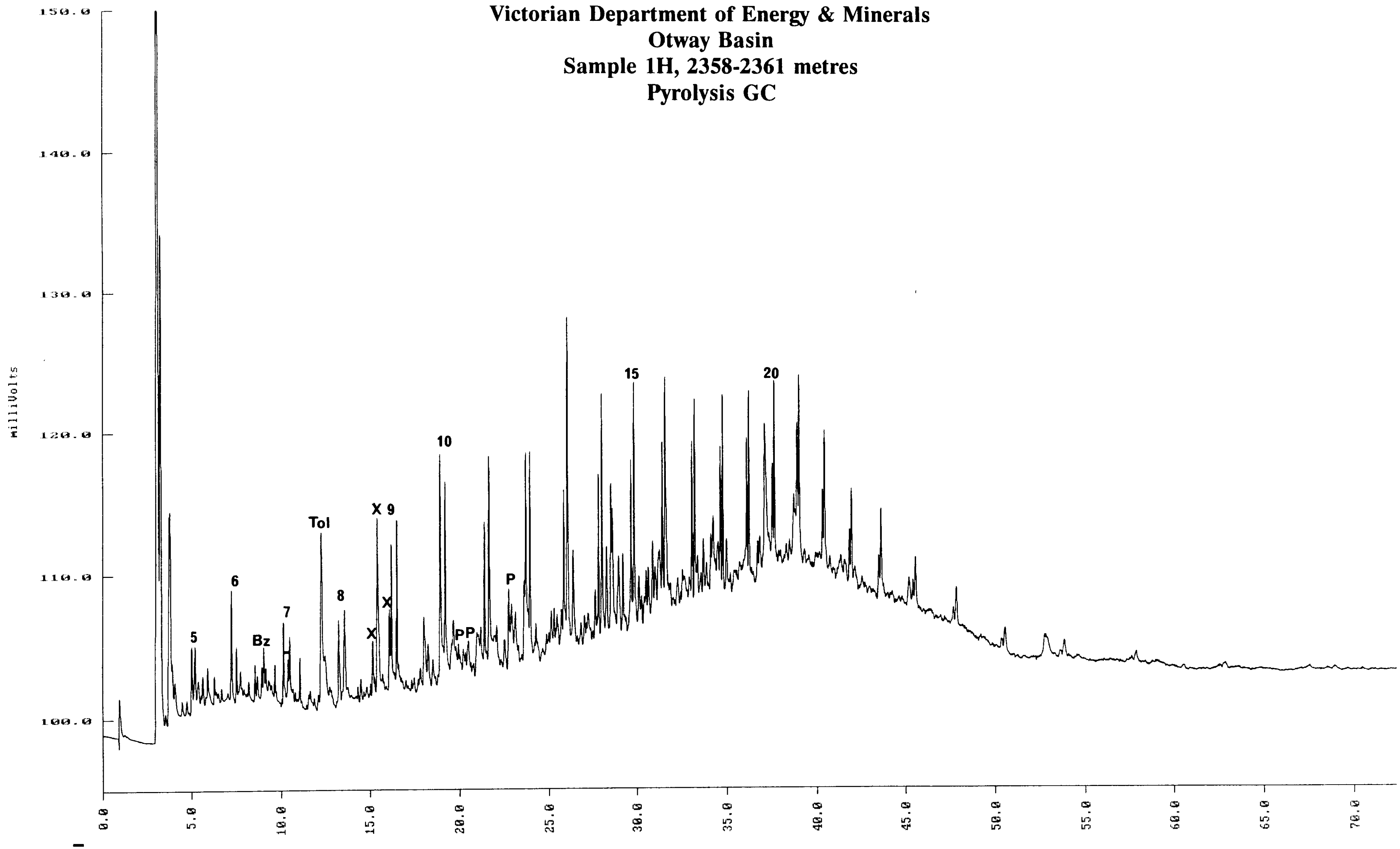

Victorian Department of Energy & Minerals
Otway Basin
Sample 1F, 2250-2253 metres
Pyrolysis GC
milliVolts
180.0
160.0
140.0
120.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
5
6
Bz
7
Tol
8
X
X
X
9
10
P
P
15
20

FIGURE 5



Victorian Department of Energy & Minerals
Otway Basin
Sample 1H, 2358-2361 metres
Pyrolysis GC
milliVolts
150.0
140.0
130.0
120.0
110.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
5
6
Bz
7
Tol
8
X
X 9
X
10
PP
P
15
20

FIGURE 6

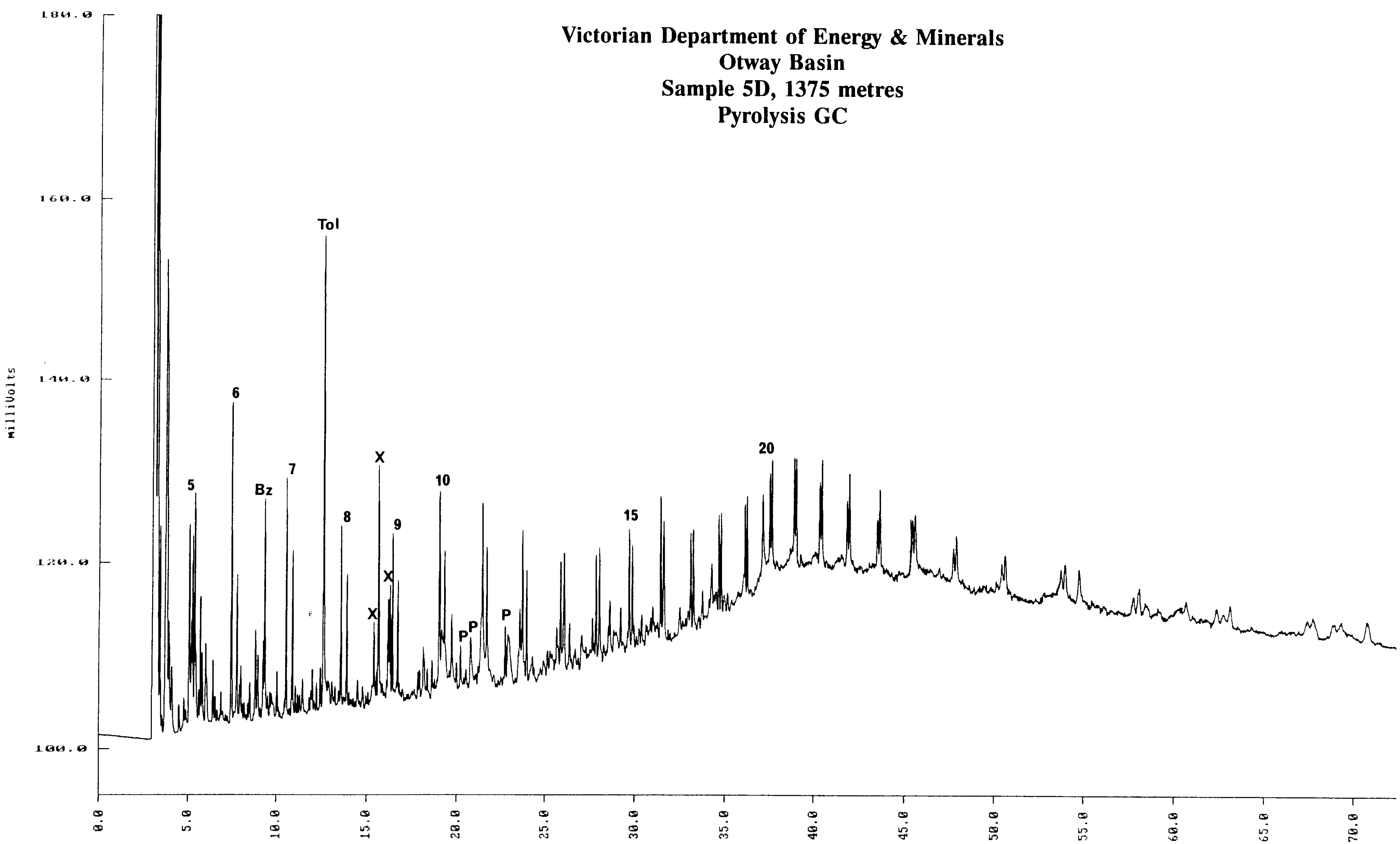

Victorian Department of Energy & Minerals
Otway Basin
Sample 5D, 1375 metres
Pyrolysis GC
milliVolts
180.0
160.0
140.0
120.0
100.0
Tol
6
5
Bz
7
8
X
9
X
X
10
P
P
P
15
20
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0

FIGURE 7

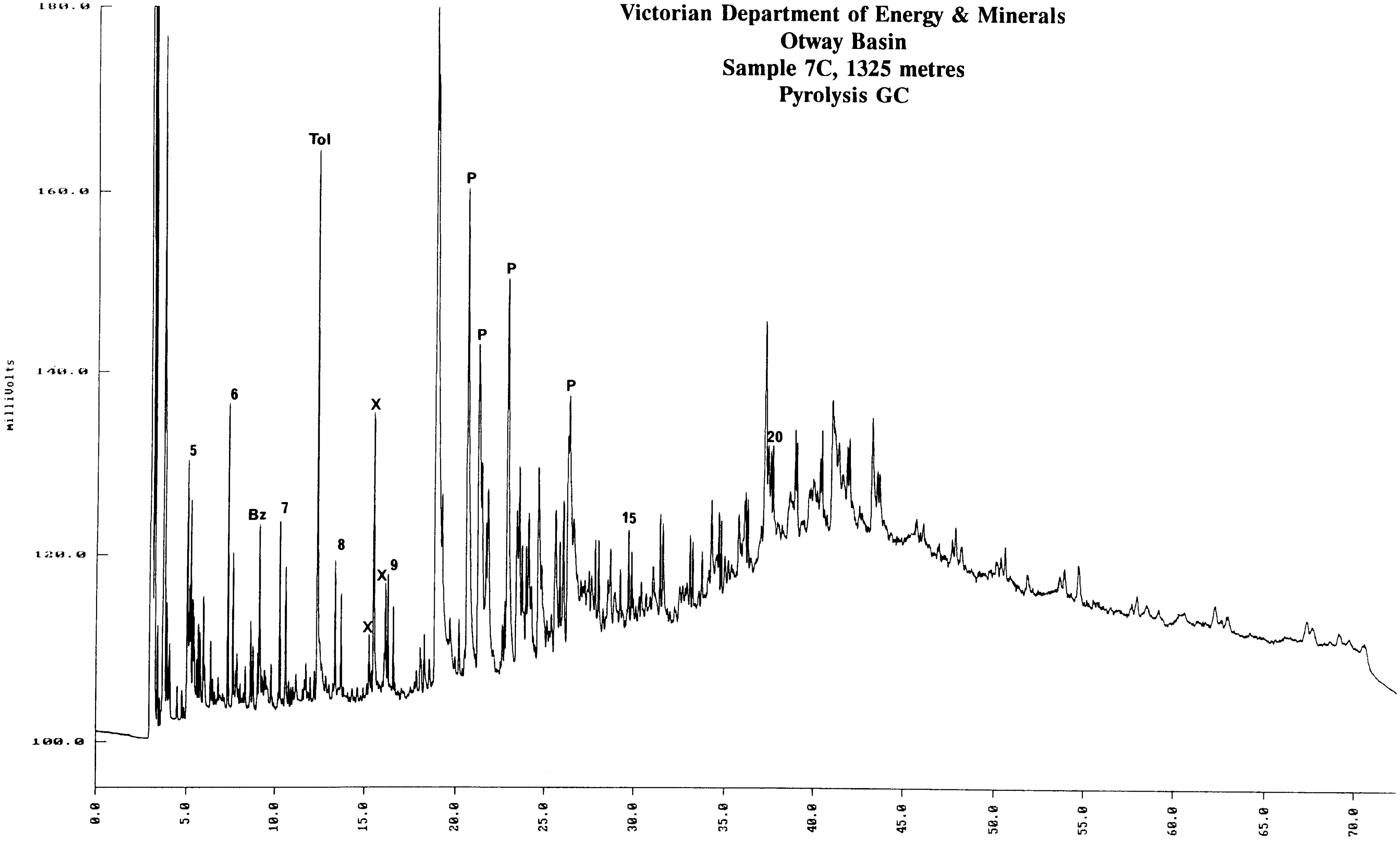

Victorian Department of Energy & Minerals
Otway Basin
Sample 7C, 1325 metres
Pyrolysis GC
milliVolts
180.0
160.0
140.0
120.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
5
6
Bz
7
Tol
8
X
X
X
9
P
P
P
P
15
20

FIGURE 8

Victorian Department of Energy & Minerals
Otway Basin
Sample 7E, 2525 metres
Pyrolysis GC

