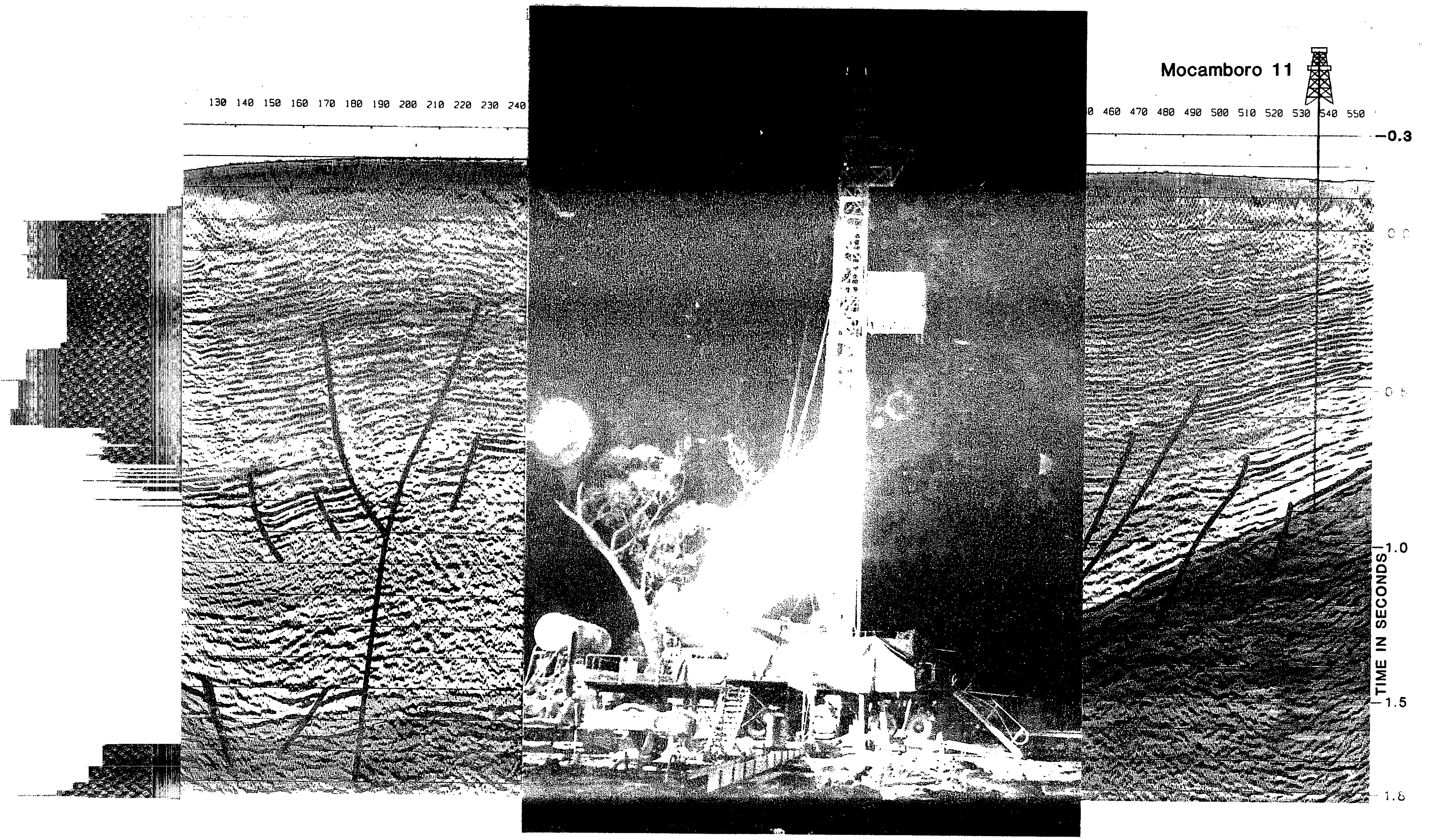
# Mocamboro No. 11

## Well Completion Report






Geological Survey of Victoria
Basin Studies

Department of
Manufacturing
and Industry
Development

VOL. I: TEXT & APPENDICES

1991

# GEOLOGICAL SURVEY OF VICTORIA

## BASIN STUDIES

# Mocamboro 11

## Well completion report

Unpublished report No.1991/65

Volume 1
Text and appendices

Department of
Manufacturing
and Industry
Development

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PREFACE

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## GEOCHEMISTRY REPORT

AMDEL CORE SERVICES

12 July 1991

Department of Mines Industry
and Development
PO Box 173
EAST MELBOURNE VIC 3002

Attention: John Leonard (Basin Studies Manager)

**REPORT: 009/825**

**CLIENT REFERENCE:** Fax from Tabassi and Associates 11/2/91

**MATERIAL:** SWC, Core and Cuttings

**LOCALITY:** Mocamboro-11

**WORK REQUIRED:** Geochemistry

Please direct technical enquiries regarding this work to the signatory below under whose supervision the work was carried out.

for

**BRIAN L WATSON**
Laboratory Supervisor
on behalf of Amdel Core Services Pty Ltd



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(Incorporated in South Australia)
ACN: 008 273 005

## 1. INTRODUCTION

Core, sidewall core and cuttings samples from Mocamboro-11 were received for geochemical analyses with the following aims:

- to determine the maturity, source richness and source quality of the shales and siltstones intersected in this location
- to isolate migrated hydrocarbons from sandstone units intersected in this well and determine the source affinity and maturity of these oils
- to determine whether the oils isolated from the sandstones in this location were generated "in situ" or alternatively migrated from a distant source.

This report is a formal presentation of results reported by facsimile as analyses were completed and includes an interpretation of the complete data set.

## 2. ANALYTICAL PROCEDURES

Analytical procedures used in this study are presented in Appendix 1 of this report.