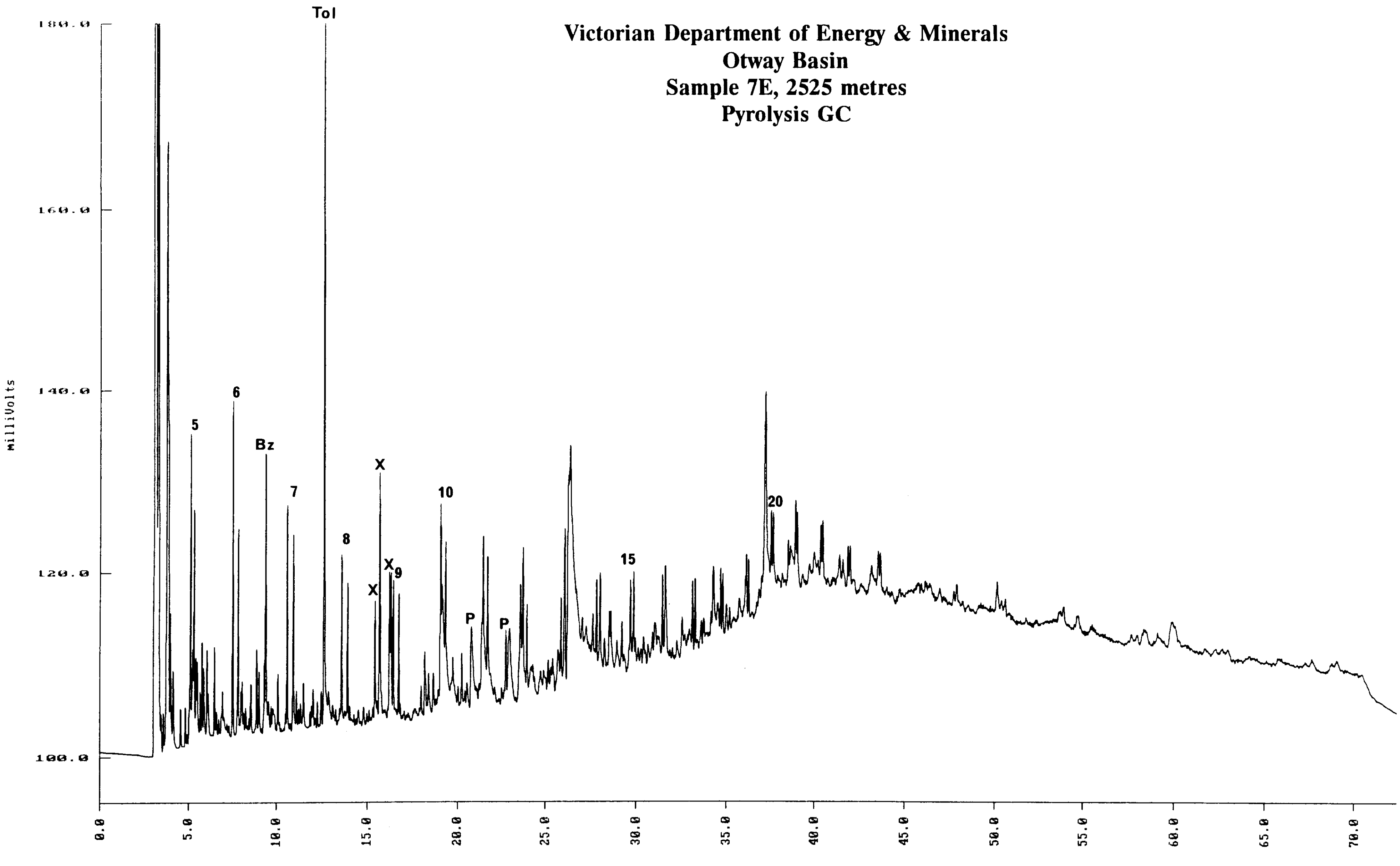


FIGURE 9

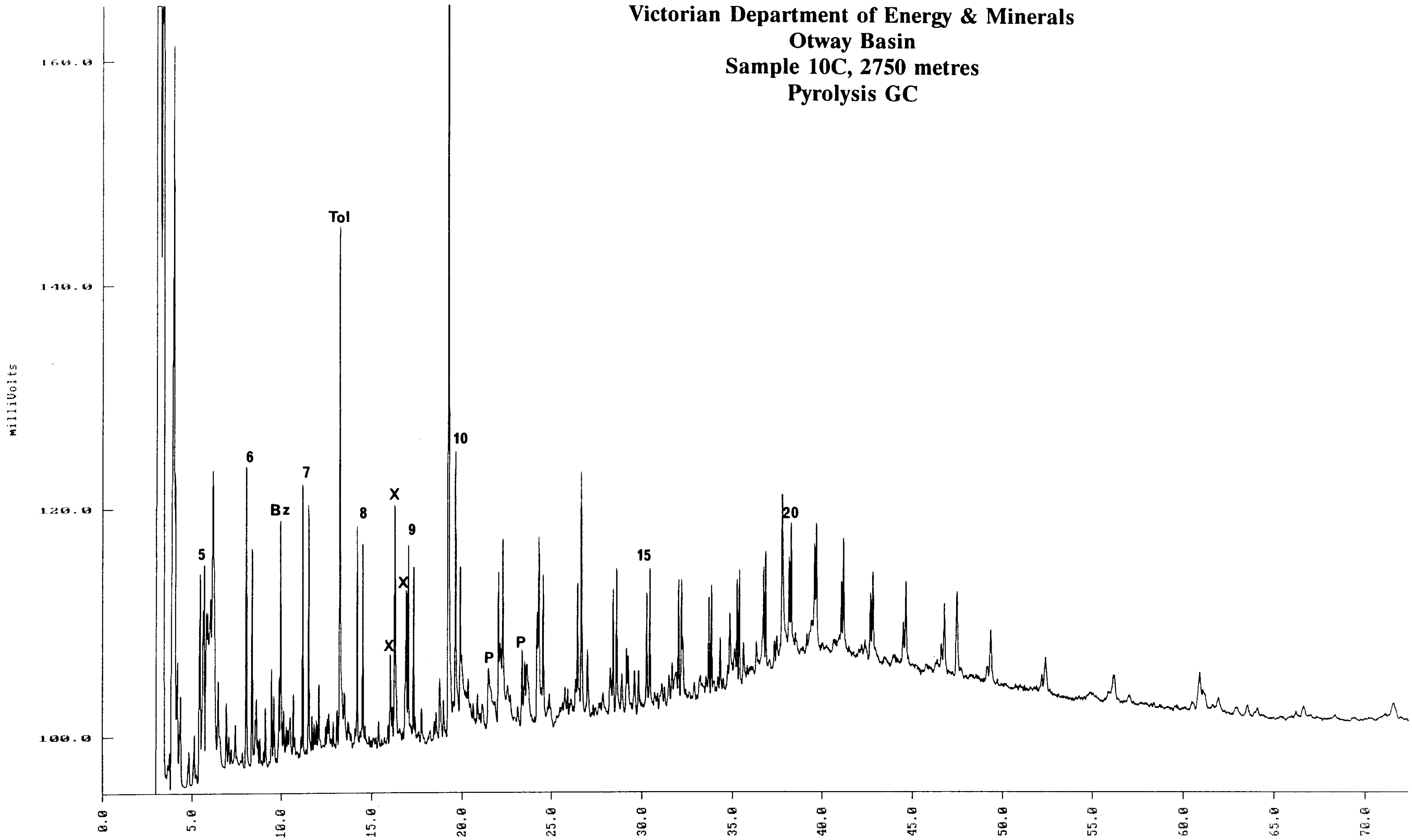

Victorian Department of Energy & Minerals
Otway Basin
Sample 10C, 2750 metres
Pyrolysis GC
milliVolts
160.0
140.0
120.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
5
6
Bz
7
Tol
8
X
X
X
9
10
P
P
15
20

FIGURE 10

Victorian Department of Energy & Minerals
Otway Basin
Sample 10D, 2975 metres
Pyrolysis GC

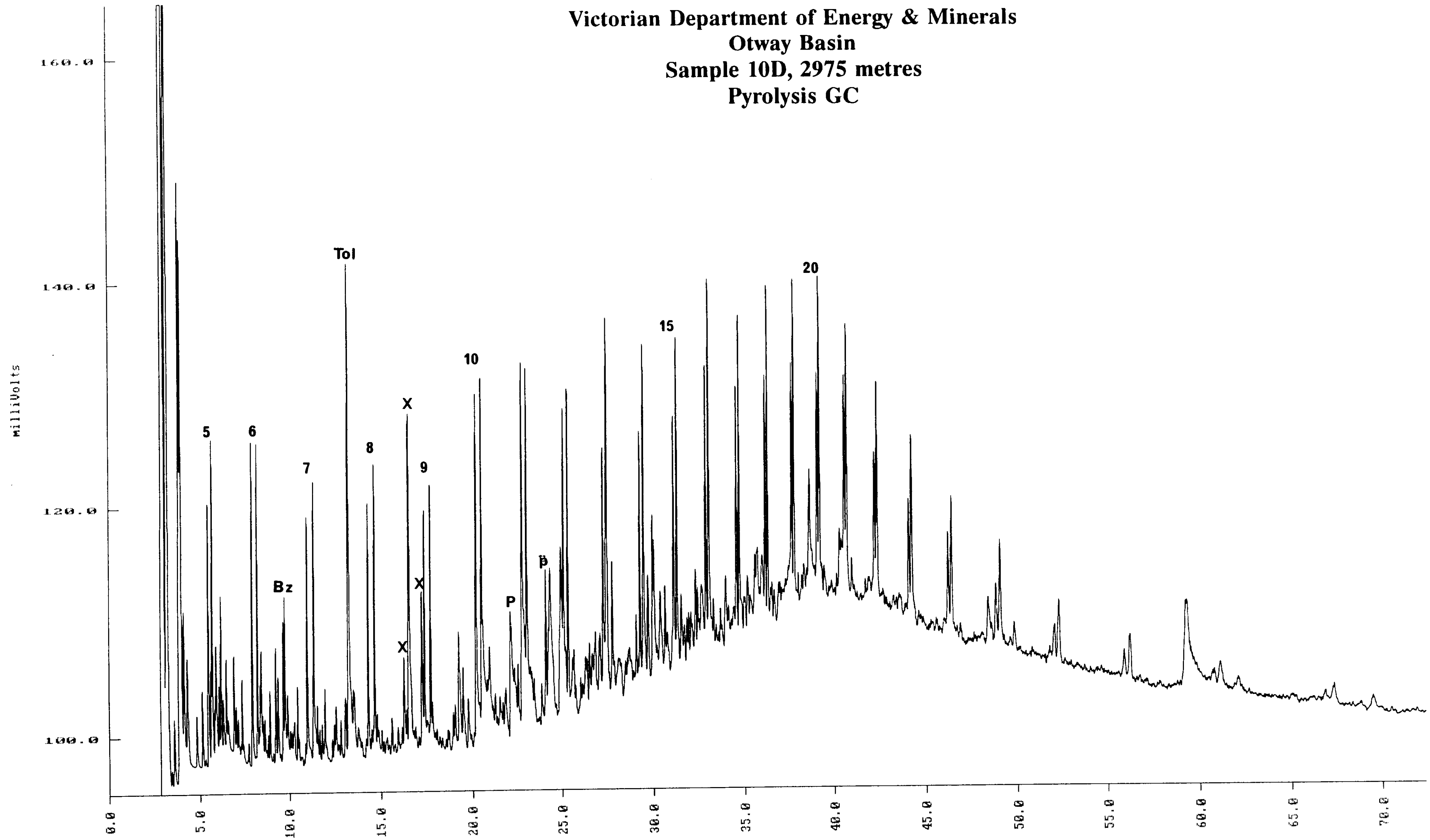
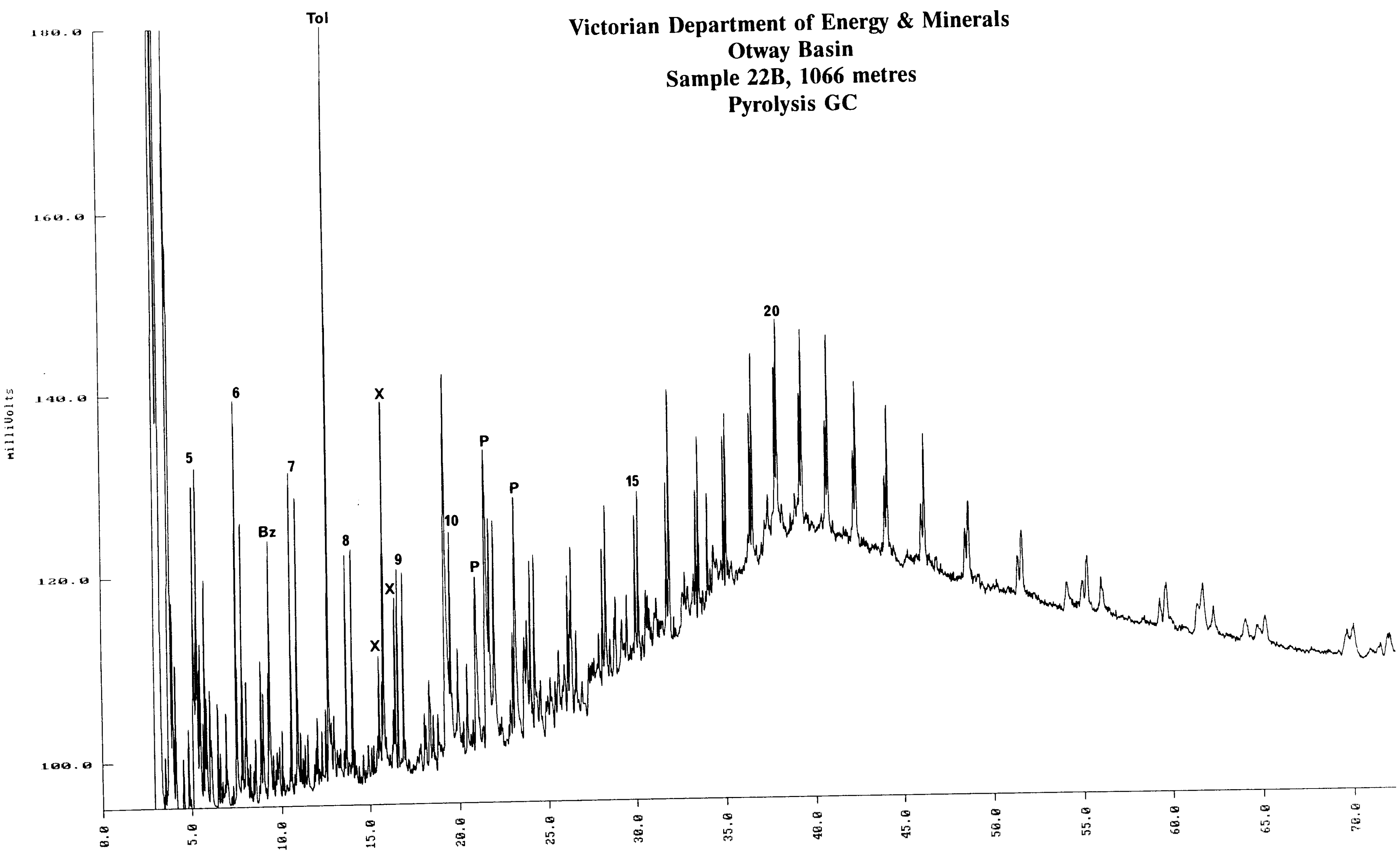


FIGURE 11



Victorian Department of Energy & Minerals
Otway Basin
Sample 22B, 1066 metres
Pyrolysis GC
MilliVolts
180.0
160.0
140.0
120.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
Tol
5
6
Bz
7
8
X
X
X
9
10
P
P
P
15
20

FIGURE 12

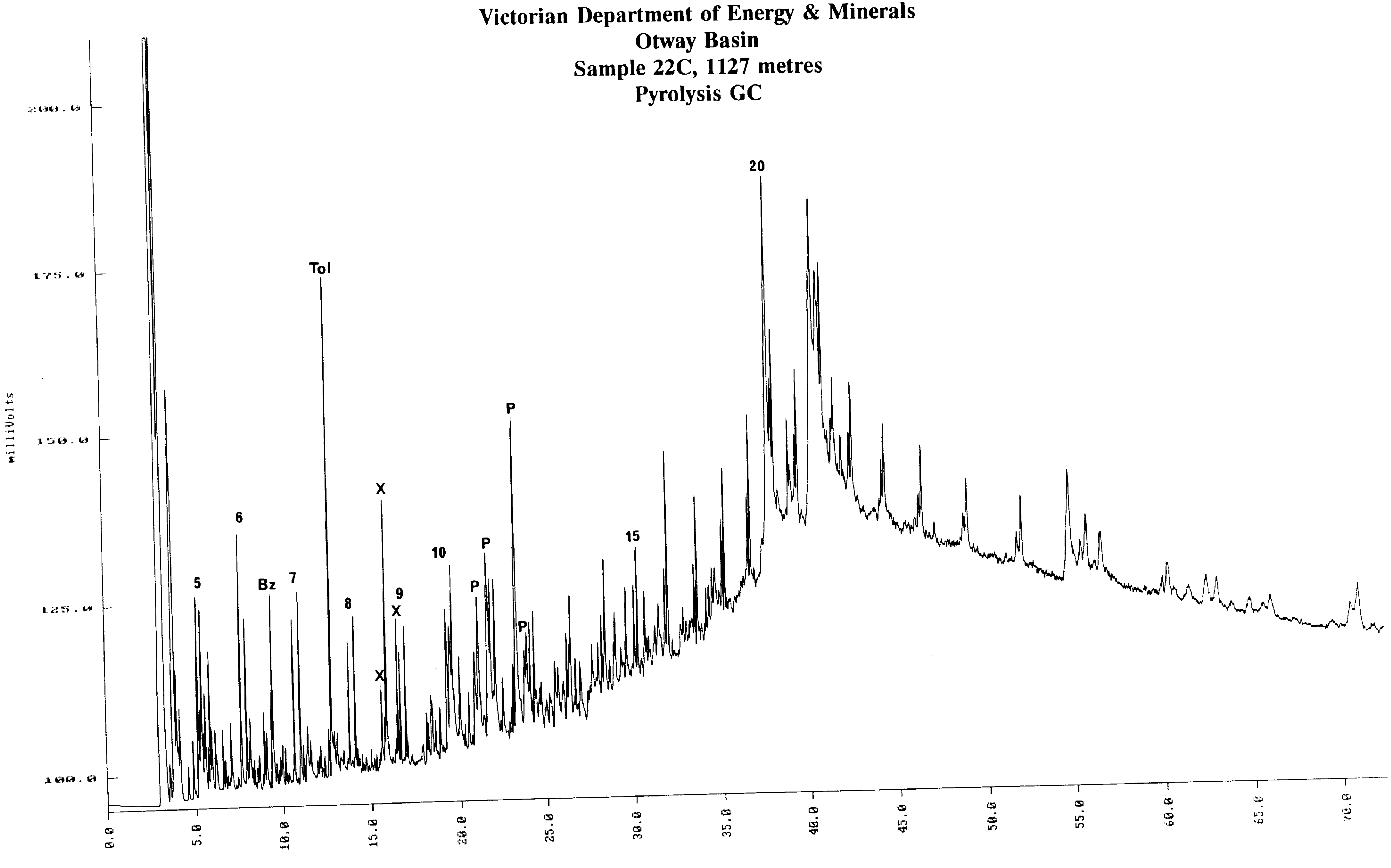

Victorian Department of Energy & Minerals
Otway Basin
Sample 22C, 1127 metres
Pyrolysis GC
milliVolts
200.0
175.0
150.0
125.0
100.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
65.0
70.0
5
6
Bz
7
Tol
8
X
X
9
X
10
P
P
P
P
15
20