## 3. RESULTS

TOC and Rock-Eval pyrolysis data are presented in Table 1. Figure 1 is a plot of Hydrogen Index versus $T_{max}$ illustrating kerogen Type and maturity. Table 2 is a summary of the Vitrinite Reflectance determinations. This data is presented graphically in Figure 2. Histogram plots of this data are presented in Appendix 2.

Extract Yield, Bulk Composition and Alkane Ratios calculated from chromatograms of the $C_{12}$+ saturated (aliphatic) hydrocarbons are presented in Table 3. Figures 3-8 are gas chromatograms of the saturated hydrocarbons isolated from the extracted residual oils.

Aromatic maturity ratios and calculated equivalent Vitrinite Reflectance determinations are presented in Table 4. Mass Fragmentograms of the aromatic hydrocarbons are included as Figures 10-14.

## 4. INTERPRETATION

### 4.1 SOURCE ROCK GEOCHEMISTRY

#### 4.1.1 Maturity

Vitrinite Reflectance determinations (Table 2, Figure 2) indicate that the sediments intersected in this location have maturities ranging from immature to marginally mature. This data indicates that the sedimentary sequence is sufficiently mature for the generation of:

- light oil/condensate from sediments rich in resinite and bituminite below approximately 800 metres depth (VR threshold = 0.45%)

- significant gas generation below approximately 1600 metres depth (VR ≥0.6%)

- oil from sediments rich in exinites other than resinite and bituminte below approximately 2100 metres depth (VR ≥0.7%)

Rock-Eval Hydrogen Index and $T_{max}$ data indicate maturities which are quite consistent with the maturities indicated by the measured Vitrinite Reflectance data. However, the Rock-Eval maturity data is somewhat more erratic.

Rock-Eval Production Indices are also maturation dependent. However, production indices >0.2 indicate that the following samples contain migrated hydrocarbons:

| Depth (m) | Production Index |
|---|---|
| 350 | 0.25 |
| 861 | 0.35 |
| 933 | 0.21 |

It should be noted here that the Production Index of the sample from 350 metres depth may not be reliable due to the small size of the $S_1$ and $S_2$ peaks from which it is calculated.