FIGURE 13

Otway Basin
1C 1650-1652 metres
GC of saturates fraction

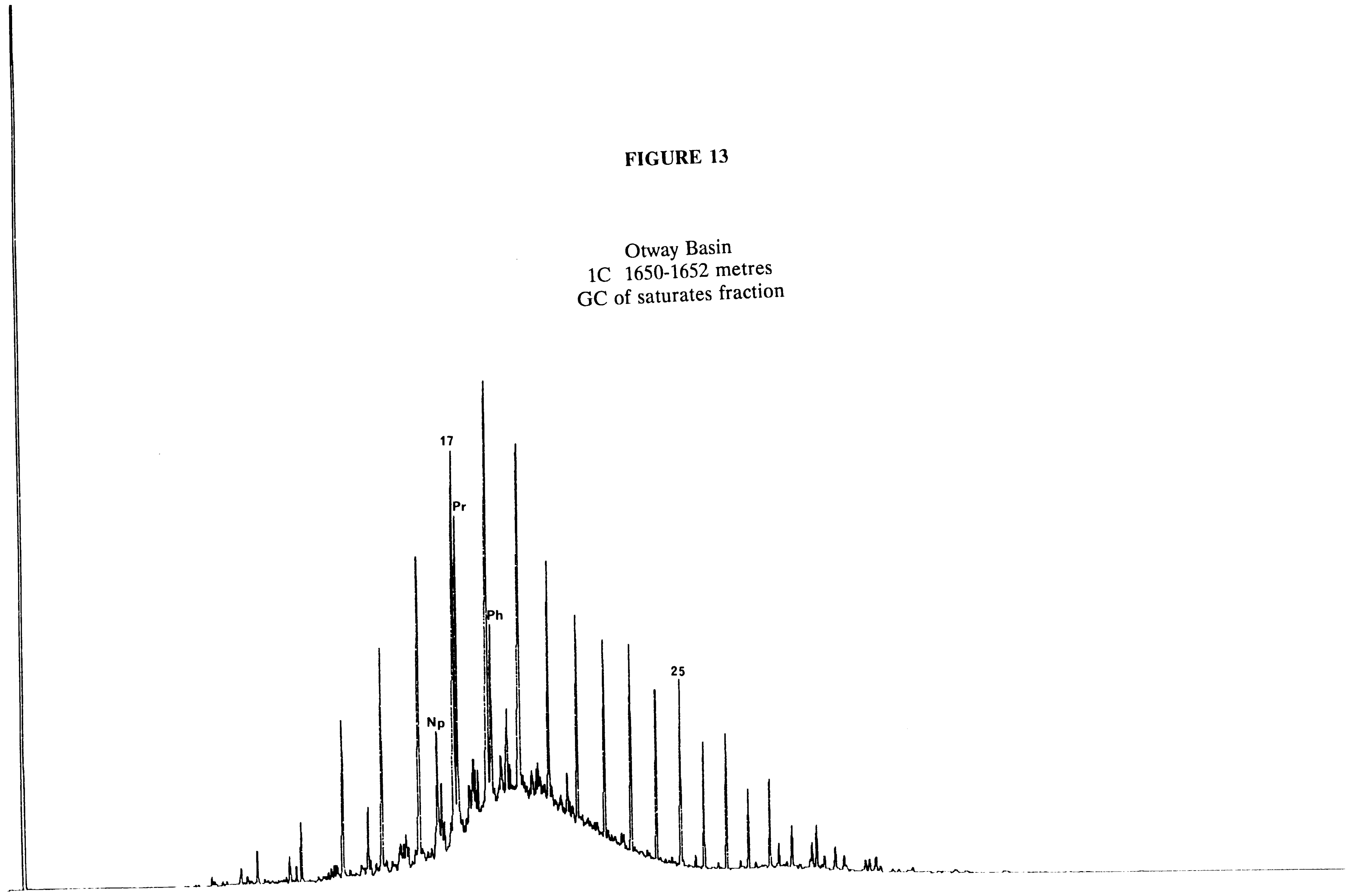


FIGURE 14

Otway Basin
1H 2358-2361 metres
GC of saturates fraction

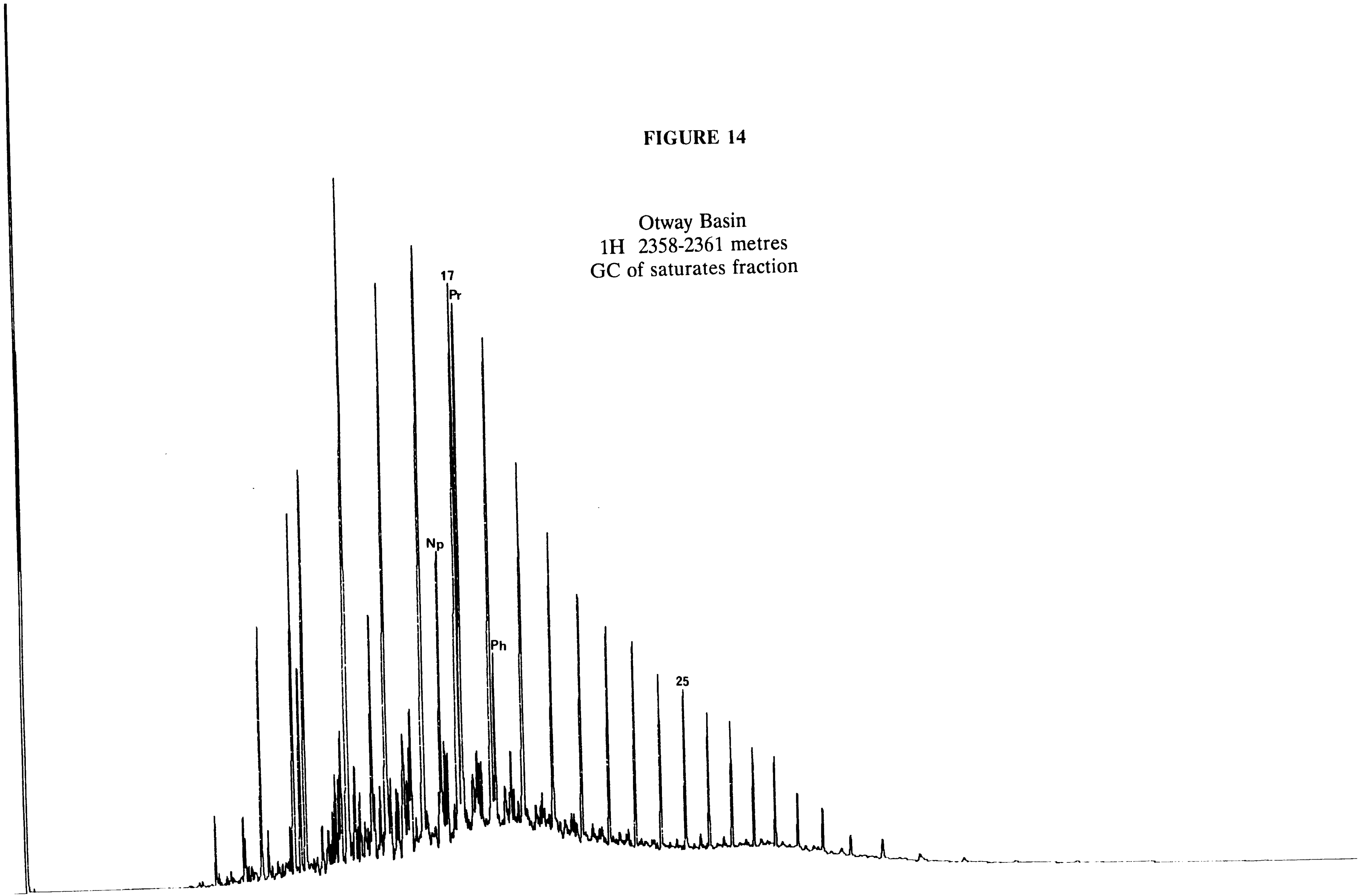


FIGURE 15

Otway Basin
4A 1965 metres
GC of saturates fraction

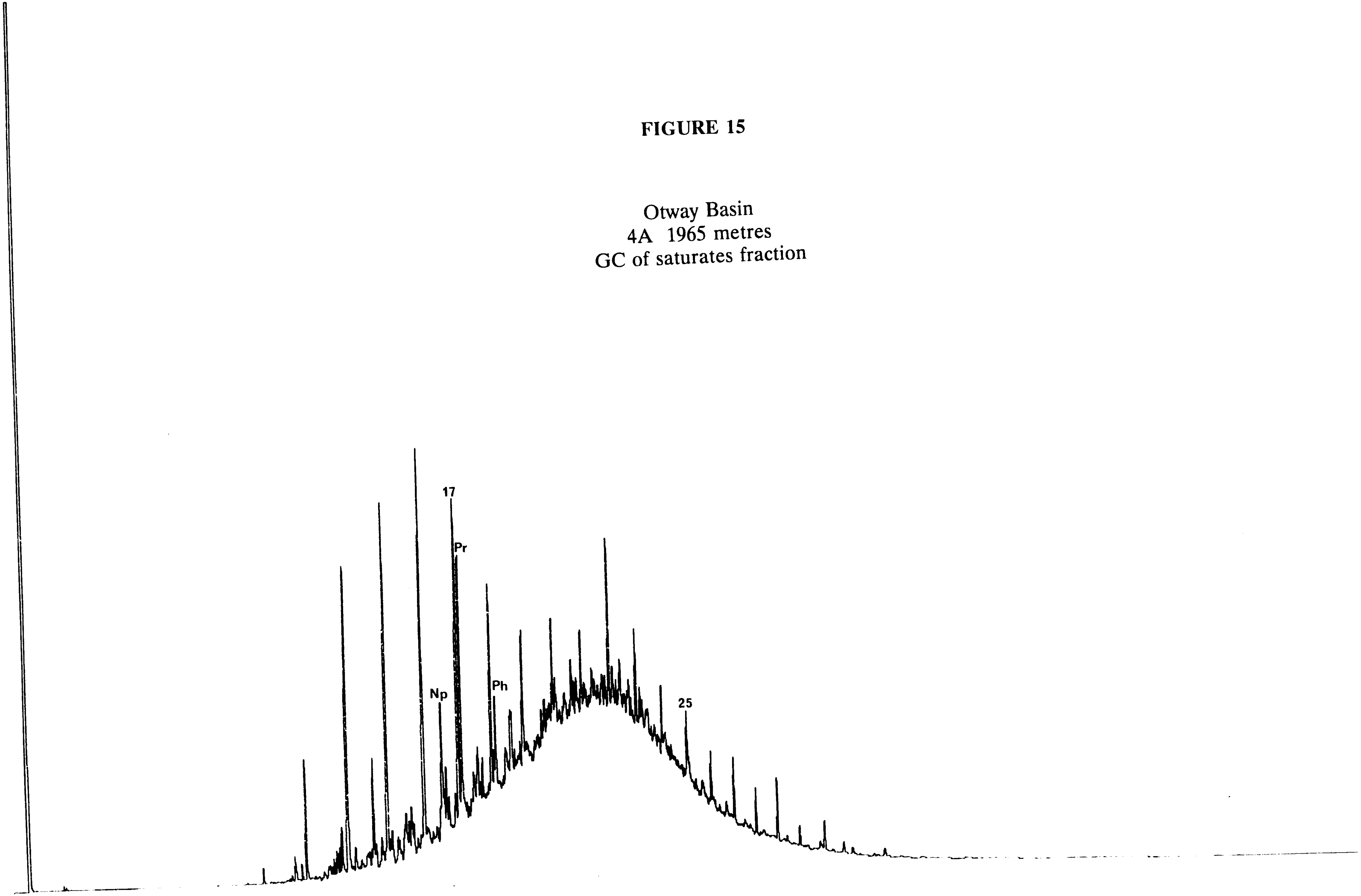


FIGURE 16

Otway Basin
5F 2080 metres
GC of saturates fraction

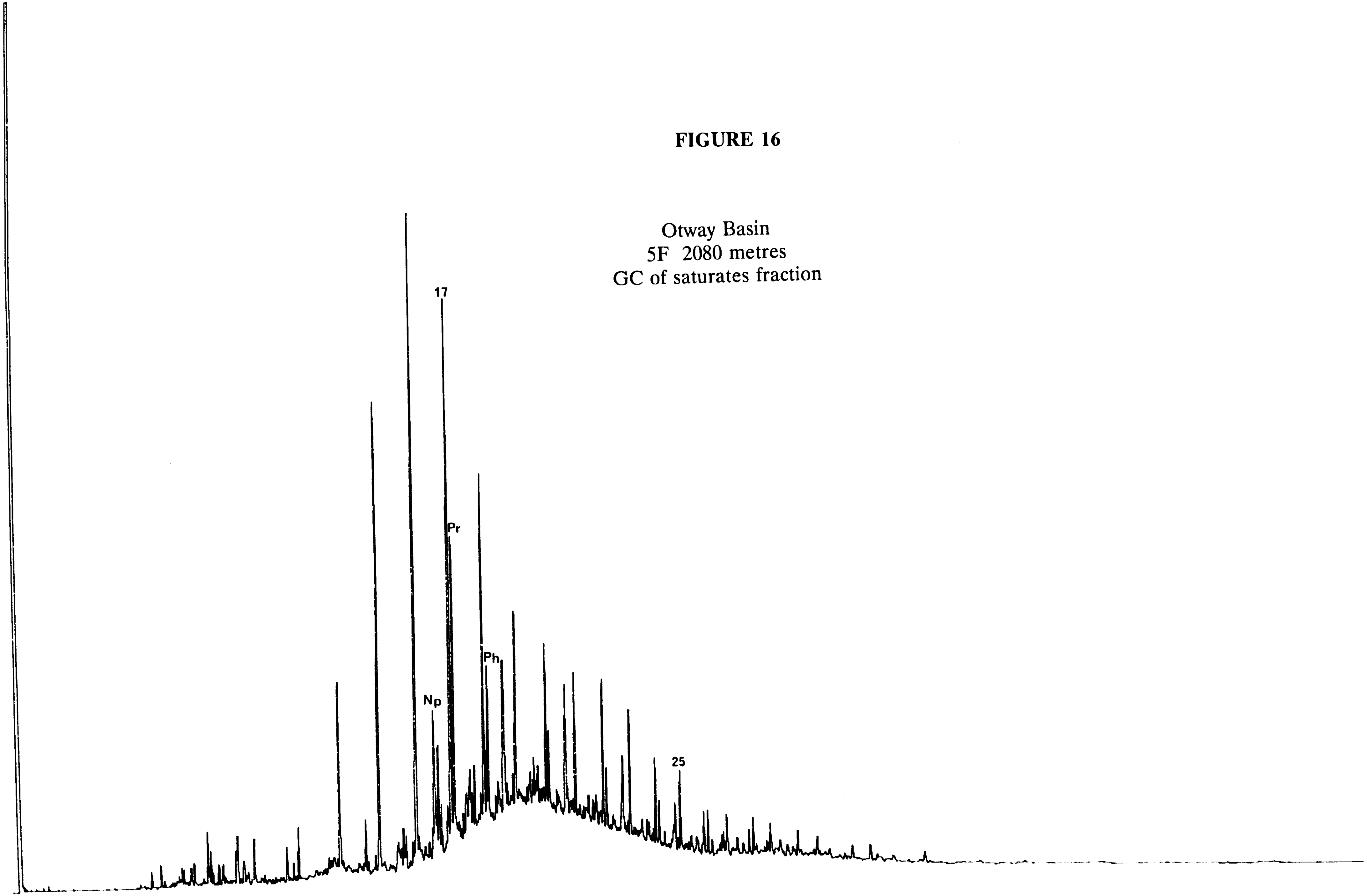


FIGURE 17

Otway Basin
7C 1325 metres
GC of saturates fraction

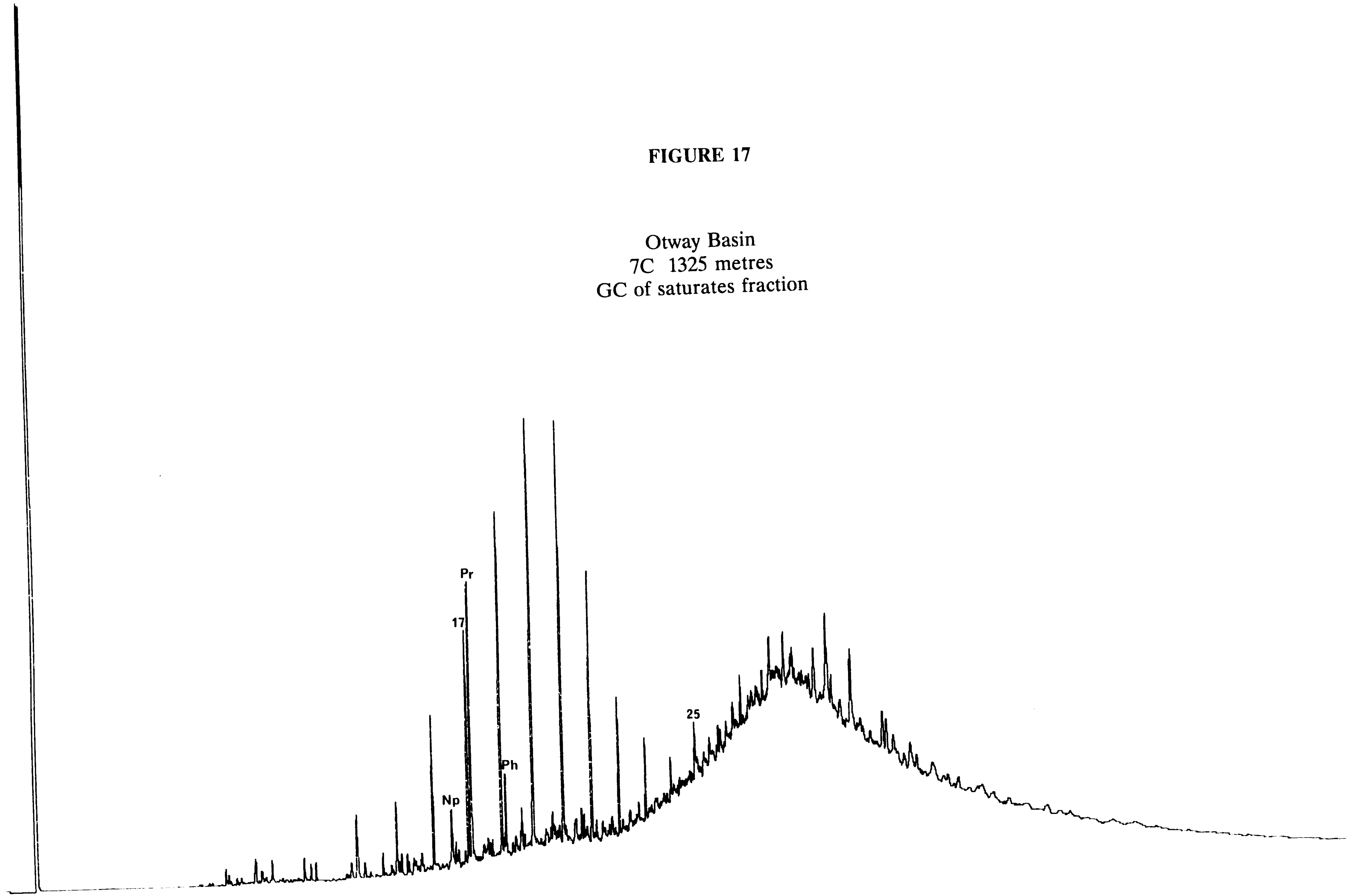