Residual oil was identified optically in sidewall cores from 626.0, 667.5 and 792.0 metres depth (Appendix 2).

4.1.2 Source Richness

Source richness for the generation of hydrocarbons is generally poor ($S_1 + S_2$ = 0.13-0.90 kg of hydrocarbons/tonne) in the samples analysed. However, two samples (426-429 and 626 metres depth) have $S_1 + S_2$ values which are indicative of excellent source richness ($S_1 + S_2$ = 79.99 and 36.88 kg of hydrocarbons/tonne respectively). These two samples also have excellent organic richness (TOC = 35.00 and 16.50%). Organic richness is uniformly poor in remaining samples examined (TOC = 0.18-1.03%).

4.1.3 Kerogen Type and Source Quality

Rock-Eval Hydrogen Index and $T_{max}$ data (Table 1, Figure 1) indicates that the majority of the samples examined contain organic matter which has bulk compositions ranging from Type III to Type IV kerogen. However, the two organic rich samples (426-429 and 626 metres depth) contain organic matter which has the bulk composition of Type II-III kerogen. Organic Petrology of these two samples (Appendix 2) illustrates that they contain organic matter which consists largely of vitrinite, with moderate amounts of exinite (sporinite, cutinite, resinite and bituminite) and lesser amounts of inertinite.

## 4.2 OIL CHEMISTRY

### 4.2.1 Genetic Affinity

The terrestrial source affinity of the oils extracted from the sandstone core and sidewall core from Mocamboro-11 is evident from the pristane/n-heptadecane, phytane/n-octadecane ratios (Table 3, Figure 9) and alkane distribution. However, these pristane/n-heptadecane and phytane/n-octadecane ratios are also influenced by biodegradation. Biodegradation removes normal alkanes in preference to branched alkanes and cycloalkanes which causes both of these ratios to increase (Figure 9). This biodegradation has had a more pronounced effect on the pristane/n-heptadecane ratios than on the phytane/n-octadecane ratios. The high abundance of $C_{25}$+ alkanes is also typical of oil generated from terrestrial organic matter.

Pristane/phytane ratios range from 2.01-4.03 in these oils but generally lie within the range of 2.01-2.85. These values indicate that the source of these oils was deposited in slightly oxic conditions. Oxic conditions typically occur in terrestrial environments of deposition.

GC-MS of cycloalkanes (naphthenes) were not performed on these oils due to their degree of biodegradation.

### 4.2.2 Oil Maturity

Aromatic maturity ratios (Table 4) indicate the residual oils present in the three cores examined from the 1289.6-1317 metres depth interval are generated and expulsed at essentially the same maturity ($VR_{calc}$ = 0.98-1.05%; Boreham et al calculation).

This maturity is significantly higher than that of the sedimentary sequence intersected in this location and indicates this oil has not been generated in situ. The available information suggests that this oil was generated either at depth in this location (between approximately 3100-3700 metres depth using an extrapolation of the measured Vitrinite Reflectance versus depth curve) or alternatively from a more mature part of the basin.

The isomerisation reactions influencing the abundance of the methyl phenanthrene isomers and phenanthrene abundance has been found to be influenced by clay catalysis and is not purely a thermally dependent reaction.

These recent findings indicate that the MPI derived maturity is not as precise a measure of maturity of the oil source at the time of primary migration as was previously believed. However, the lack of any noticeable odd-over-even carbon number preference is consistent with the maturity calculated from the aromatic maturity ratios ($VR_{calc}$ = 0.98-1.05%).

Pristane/n-heptadecane and phytane/n-octadecane ratios are also maturation dependent but have been altered by the biodegradation of these oils. These ratios cannot be used as indicators of maturation levels for the oils reservoired in this location.