FIGURE 18

Otway Basin
7E 2525 metres
GC of saturates fraction

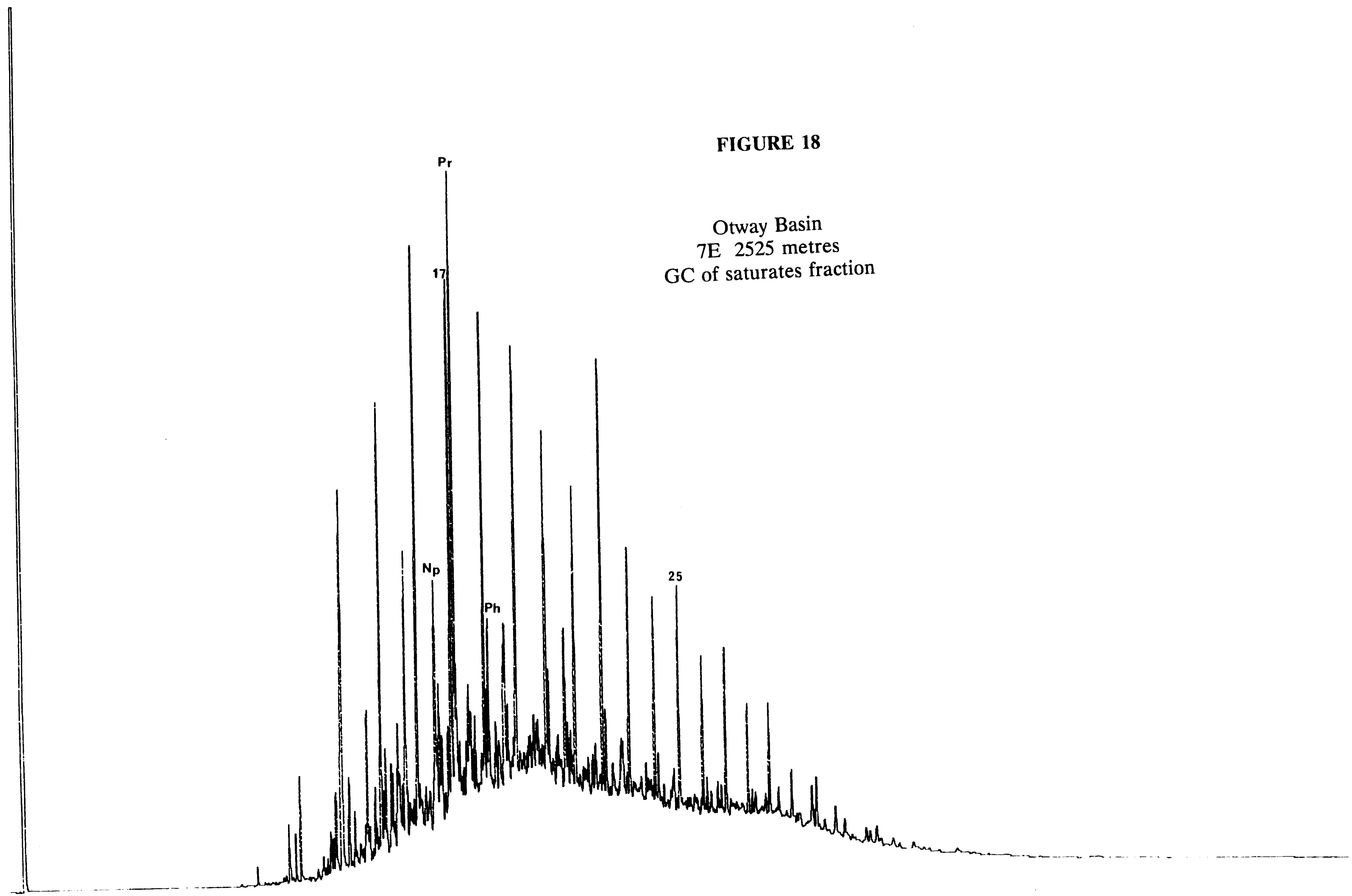


FIGURE 19

Otway Basin
8B 853 metres
GC of saturates fraction

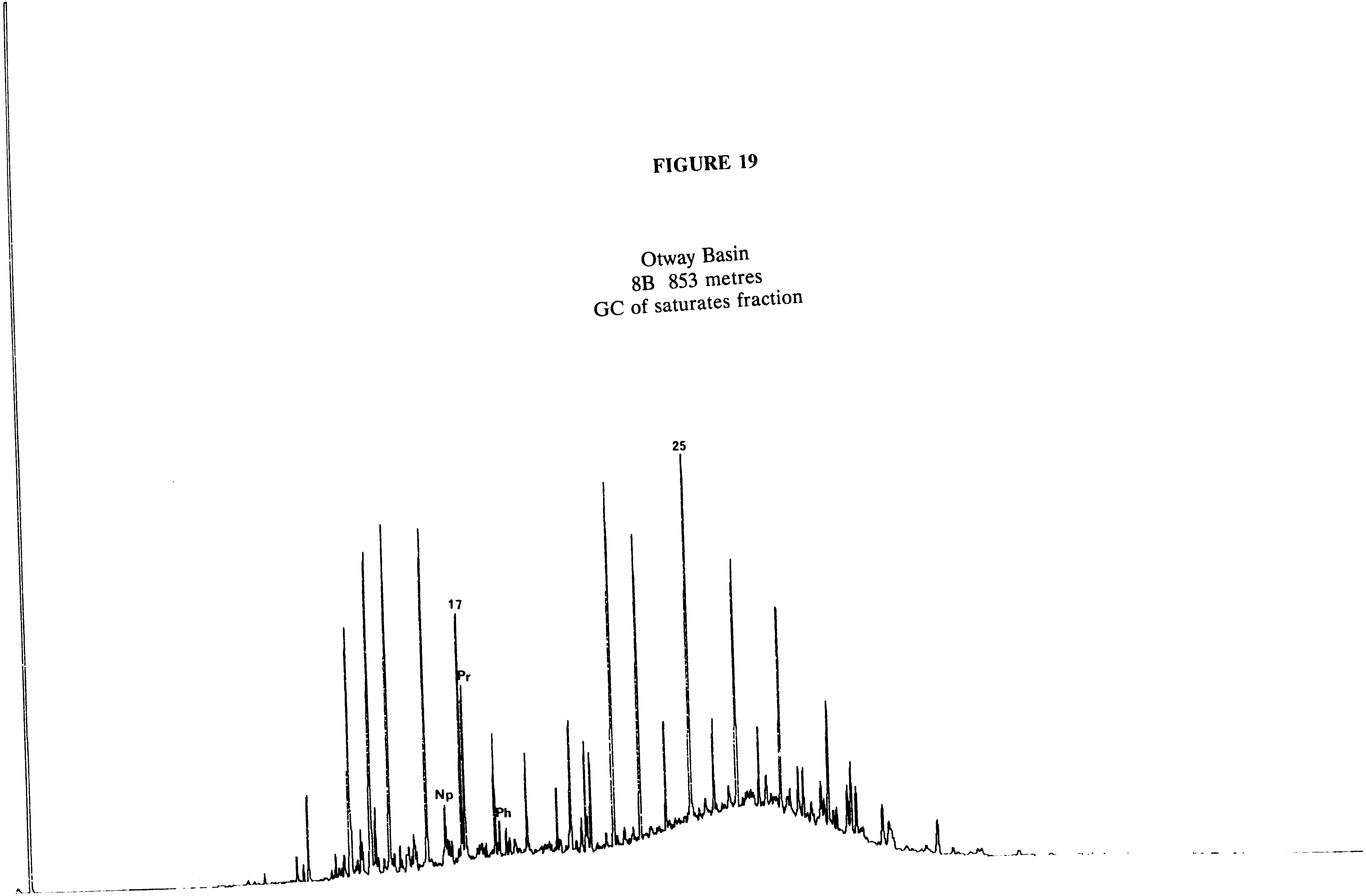


FIGURE 20

Otway Basin
9A 600 metres
GC of saturates fraction

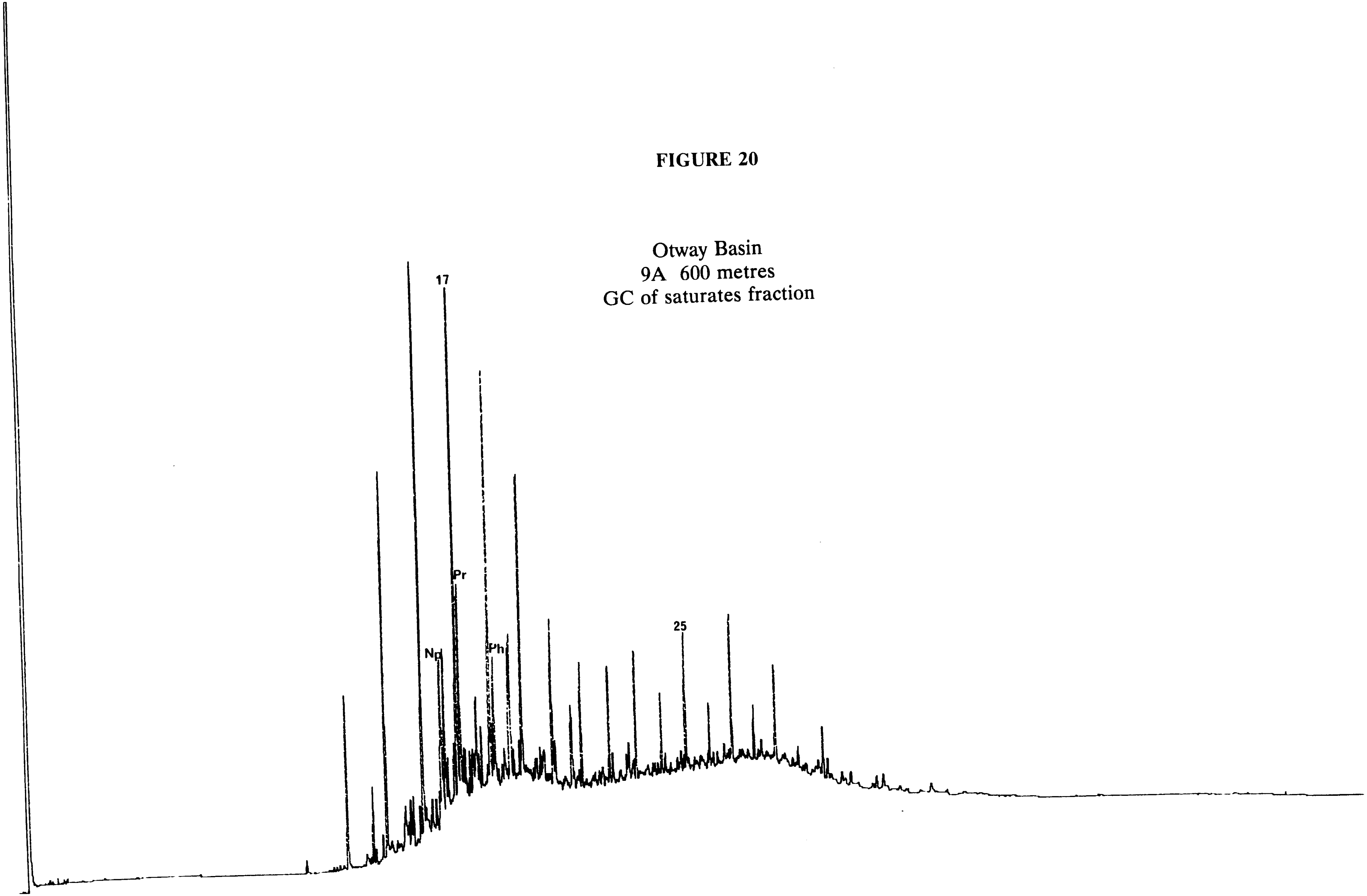


FIGURE 21

Otway Basin
10C 2750 metres
GC of saturates fraction

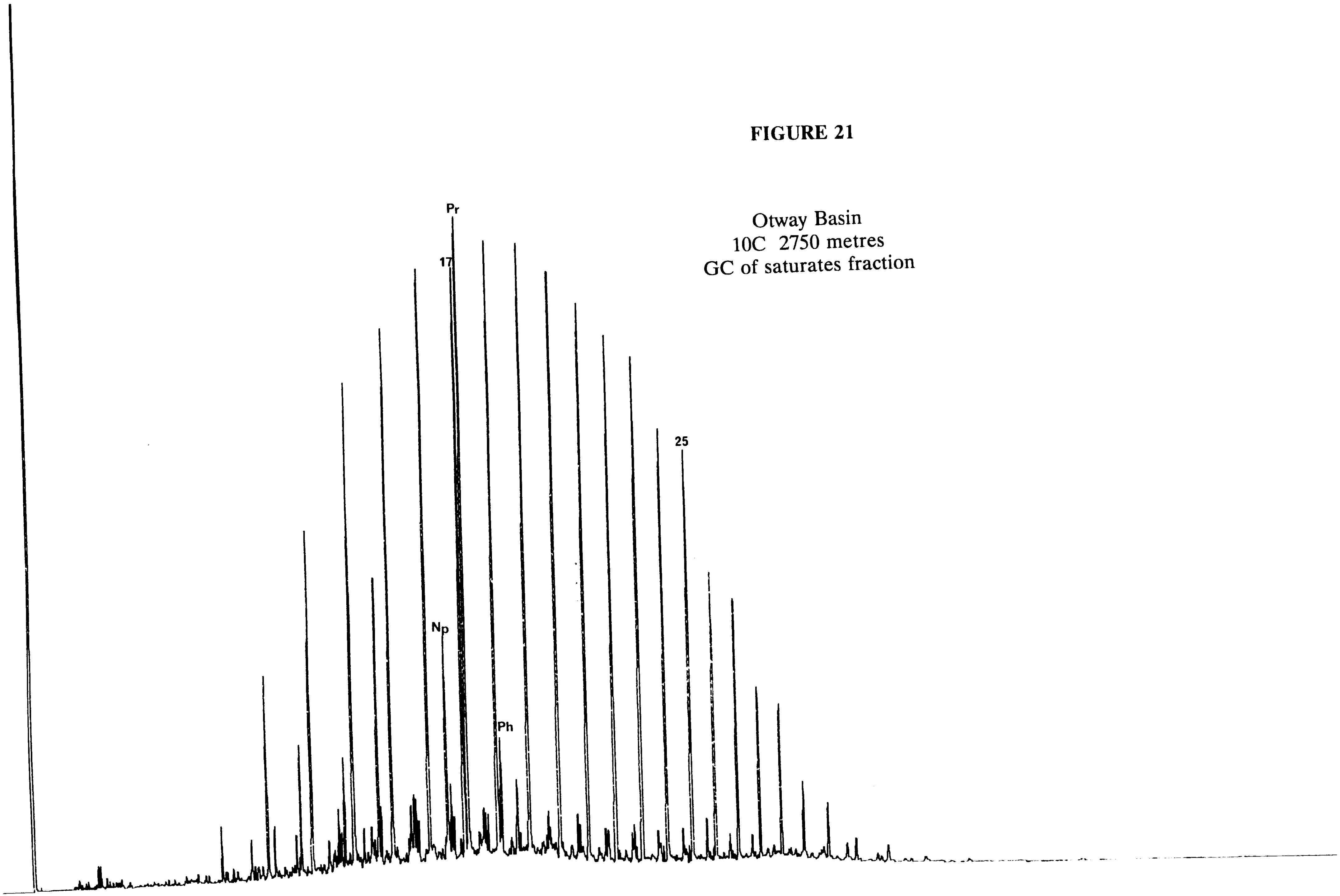


FIGURE 22

Otway Basin
14A 1400 metres
GC of saturates fraction

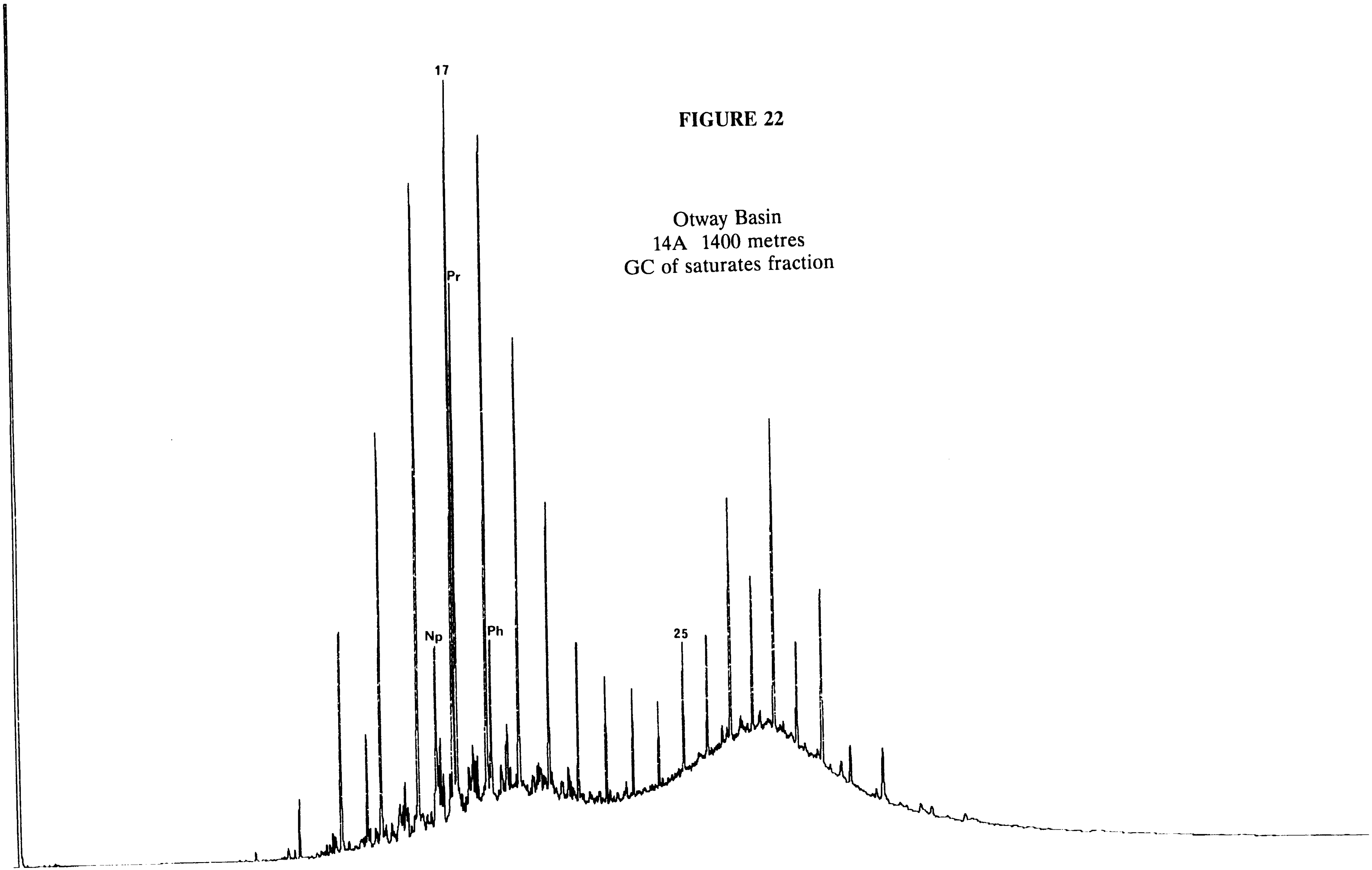


FIGURE 23

Otway Basin
15A 825 metres
GC of saturates fraction

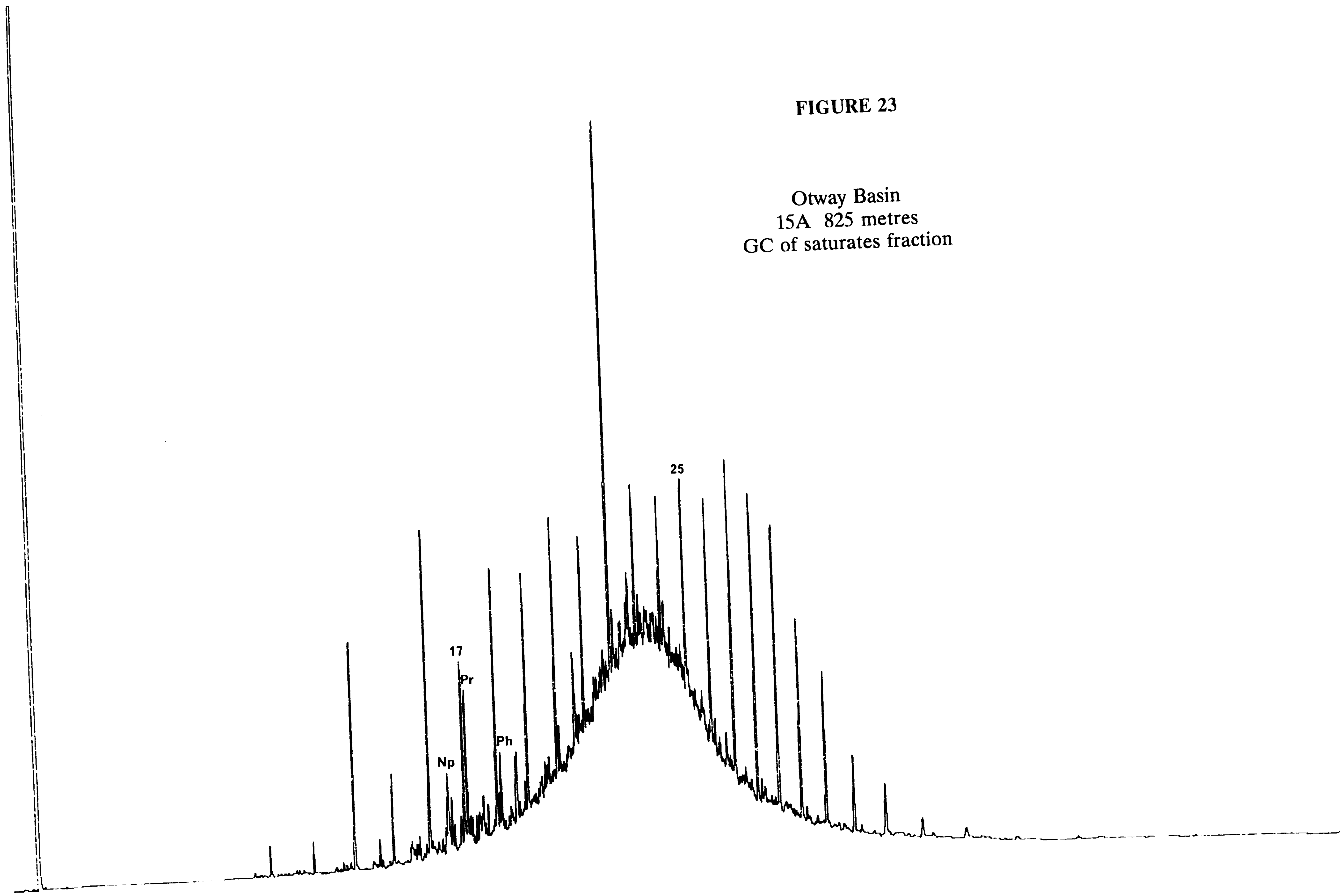


FIGURE 24

Otway Basin
17E 3513 metres
GC of saturates fraction

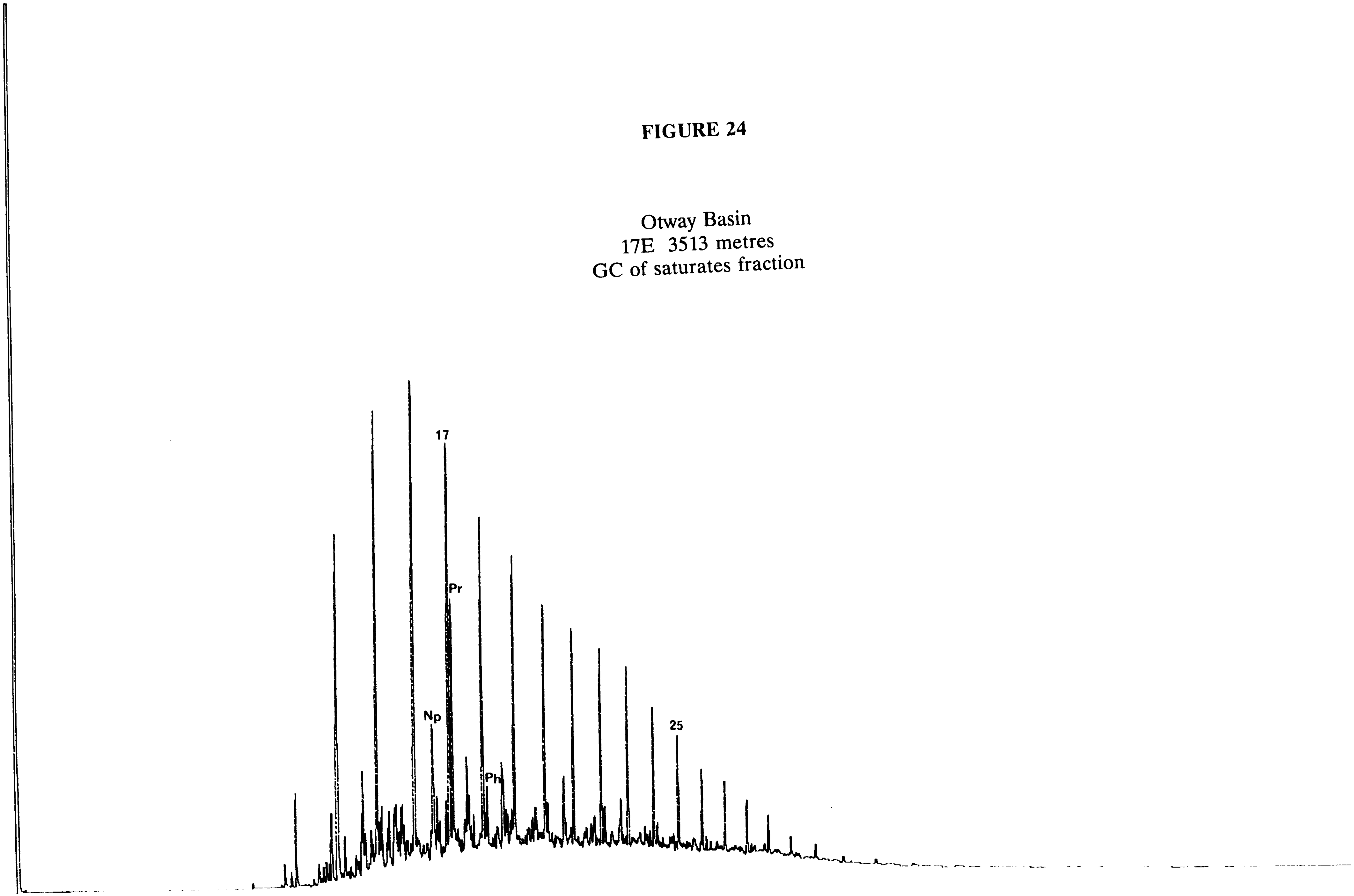


FIGURE 25

Otway Basin
21C 1255 metres
GC of saturates fraction

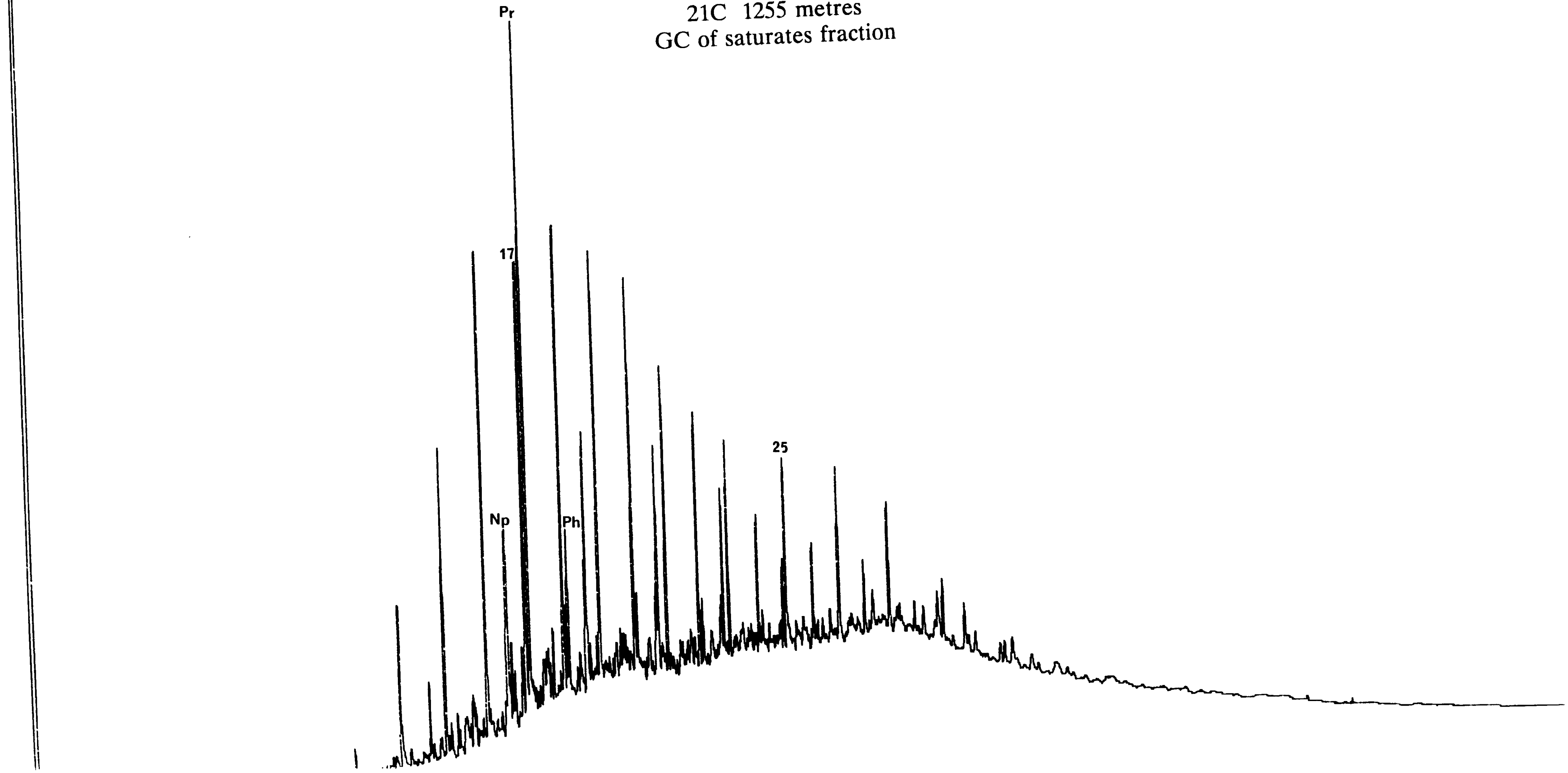


FIGURE 26

Otway Basin
22B 1066 metres
GC of saturates fraction

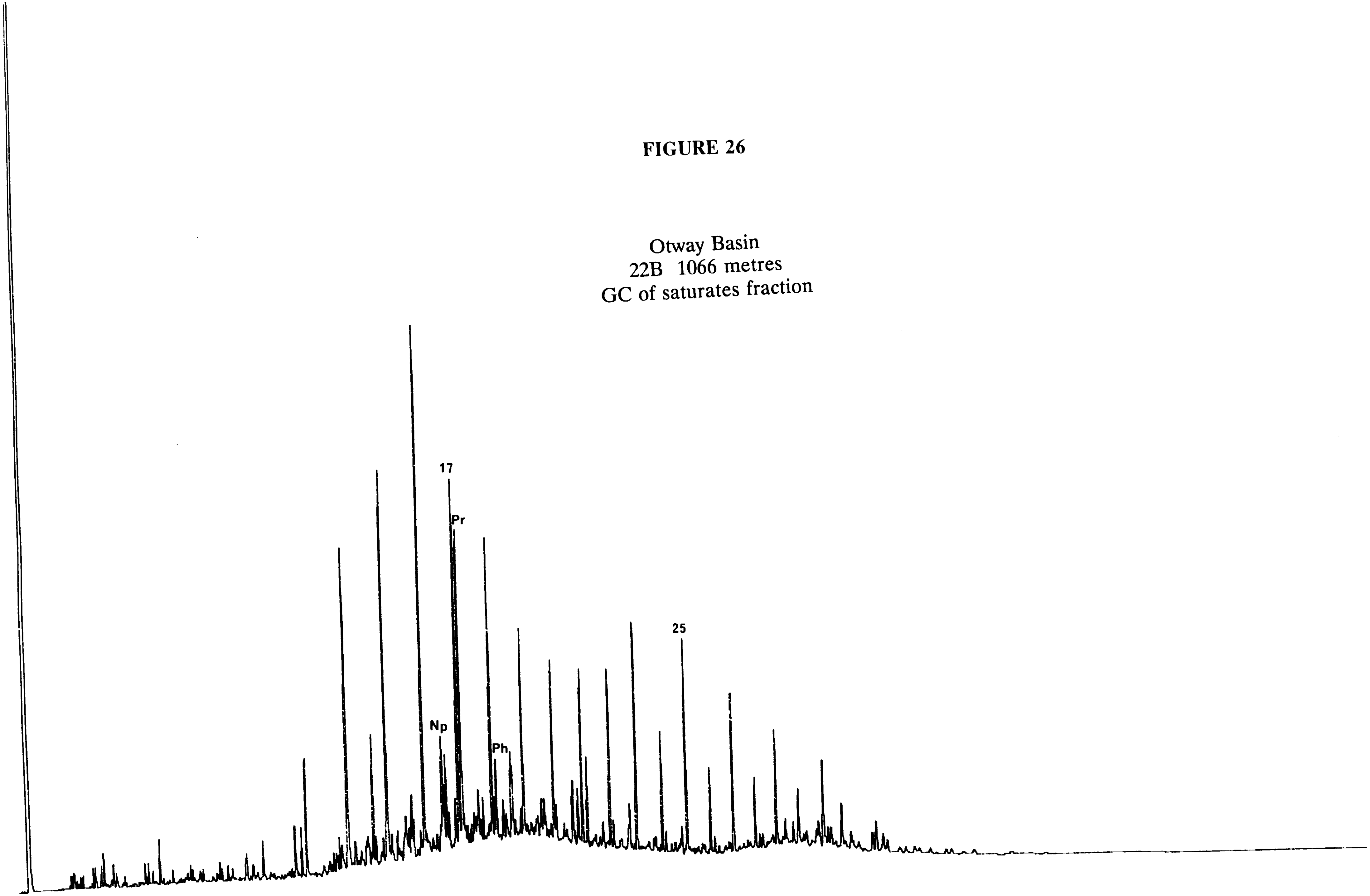


FIGURE 27

Otway Basin
22C 1127 metres
GC of saturates fraction

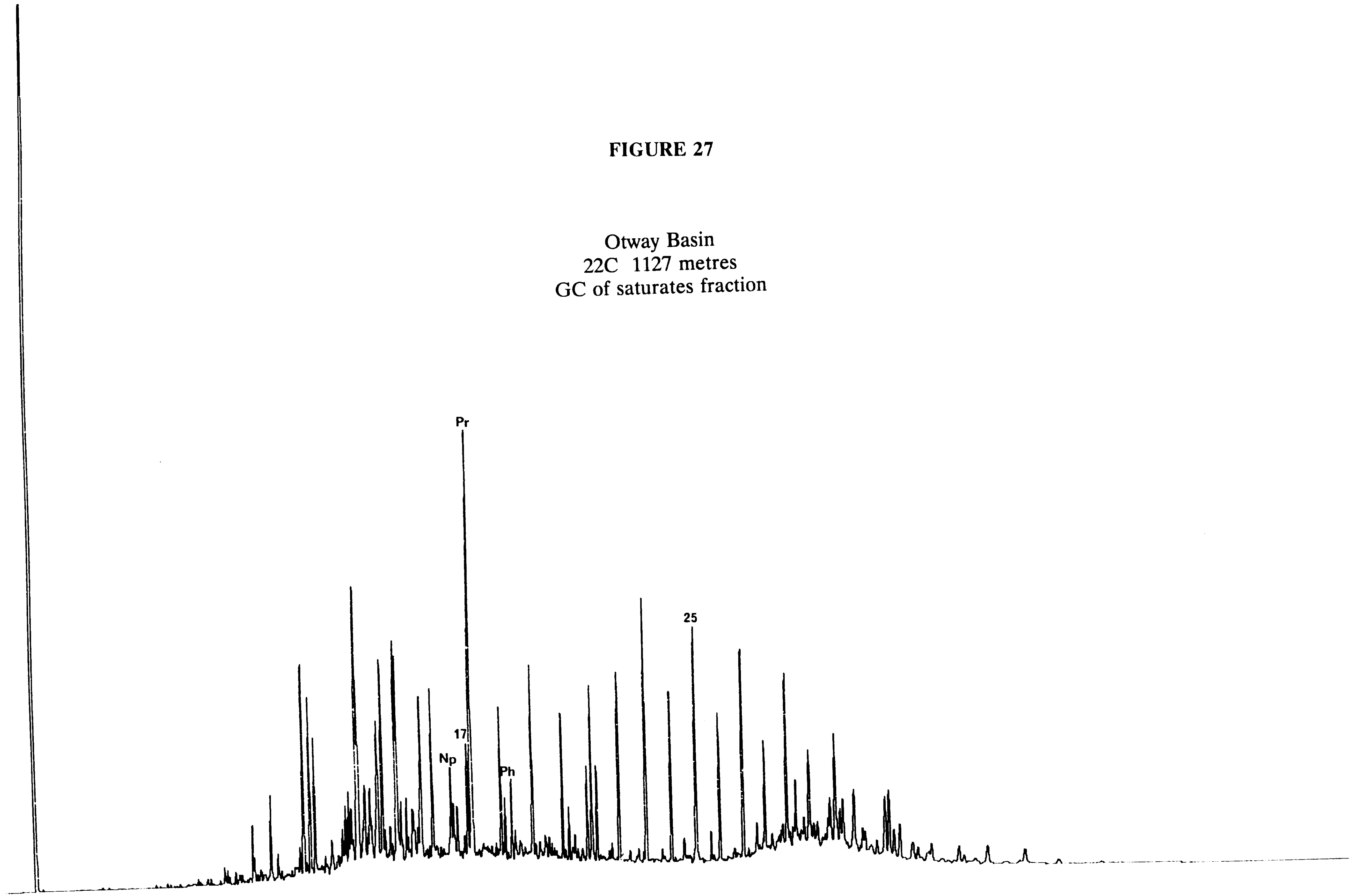


FIGURE 28

Otway Basin