# TABLE 1



AMDEL CORE SERVICES

Rock-Eval Pyrolysis 15/03/91

Client: Tabassi & Associates Pty.Ltd

Well: Mocamboro-11

| Depth | T Max | S1 | S2 | S3 | S1+S2 | PI | S2/S3 | PC | TOC | HI | OI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 159 | | | | | | | | | 0.35 | | |
| 260 | 398 | 0.07 | 0.46 | 0.40 | 0.53 | 0.13 | 1.15 | 0.04 | 0.83 | 55 | 48 |
| 307.5-313 | 277 | 0.01 | 0.12 | 0.34 | 0.13 | 0.08 | 0.35 | 0.01 | 0.54 | 22 | 62 |
| 350 | 275 | 0.05 | 0.16 | 0.39 | 0.21 | 0.25 | 0.41 | 0.01 | 0.50 | 32 | 78 |
| 400 | 377 | 0.09 | 0.46 | 0.36 | 0.55 | 0.17 | 1.27 | 0.04 | 0.69 | 66 | 52 |
| 426-429 | 428 | 1.25 | 78.74 | 7.08 | 79.99 | 0.02 | 11.12 | 6.66 | 35.00 | 224 | 20 |
| 465 | 438 | 0.04 | 0.26 | 0.32 | 0.30 | 0.13 | 0.81 | 0.02 | 0.60 | 43 | 53 |
| 500 | 438 | 0.07 | 0.67 | 0.29 | 0.74 | 0.09 | 2.31 | 0.06 | 0.93 | 72 | 31 |
| 550 | 441 | 0.05 | 0.46 | 0.35 | 0.51 | 0.10 | 1.31 | 0.04 | 0.86 | 53 | 40 |
| 582.5 | 439 | 0.06 | 0.64 | 0.30 | 0.70 | 0.09 | 2.13 | 0.05 | 1.03 | 62 | 29 |
| 605 | 439 | 0.06 | 0.44 | 0.35 | 0.50 | 0.12 | 1.25 | 0.04 | 0.75 | 58 | 46 |
| 626 | 438 | 0.55 | 36.33 | 2.61 | 36.88 | 0.01 | 13.91 | 3.07 | 16.50 | 220 | 15 |
| 759.3-763.3 | | | | | | | | | 0.30 | | |
| 792 | 443 | 0.10 | 0.80 | 0.40 | 0.90 | 0.11 | 2.00 | 0.07 | 0.98 | 81 | 40 |
| 808 | | | | | | | | | 0.23 | | |
| 861 | 438 | 0.14 | 0.27 | 0.48 | 0.41 | 0.35 | 0.56 | 0.03 | 0.44 | 61 | 109 |
| 890 | | | | | | | | | 0.18 | | |
| 933 | 436 | 0.12 | 0.47 | 3.33 | 0.59 | 0.21 | 0.14 | 0.04 | 0.62 | 75 | 537 |

TABLE 2

SUMMARY OF VITRINITE REFLECTANCE MEASUREMENTS

MOCAMBORO-11

| Depth (m) | Mean Maximum Reflectance (%) | Standard Deviation | Range | Number of Determinations |
|---|---|---|---|---|
| 96.8 - 103.0 | 0.32 | 0.03 | 0.27 - 0.38 | 24 |
| 159.0 | 0.33 | 0.03 | 0.30 - 0.40 | 11 |
| 213.4 - 214.4 | 0.34 | 0.04 | 0.25 - 0.45 | 31 |
| 260+ | 0.33 | 0.02 | 0.27 - 0.36 | 9 |
| 307.5 - 313.4 | 0.38 | 0.01 | 0.36 - 0.40 | 6 |
| 350+ | 0.39 | 0.04 | 0.33 - 0.42 | 4 |
| 400+ | 0.38 | 0.06 | 0.28 - 0.51 | 12 |
| 426 - 429+ | 0.39 | 0.03 | 0.31 - 0.43 | 27 |
| 465+ | 0.41 | 0.03 | 0.36 - 0.48 | 9 |
| 500+ | 0.41 | 0.04 | 0.38 - 0.48 | 6 |
| 556.0 | 0.44 | 0.05 | 0.38 - 0.52 | 14 |
| 582.0 | 0.45 | 0.03 | 0.41 - 0.49 | 4 |
| 605.0 | 0.45 | 0.02 | 0.40 - 0.48 | 12 |
| 626.0 | 0.41 | 0.03 | 0.36 - 0.47 | 24 |
| 667.5 | 0.44 | 0.04 | 0.38 - 0.49 | 27 |
| 705.1 - 706.3 | 0.45 | 0.03 | 0.39 - 0.48 | 5 |
| 759.3 - 763.3 | 0.48 | 0.04 | 0.42 - 0.52 | 4 |
| 792.0 | 0.44 | 0.04 | 0.38 - 0.54 | 21 |
| 808.0 | 0.42 | 0.02 | 0.39 - 0.44 | 4 |
| 861.0 | 0.55 | 0.04 | 0.48 - 0.61 | 13 |
| 933.0 | 0.45 | 0.03 | 0.41 - 0.52 | 10 |
| 997.3 - 1000.0 | 0.53 | 0.05 | 0.40 - 0.60 | 31 |
| 1061.1 - 1066.7 | 0.50 | 0.05 | 0.40 - 0.58 | 20 |
| 1161.8 - 1166.1 | 0.50 | 0.03 | 0.47 - 0.54 | 4 |
| 1346.0 | 0.56 | 0.07 | 0.45 - 0.66 | 17 |

+ Cuttings samples
* Influenced by re-worked vitrinite

## TABLE 3

## EXTRACT YIELD $C_{12+}$ BULK COMPOSITION AND ALKANE RATIOS OF RESIDUAL OILS

## MOCAMBORO-11

| Depth (m) | Extract Yield (ppm) | $C_{12}$+ Bulk Composition | | | Alkane Ratios | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sats | Arom | NSO + Asph (%) | Np/Pr | Pr/Ph | Pr/ n-$C_{17}$ | Ph/ n-$C_{18}$ | TMTD/ Pr |
| 580.0 | 151.8 | 26.32 | 10.53 | 63.15 | 0.33 | 2.06 | 0.64 | 0.11 | 0.56 |
| 1198.0 | 36.0 | 16.07 | 16.07 | 67.86 | 0.18 | 2.85 | 0.85 | 0.11 | 0.24 |
| 1241.0 | 182.5 | 15.56 | 8.88 | 75.56 | 0.47 | 2.01 | 0.81 | 0.08 | - |
| 1289.6 | 97.7 | 38.93 | 15.44 | 45.64 | 0.13 | 2.48 | 1.27 | 0.35 | 0.08 |
| 1304.5 | 800.6 | 14.62 | 13.68 | 71.70 | 0.28 | 2.40 | 1.56 | 0.21 | 0.36 |
| 1317.0 | 6048.8 | 5.46 | 17.73 | 76.81 | 0.38 | 4.03 | 3.26 | 0.56 | 0.72 |

Sats = saturated hydrocarbons
Arom = aromatic hydrocarbons
NSO = compounds containing nitrogen sulphur and oxygen
Asph = asphaltenes

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

TABLE 4

TABLE 1: AROMATIC MATURITY DATA

| | | | | | VR CALC | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE | MPI | MPR | DNR | MPDF | A | B | C | D | E | F |
| MOCAMBORO-11 | | | | | | | | | | |
| 1289.6 m | 1.183 | 1.421 | 1.389 | 0.513 | 1.11 | 1.59 | 1.09 | 1.53 | 1.05 | 0.98 |
| 1304 m | 1.154 | 1.250 | 1.640 | 0.502 | 1.09 | 1.61 | 1.04 | 1.64 | 1.03 | 0.96 |
| 1317 m | 1.085 | 1.213 | 1.569 | 0.497 | 1.05 | 1.65 | 1.02 | 1.61 | 0.98 | 0.95 |