22E 1432 metres
GC of saturates fraction

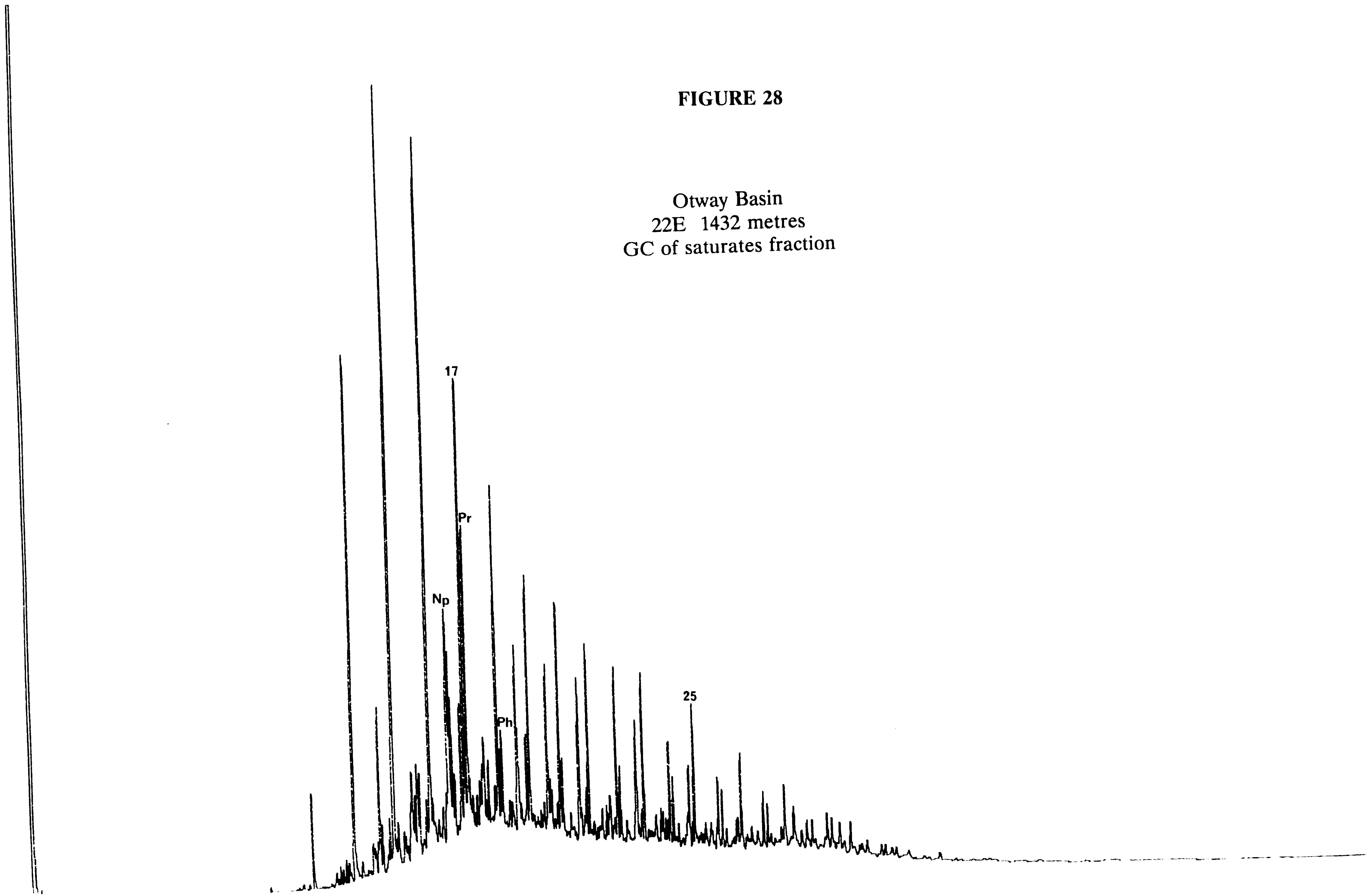


FIGURE 29

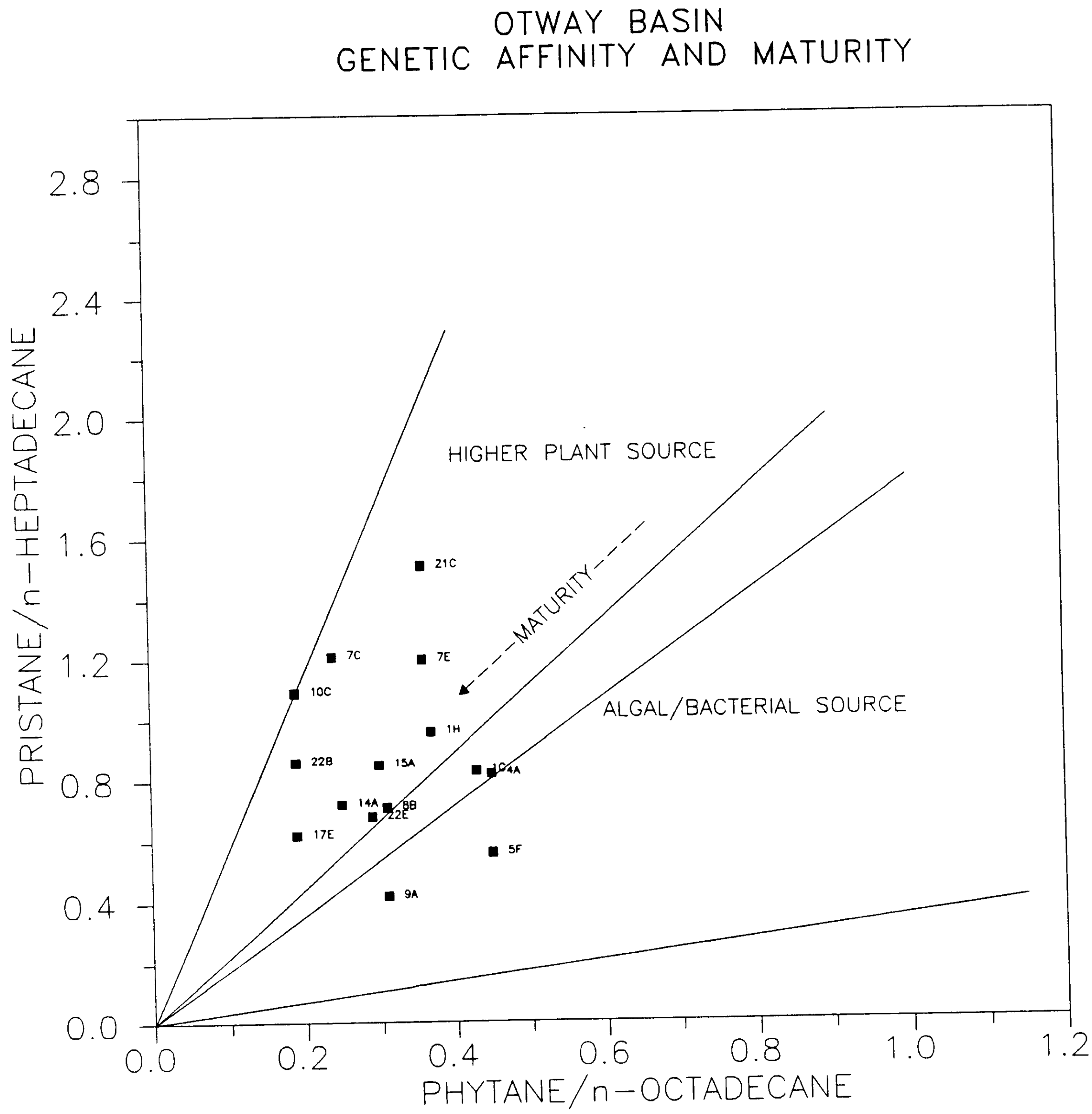

OTWAY BASIN
GENETIC AFFINITY AND MATURITY
HIGHER PLANT SOURCE
MATURITY
ALGAL/BACTERIAL SOURCE
21C
7C
7E
10C
1H
22B
15A
1C
4A
14A
8B
22E
17E
5F
9A
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
PRISTANE/n-HEPTADECANE
0.0
0.2
0.4
0.6
0.8
1.0
1.2
PHYTANE/n-OCTADECANE

FIGURE 30

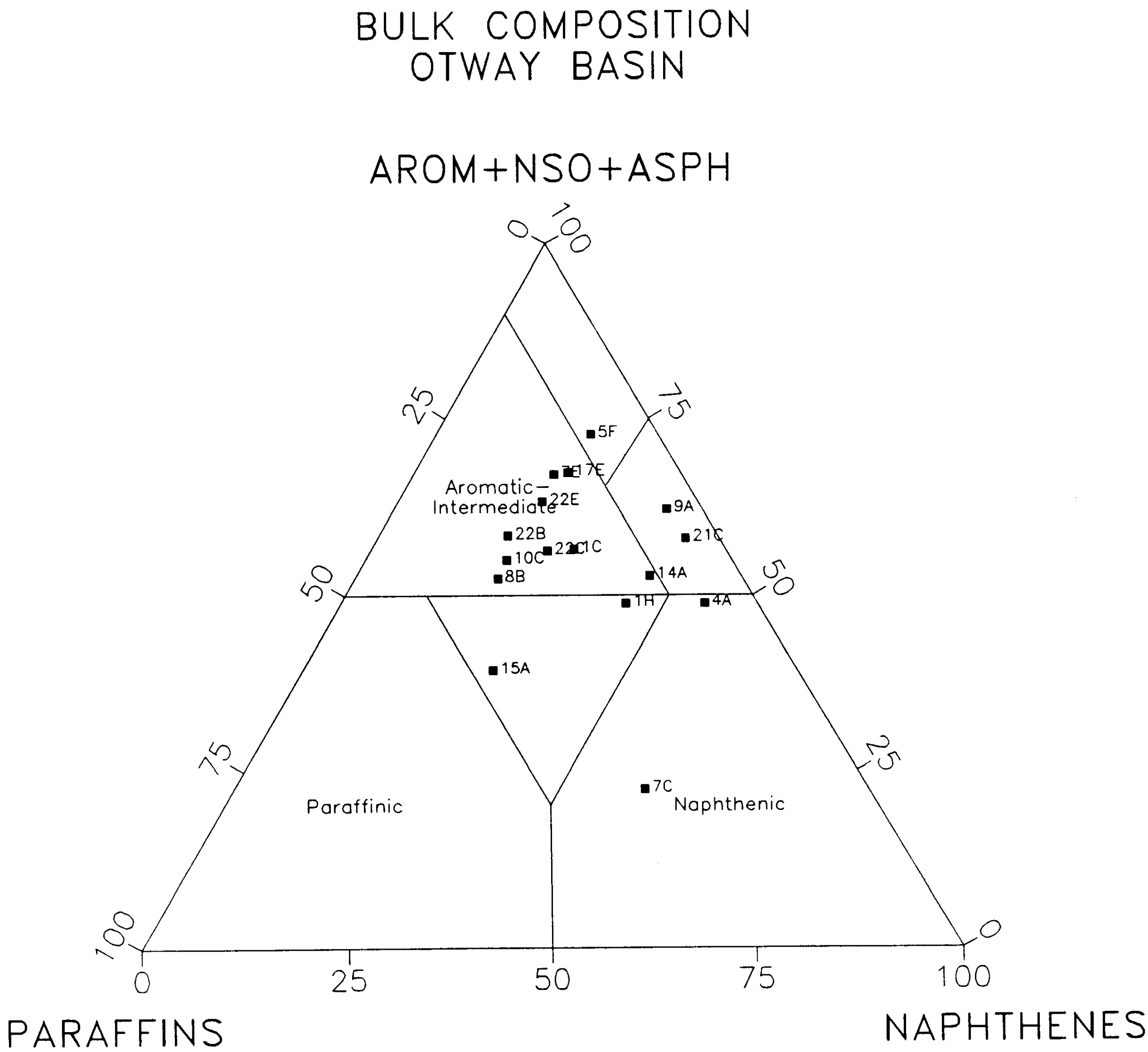
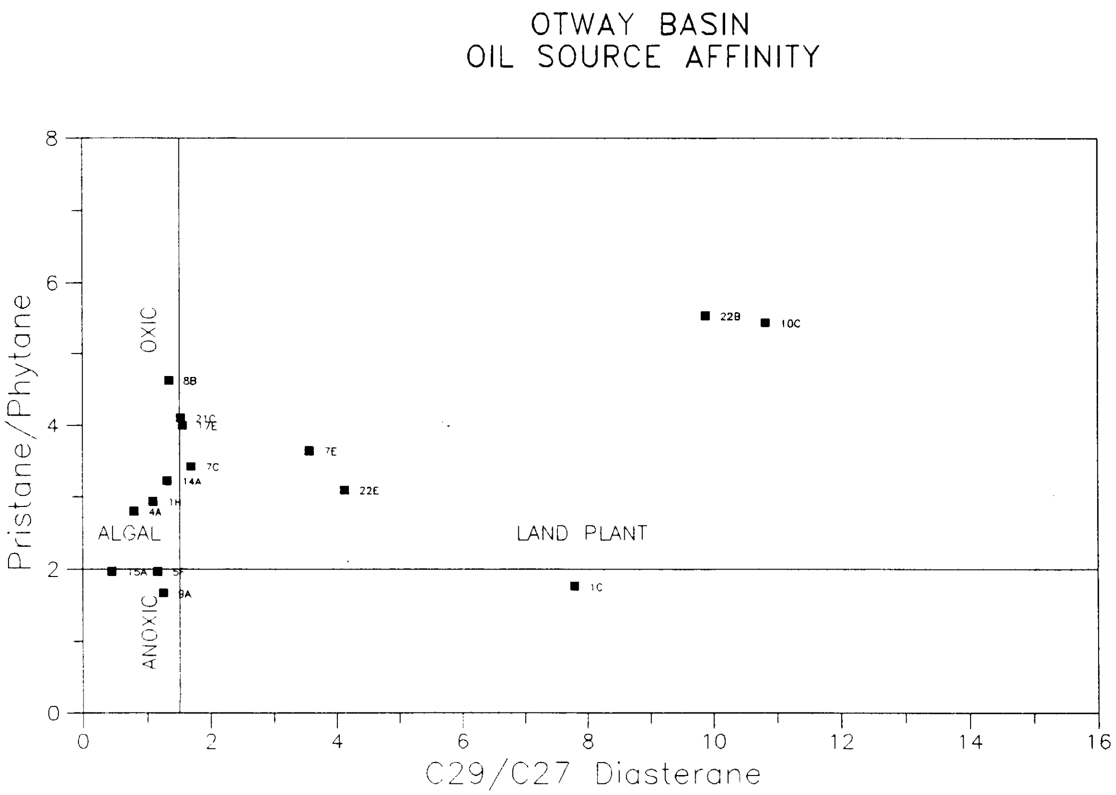
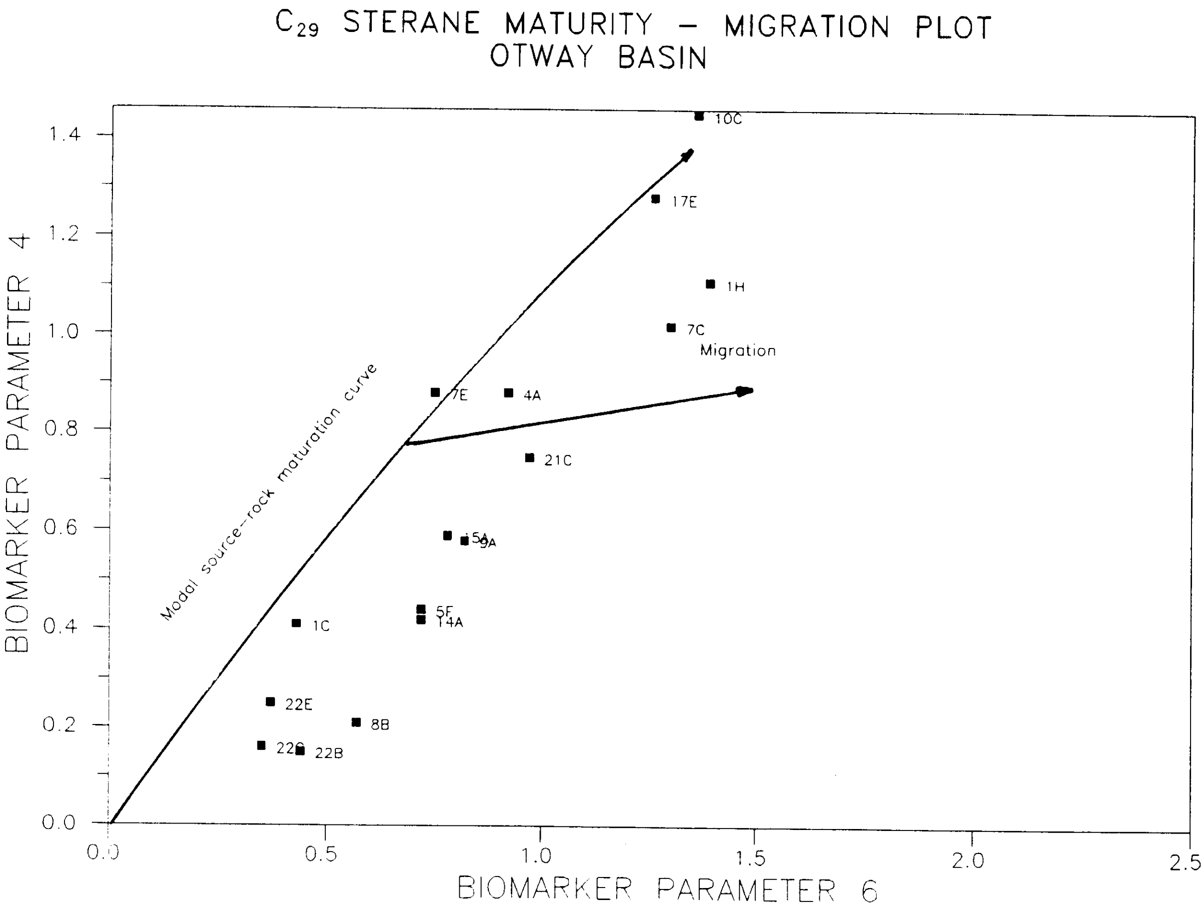