# 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):

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

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

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

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

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

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

$$VR_{calc}\ (d) = 0.046\ DNR + 0.89\ (\text{for } VR = 0.9\text{-}1.5\%)$$

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

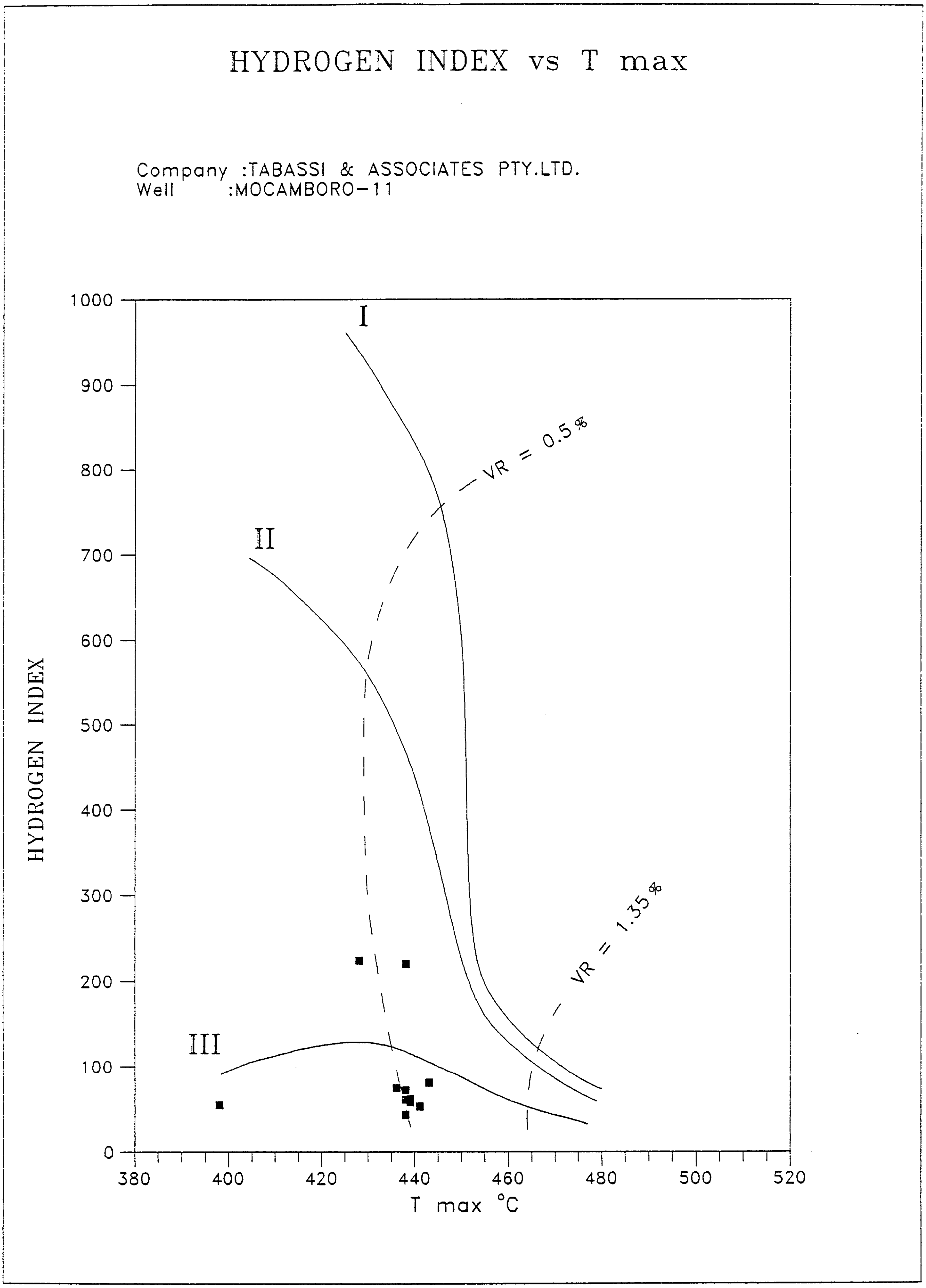
$$VR_{calc}\ (e) = 0.7\ MPI + 0.22\ (\text{for } VR < 1.7\%)$$