BULK COMPOSITION
OTWAY BASIN
AROM+NSO+ASPH
PARAFFINS
NAPHTHENES
Aromatic–Intermediate
Paraffinic
Naphthenic
5F
17E
22E
9A
21C
22B
10C
8B
14A
1H
4A
15A
7C
0
25
50
75
100

FIGURE 31



OTWAY BASIN
OIL SOURCE AFFINITY
Pristane/Phytane
C29/C27 Diasterane
OXIC
ANOXIC
ALGAL
LAND PLANT
0
2
4
6
8
10
12
14
16
8B
7E
7C
14A
22E
4A
1H
15A
5F
8A
1C
22B
10C

FIGURE 32



C_{29} STERANE MATURITY – MIGRATION PLOT
OTWAY BASIN
BIOMARKER PARAMETER 4
BIOMARKER PARAMETER 6
Modal source-rock maturation curve
Migration
10C
17E
1H
7C
7E
4A
21C
15A
9A
5F
14A
1C
22E
8B
22C
22B
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.5
1.5
2.0
2.5

FIGURE 33

STERANE DISTRIBUTIONS
OTWAY BASIN

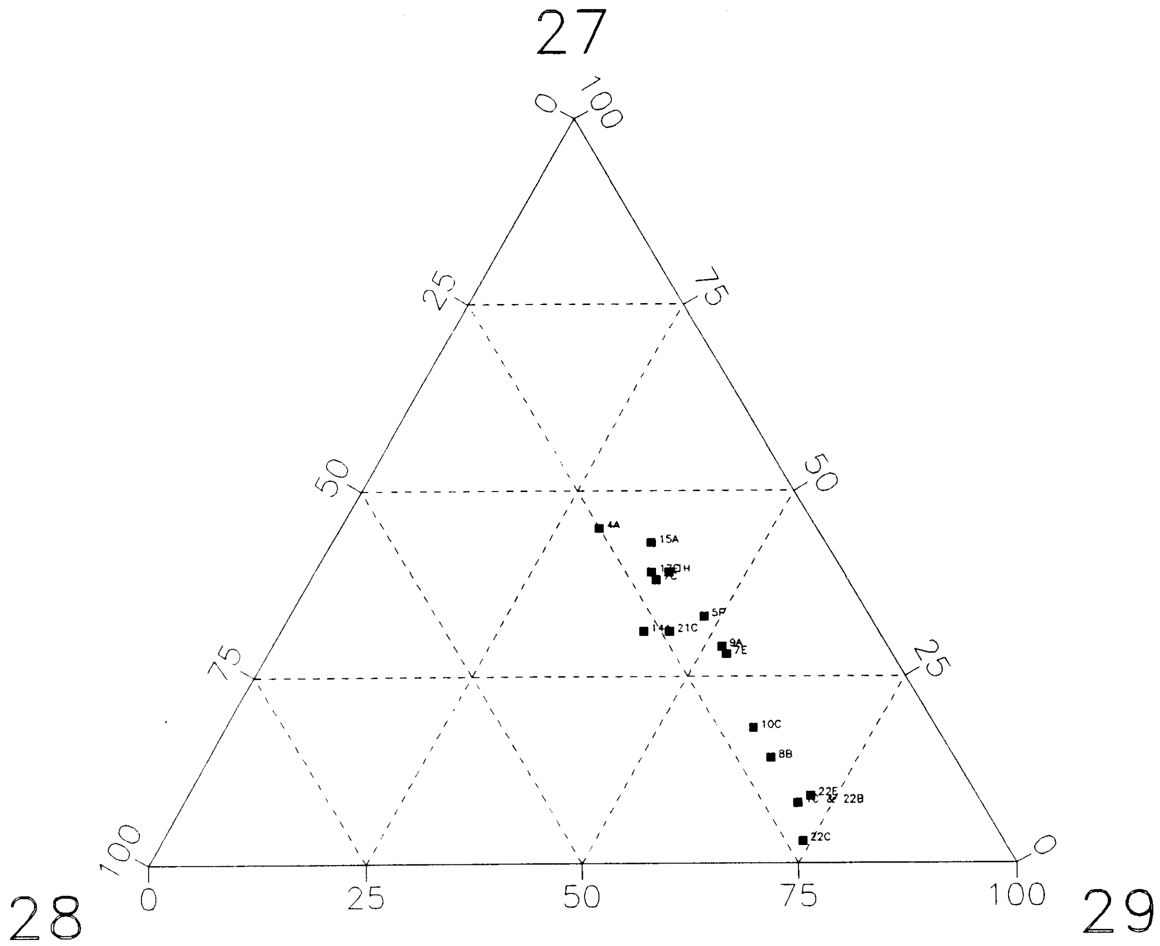
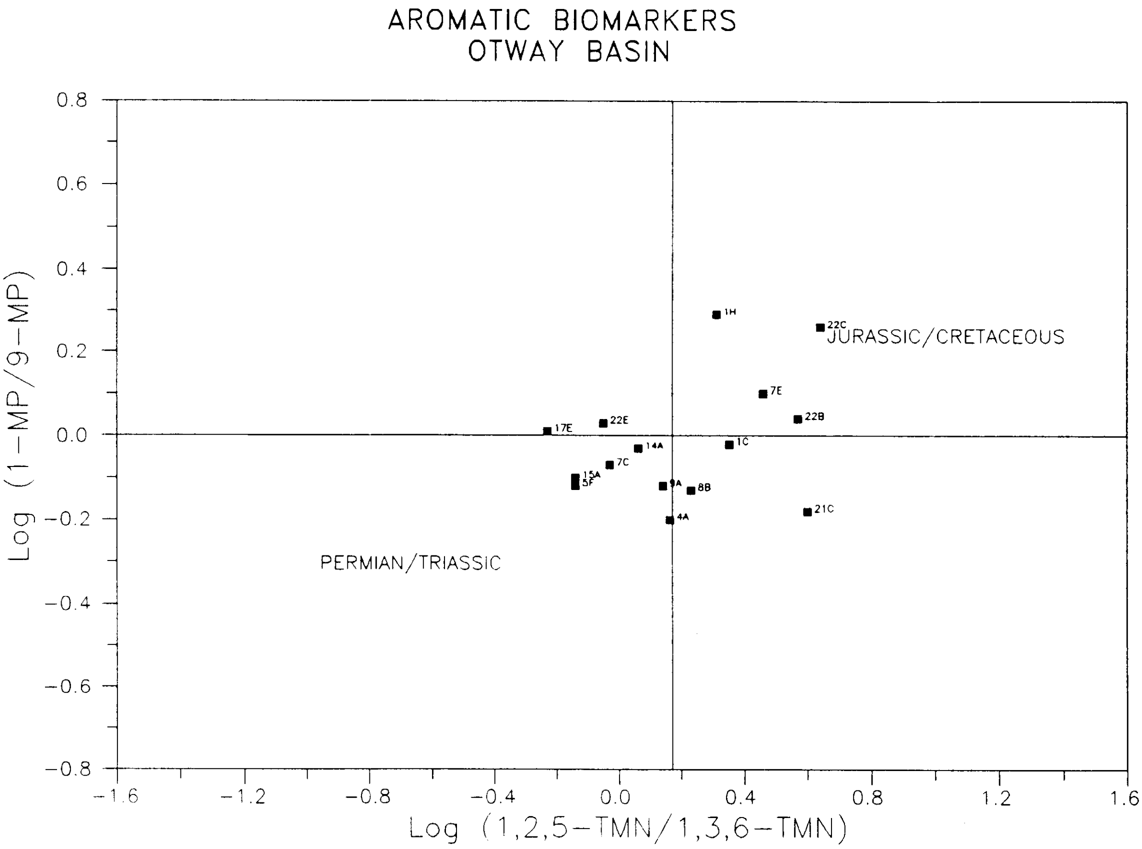


FIGURE 34


AROMATIC BIOMARKERS
OTWAY BASIN
Log (1-MP/9-MP)
Log (1,2,5-TMN/1,3,6-TMN)
JURASSIC/CRETACEOUS
PERMIAN/TRIASSIC
1H
22C
7E
22B
17E
22E
1C
14A
7C
15A
5F
9A
8B
4A
21C
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.8
1.2
1.6

APPENDIX 1

ANALYTICAL PROCEDURES

1. Sample Preparation

Samples (as received) were ground in a Siebtechnik mill for 20-30 seconds.

2. Total Organic Carbon (TOC)

Total organic carbon was determined by digestion of a known weight (approximately 0.2 g) of powdered rock in HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco WR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

3. Rock-Eval Pyrolysis

A 100 mg portion of powdered rock was analysed by the Rock-Eval pyrolysis technique (Girdel IFP-Fina Mark 2 instrument; operating mode, Cycle 1).

4. Organic Petrology

Representative portions of each sample (crushed to -14+35 BSS mesh) were obtained with a sample splitter and then mounted in cold setting Glasscraft resin using a 2.5 cm diameter mould. Each block was ground flat using diamond impregnated laps and carborundum paper. The surface was then polished with aluminium oxide and finally magnesium oxide.

Reflectance measurements were made with a Leitz MPV1.1 microphotometer fitted to a Leitz Ortholux microscope and calibrated against synthetic standards. All measurements were taken using oil immersion (n = 1.518) and incident monochromatic light (wavelength 546 nm) at a temperature of $23 \pm 1\,°C$. Fluorescence observations were made on the same microscope utilising a 3 mm BG3 excitation filter, a TK400 dichroic mirror and a K510 suppression filter.

5. Isolation of Residual Oil

Core chips and cuttings samples were extracted with dichloromethane in Soxhlet apparatus for 8 hours. Removal of solvent by careful rotary evaporation gave the oil (nominal C_{12+} fraction).

6. Liquid Chromatography

Asphaltenes were not precipitated from the condensate prior to liquid chromatography. The samples were separated into hydrocarbons (saturates and aromatics) and polar compounds (resins) by liquid chromatography on activated alumina (sample: adsorbent ratio = 1.100). Hydrocarbons were eluted with petroleum ether/dichloromethane (75:25) and resins with methanol/dichloromethane (65:35).

The saturated and aromatic hydrocarbons were then separated by liquid chromatography on activated silica gel (sample/adsorbent ratio = 1:100). The saturated hydrocarbons were eluted with petroleum ether and the aromatic hydrocarbons with petroleum ether/dichloromethane (91:9).

7. Gas Chromatography

Whole oils and saturated hydrocarbons (alkanes) were examined by gas chromatography using the following instrumental parameters:

Gas Chromatograph:	Perkin Elmer 8500 operated in the split injection mode
Column:	25 m x 0.3 mm fused silica, SGE QC3/BP1
Detector Temperature:	300°C
Column Temperature:	40°C for 1 minute, then 8° per minute to 300°C and held isothermal at 300°C until all peaks eluted
Quantification:	Relative concentrations of individual hydrocarbons were obtained by measurement of peak areas with a Perkin-Elmer LCI 100 integrator. The areas of peaks responding to aromatic hydrocarbons were multiplied by appropriate response factors

8. Thin Layer Chromatography (TLC)

Aromatic hydrocarbons were isolated from the extracted oil by preparative TLC using Merck GF_{254} silica plates and distilled AR grade n-pentane as eluent. Naphthalene and anthracene were employed as reference standards for the diaromatic and triaromatic hydrocarbons, respectively. These two bands, visualised under UV light, were scraped from the plate and the aromatic hydrocarbons redissolved in dichloromethane.

9. Gas Chromatography-Mass Spectrometry (GC-MS)

The di- and triaromatic hydrocarbons isolated from the extracted oil by thin layer chromatography were analysed by GC-MS.

GC-MS analysis of the aromatic hydrocarbons was undertaken in the selected ion detection (SID) mode. The instrument and its operating parameters were as follows:

System:	Perkin-Elmer 8420 GC coupled with a Finigan Ion Trap mass selective detector and data system
Column:	25 mm x 0.2 mm i.d. HP BP5 cross-linked methylsilicone phase fused silica, interfaced to source of mass spectrometer
Injector:	Split injection (8:1)
Carrier Gas:	He at 60 Kpa head pressure
Column Temperature:	50-260°C @ 4°/minute
Mass Spectrometer Conditions:	Selected ion monitoring

The following mass fragmentograms were recorded:

m/z	**Compound Type**
155 + 156	dimethylnaphthalenes
169 + 170	trimethylnaphthalenes
178	phenanthrene
191 + 192	methylphenanthrene

The area of the phenanthrene peak was multiplied by a response factor of 0.667 when calculating the methylphenanthrene index (MPI).

Naphthenes (branched/cyclic alkanes) were isolated from the oil by molecular sieve separation of the saturates fraction.

GC-MS analysis of the naphthenes was undertaken in the multiple ion detection (MID) mode. Instrumental conditions are given below.

System:	HP 5890 Series II Plus GC coupled to HP 5972 MSD
Column:	25 mm x 0.25 mm i.d. HPS MS cross-linked methylsilicone phase fused silica, interfaced directly to source of mass spectrometer
Injector:	Splitless 2μL
Carrier Gas:	Helium at a linear velocity of 26 cm/minute
Column Temperature:	50°C for 2 minutes then 50-290°C @ 7°/minute
Mass Spectrometer Conditions:	70 eV EI; 9-ion selected ion monitoring, 70 millisec dwell time for each ion

The following mass fragmentograms were recorded:

m/z	Compound Type
83	alkylcyclohexanes
123	drimanes, diterpanes
177	demethylated triterpanes
183	acyclic alkanes (incl isoprenoids, botryococcanes)
191	triterpanes (incl hopanes, moretanes)
205	methyltriterpanes
217	steranes
218	steranes
231	4-methylsteranes
259	diasteranes

APPENDIX 2

HISTOGRAM PLOTS OF VITRINITE REFLECTANCE DATA

Vitrinite Reflectance Values

Sample: *1a*
Depth: *700 m.*

Sorted List

0.37	0.43	0.51
0.39	0.43	0.51
0.40	0.44	
0.40	0.44	
0.42	0.44	
0.42	0.45	
0.42	0.46	
0.42	0.47	
0.43	0.48	
0.43	0.51	

Number of values	22
Mean of values	0.44
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

37–39	**
40–42	******
43–45	********
46–48	***
49–51	***

Vitrinite Reflectance Values

Sample: *1d*
Depth: *2000 m.*

Sorted List

0.55	0.60
0.56	0.62
0.56	0.63
0.57	0.63
0.57	0.64
0.58	0.65
0.58	0.66
0.59	0.68
0.59	
0.60	

Number of values	18
Mean of values	0.60
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

55–57	*****
58–60	******
61–63	***
64–66	***
67–69	*

Vitrinite Reflectance Values

Sample: *1f*
Depth: *2250–2253 m.*

Sorted List

0.55	0.67	0.78
0.56	0.68	0.80
0.57	0.69	
0.59	0.69	
0.60	0.69	
0.60	0.69	
0.61	0.70	
0.67	0.72	
0.67	0.77	
0.67	0.78	

Number of values	22
Mean of values	0.67
Standard Deviation	0.07

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

55–57	***
58–60	***
61–63	*
64–66	
67–69	*********
70–72	**
73–75	
76–78	***

Vitrinite Reflectance Values

Sample: *1g*
Depth: *2300 m.*

Sorted List

0.58	0.68
0.61	0.68
0.63	
0.63	
0.64	
0.65	
0.66	
0.66	
0.67	
0.67	

Number of values	12
Mean of values	0.65
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

58–60	*
61–63	***
64–66	****
67–69	****

Vitrinite Reflectance Values

Sample: *1h*
Depth: *2358–2361 m.*

Sorted List

0.68	0.82	0.89
0.68	0.83	0.91
0.73	0.83	
0.75	0.83	
0.75	0.84	
0.76	0.84	
0.79	0.84	
0.81	0.85	
0.81	0.85	
0.81	0.86	

Number of values	22
Mean of values	0.81
Standard Deviation	0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

68–70	**
71–73	*
74–76	***
77–79	*
80–82	****
83–85	********
86–88	*
89–91	**

Vitrinite Reflectance Values

Sample: *2b*
Depth: *1902–1907 m.*

Sorted List

0.41	0.45	0.50
0.42	0.45	0.50
0.43	0.46	0.50
0.43	0.46	0.52
0.43	0.47	
0.44	0.47	
0.44	0.48	
0.45	0.48	
0.45	0.48	
0.45	0.49	

Number of values	24
Mean of values	0.46
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

41–43	*****
44–46	*********
47–49	******
50–52	****

Vitrinite Reflectance Values

Sample: *2d*
Depth: *2716–2719 m.*

Sorted List

0.65	0.74
0.65	0.76
0.66	0.79
0.66	0.83
0.69	0.83
0.70	0.88
0.72	
0.72	
0.73	
0.73	

Number of values	16
Mean of values	0.73
Standard Deviation	0.07

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

65–67	****
68–70	**
71–73	****
74–76	**
77–79	*
80–82	
83–85	**
86–88	*

Vitrinite Reflectance Values

Sample: *2e*
Depth: *2977–2978 m.*

Sorted List

0.81
0.83
0.83
0.84
0.85
0.86
0.86
0.87
0.88

Number of values	9
Mean of values	0.85
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

81–83	***
84–86	****
87–89	**

Vitrinite Reflectance Values

Sample: *4a*
Depth: *1965 m.*

Sorted List

0.45	0.53
0.48	0.54
0.48	0.54
0.48	
0.48	
0.49	
0.49	
0.51	
0.52	
0.52	

Number of values	13
Mean of values	0.50
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

45–47	*
48–50	******
51–53	****
54–56	**

Vitrinite Reflectance Values

Sample: *4f*
Depth: *3197–3200 m.*

Sorted List

0.66
0.70
0.73
0.77
0.83
0.85
0.85
0.85

Number of values	8
Mean of values	0.78
Standard Deviation	0.07

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

66–68	*
69–71	*
72–74	*
75–77	*
78–80	
81–83	*
84–86	***

Vitrinite Reflectance Values

Sample: *5e*
Depth: *1395 m.*

Sorted List

0.40	0.50
0.40	0.50
0.45	
0.45	
0.46	
0.46	
0.47	
0.47	
0.48	
0.48	

Number of values	12
Mean of values	0.46
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

40–42	**
43–45	**
46–48	******
49–51	**

Vitrinite Reflectance Values

Sample: *5f*
Depth: *2080 m.*

Sorted List

0.44	0.52
0.45	0.54
0.46	0.57
0.46	0.58
0.46	
0.46	
0.48	
0.49	
0.50	
0.51	

Number of values	14
Mean of values	0.49
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

44–46	******
47–49	**
50–52	***
53–55	*
56–58	**

Vitrinite Reflectance Values

Sample: *6a*
Depth: *530 m.*

Sorted List

0.36	0.41
0.37	0.42
0.38	0.43
0.38	0.43
0.38	0.43
0.39	0.44
0.39	0.45
0.40	0.45
0.41	0.46
0.41	

Number of values	19
Mean of values	0.41
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

36–38	*****
39–41	******
42–44	*****
45–47	***

Vitrinite Reflectance Values

Sample: *7b*
Depth: *1100 m.*

Sorted List

0.59
0.62

Number of values	2
Mean of values	0.61
Standard Deviation	0.01

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

59–61 *
62–64 *

Vitrinite Reflectance Values

Sample: *7c*
Depth: *1325 m.*

Sorted List

0.60	0.81
0.62	0.82
0.66	
0.66	
0.67	
0.68	
0.70	
0.71	
0.72	
0.74	

Number of values	12
Mean of values	0.70
Standard Deviation	0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

60−62	**
63−65	
66−68	****
69−71	**
72−74	**
75−77	
78−80	
81−83	**

Vitrinite Reflectance Values

Sample: *7e*
Depth: *2525 m.*

Sorted List

0.59	0.67
0.62	0.67
0.62	0.67
0.62	0.70
0.64	0.70
0.64	0.70
0.65	0.76
0.66	
0.66	
0.66	

Number of values	17
Mean of values	0.66
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

59–61	*
62–64	*****
65–67	*******
68–70	***
71–73	
74–76	*

Vitrinite Reflectance Values

Sample: *8a*
Depth: *505 m.*

Sorted List

0.33	0.36	0.40	0.44
0.34	0.37	0.40	0.45
0.34	0.37	0.40	
0.35	0.37	0.40	
0.35	0.37	0.41	
0.36	0.38	0.41	
0.36	0.39	0.43	
0.36	0.39	0.43	
0.36	0.39	0.43	
0.36	0.39	0.44	

Number of values	32
Mean of values	0.39
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

33–35	*****
36–38	***********
39–41	**********
42–44	*****
45–47	*

Vitrinite Reflectance Values

Sample: *8b*
Depth: *853 m.*

Sorted List

0.35	0.39	0.42
0.36	0.39	0.42
0.37	0.40	
0.37	0.40	
0.37	0.40	
0.38	0.40	
0.39	0.40	
0.39	0.41	
0.39	0.41	
0.39	0.42	

Number of values	22
Mean of values	0.39
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

35–37	*****
38–40	************
41–43	*****

Vitrinite Reflectance Values

Sample: *9a*
Depth: *600 m.*

Sorted List

0.29	0.33	0.35	0.38
0.29	0.33	0.35	
0.31	0.33	0.35	
0.31	0.34	0.36	
0.31	0.34	0.36	
0.32	0.34	0.36	
0.32	0.34	0.37	
0.33	0.34	0.37	
0.33	0.35	0.37	
0.33	0.35	0.38	

Number of values	31
Mean of values	0.34
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

29−31	*****
32−34	*************
35−37	***********
38−40	**

Vitrinite Reflectance Values

Sample: *9b*
Depth: *1100 m.*

Sorted List

0.43
0.45
0.45
0.45
0.46
0.46
0.48

Number of values	7
Mean of values	0.45
Standard Deviation	0.01

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

43–45	****
46–48	***

Vitrinite Reflectance Values

Sample: *10b*
Depth: *2250 m.*

Sorted List

0.67
0.69
0.70
0.77
0.78

Number of values	5
Mean of values	0.72
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

67–69	**
70–72	*
73–75	
76–78	**

Vitrinite Reflectance Values

Sample: *10c*
Depth: *2750 m.*

Sorted List

0.71	0.76	0.82	0.90
0.72	0.77	0.82	0.90
0.72	0.77	0.82	0.91
0.72	0.77	0.83	0.91
0.72	0.78	0.84	0.91
0.73	0.78	0.86	0.92
0.73	0.79	0.87	0.92
0.74	0.79	0.88	0.96
0.75	0.79	0.88	
0.75	0.80	0.88	

Number of values	38
Mean of values	0.81
Standard Deviation	0.07

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

```
71-73   *******
74-76   ****
77-79   ********
80-82   ****
83-85   **
86-88   *****
89-91   *****
92-94   **
```

Vitrinite Reflectance Values

Sample: *10d*
Depth: *2975 m.*

Sorted List

0.81
0.82
0.82
0.82
0.83

Number of values	5
Mean of values	0.82
Standard Deviation	0.01

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

81–83 *****

Vitrinite Reflectance Values

Sample: *14a*
Depth: *1400 m.*

Sorted List

0.41
0.42
0.43
0.44
0.45
0.45
0.48
0.48
0.50

Number of values	9
Mean of values	0.45
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

41–43	***
44–46	***
47–49	**
50–52	*

Vitrinite Reflectance Values

Sample: *14c*
Depth: *1800 m.*

<u>Sorted List</u>

0.43	0.47
0.44	0.48
0.44	0.48
0.44	0.49
0.45	0.49
0.45	
0.46	
0.46	
0.46	
0.47	

Number of values	15
Mean of values	0.46
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

43–45	******
46–48	*******
49–51	**

Vitrinite Reflectance Values

Sample: *14d*
Depth: *1815 m.*

<u>Sorted List</u>

0.45	0.56
0.50	0.58
0.50	0.58
0.51	0.59
0.51	0.60
0.52	
0.52	
0.53	
0.53	
0.55	

Number of values	15
Mean of values	0.54
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

45–47	*
48–50	**
51–53	******
54–56	*
57–59	****
60–62	*

Vitrinite Reflectance Values

Sample: *14f*
Depth: *2550 m.*

Sorted List

0.52	0.64
0.54	0.64
0.58	0.67
0.58	0.67
0.60	0.68
0.60	0.69
0.61	0.69
0.61	0.70
0.63	
0.63	

Number of values	18
Mean of values	0.63
Standard Deviation	0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

52–54	*
55–57	*
58–60	****
61–63	****
64–66	**
67–69	*****
70–72	*

Vitrinite Reflectance Values

Sample: *15b*
Depth: *1161 – 1167 m.*

Sorted List

0.40
0.40
0.43
0.44
0.44

Number of values	5
Mean of values	0.42
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

40–42	**
43–45	***

Vitrinite Reflectance Values

Sample: *15d*
Depth: *1645–1652 m.*

Sorted List

0.57
0.62

Number of values	2
Mean of values	0.60
Standard Deviation	0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

57–59	*
60–62	*

Vitrinite Reflectance Values

Sample: *15f*
Depth: *2194–2198 m.*

Sorted List

0.49	0.58	0.62	0.65	0.68
0.51	0.58	0.63	0.65	0.68
0.52	0.58	0.63	0.65	0.68
0.53	0.59	0.63	0.65	0.71
0.53	0.60	0.64	0.65	
0.54	0.60	0.64	0.66	
0.56	0.60	0.64	0.66	
0.57	0.60	0.64	0.67	
0.57	0.61	0.64	0.67	
0.57	0.62	0.65	0.67	

Number of values	44
Mean of values	0.61
Standard Deviation	0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

49–51	**
52–54	***
55–57	*****
58–60	********
61–63	******
64–66	*************
67–69	******
70–72	*

Vitrinite Reflectance Values

Sample: *16b*
Depth: *1100 m.*

<u>Sorted List</u>

2.16
2.23
2.25
2.62

Number of values	4
Mean of values	2.32
Standard Deviation	0.18

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

216–218	*
219–221	
222–224	*
225–227	*
228–230	
231–233	
234–236	
237–239	

Vitrinite Reflectance Values

Sample: *17c*
Depth: *2742 m.*

Sorted List

0.75	0.83	0.88	0.93
0.76	0.83	0.88	
0.76	0.84	0.89	
0.78	0.85	0.89	
0.79	0.85	0.90	
0.79	0.85	0.90	
0.79	0.85	0.90	
0.80	0.85	0.91	
0.81	0.85	0.91	
0.82	0.87	0.92	

Number of values	31
Mean of values	0.85
Standard Deviation	0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

```
75-77   ***
78-80   *****
81-83   ****
84-86   *******
87-89   *****
90-92   ******
93-95   *
```

Vitrinite Reflectance Values

Sample: *17d*
Depth: *3001 m.*

Sorted List

0.78	0.91	0.94
0.80	0.92	0.95
0.88	0.92	0.99
0.89	0.92	1.01
0.89	0.92	
0.90	0.92	
0.90	0.92	
0.91	0.93	
0.91	0.93	
0.91	0.93	

Number of values	24
Mean of values	0.91
Standard Deviation	0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

78–80	**
81–83	
84–86	
87–89	***
90–92	************
93–95	*****
96–98	
99–101	**

Vitrinite Reflectance Values

Sample: *17e*
Depth: *3513 m.*

Sorted List

1.21	1.30
1.23	1.30
1.23	1.30
1.23	1.30
1.24	1.31
1.26	
1.28	
1.29	
1.29	
1.29	

Number of values	15
Mean of values	1.27
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

121–123 ****
124–126 **
127–129 ****
130–132 *****

Vitrinite Reflectance Values

Sample: *20a*
Depth: *1880 m.*

Sorted List

0.50	0.57	0.62
0.51	0.57	0.63
0.52	0.58	0.65
0.53	0.58	0.66
0.55	0.59	
0.55	0.59	
0.56	0.59	
0.56	0.60	
0.57	0.61	
0.57	0.61	

Number of values	24
Mean of values	0.58
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

50–52	***
53–55	*
56–58	**********
59–61	******
62–64	**
65–67	**

Vitrinite Reflectance Values

Sample: *21b*
Depth: *1135 m.*

Sorted List

0.35	0.39
0.36	0.43
0.37	0.44
0.37	0.45
0.37	
0.37	
0.38	
0.38	
0.38	
0.38	

Number of values	14
Mean of values	0.39
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

35–37	******
38–40	*****
41–43	*
44–46	**

Vitrinite Reflectance Values

Sample: *21d*
Depth: *1795 m.*

Sorted List

0.36	0.43	0.46
0.37	0.44	0.46
0.38	0.44	0.46
0.39	0.44	0.46
0.39	0.44	0.47
0.39	0.45	0.48
0.42	0.45	
0.42	0.45	
0.43	0.46	
0.43	0.46	

Number of values	26
Mean of values	0.43
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

36–38	***
39–41	***
42–44	*********
45–47	**********
48–50	*

Vitrinite Reflectance Values

Sample: *21e*
Depth: *1840 m.*

<u>Sorted List</u>

0.55
0.56
0.57
0.58
0.59
0.60
0.62
0.62
0.69

Number of values	9
Mean of values	0.60
Standard Deviation	0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

55–57	***
58–60	***
61–63	**
64–66	
67–69	*

Vitrinite Reflectance Values

Sample: *22a*
Depth: *731 m.*

Sorted List

0.39	0.46
0.41	0.47
0.41	0.47
0.43	0.47
0.44	0.53
0.44	
0.45	
0.45	
0.46	
0.46	

Number of values	15
Mean of values	0.45
Standard Deviation	0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

39–41	***
42–44	***
45–47	********
48–50	
51–53	*

Vitrinite Reflectance Values

Sample: *22c*
Depth: *1127 m.*

Sorted List

0.48	0.57	0.61	0.65
0.48	0.59	0.62	0.65
0.50	0.60	0.62	0.65
0.52	0.60	0.63	0.65
0.53	0.60	0.63	0.65
0.55	0.60	0.63	0.68
0.56	0.61	0.63	
0.56	0.61	0.63	
0.57	0.61	0.64	
0.57	0.61	0.64	

Number of values	36
Mean of values	0.60
Standard Deviation	0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

48–50	***
51–53	**
54–56	*
57–59	******
60–62	***********
63–65	************
66–68	*

Vitrinite Reflectance Values

Sample: *22f*
Depth: *1517 m.*

Sorted List

0.57
0.62
0.63
0.73

Number of values	4
Mean of values	0.64
Standard Deviation	0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

57–59	*
60–62	*
63–65	*
66–68	
69–71	
72–74	*

Vitrinite Reflectance Values

Sample: *22d*
Depth: *1280 m.*

Sorted List

0.48	0.58
0.48	0.58
0.51	0.65
0.51	0.69
0.52	
0.52	
0.53	
0.54	
0.55	
0.55	

Number of values	14
Mean of values	0.55
Standard Deviation	0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

48–50	**
51–53	*****
54–56	***
57–59	**
60–62	
63–65	*
66–68	
69–71	*