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

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

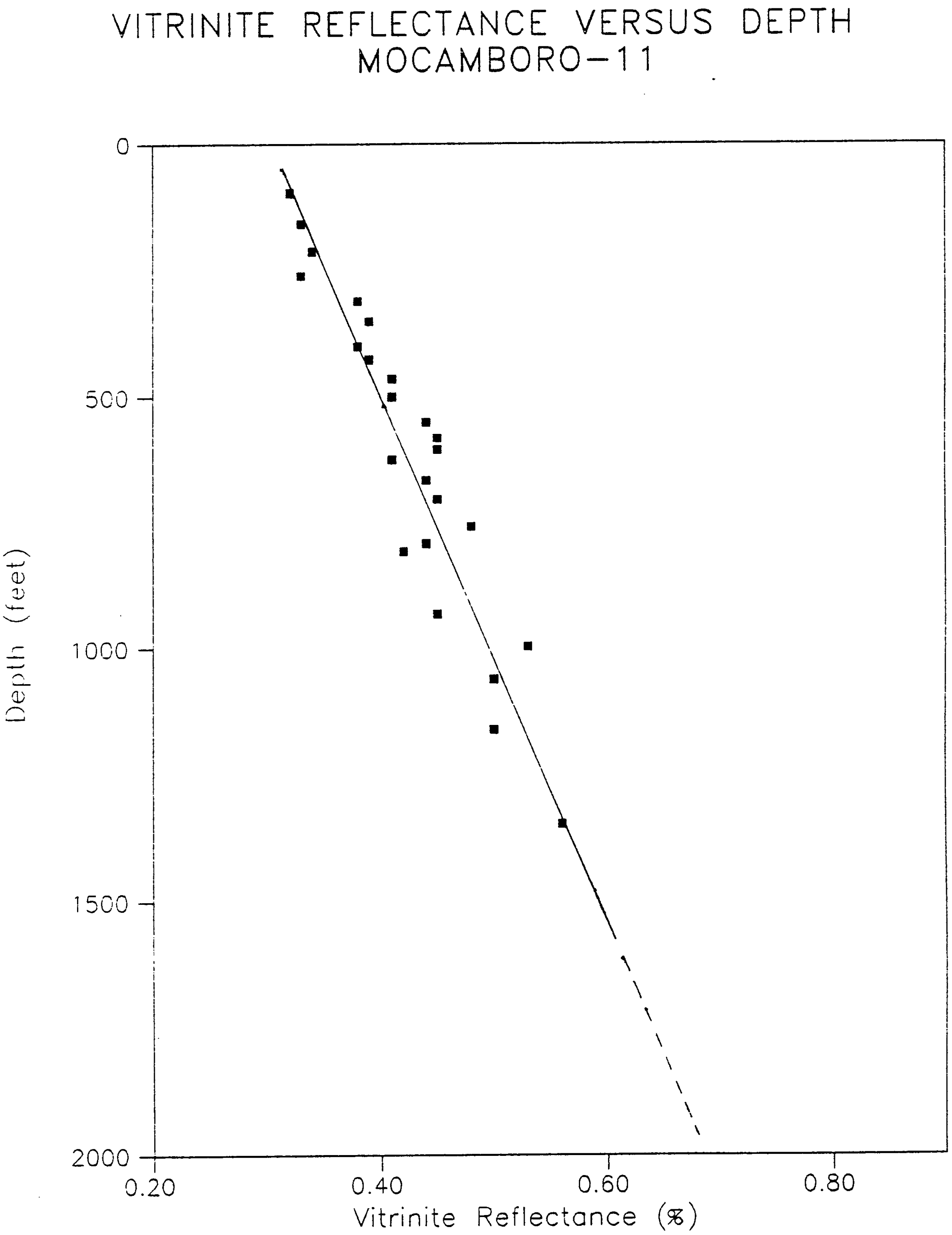
$$VR_{calc}\ (f) = -0.166 + 2.242\ MPDF$$

FIGURE 1



HYDROGEN INDEX vs T max
Company :TABASSI & ASSOCIATES PTY.LTD.
Well :MOCAMBORO-11
I
II
III
VR = 0.5 %
VR = 1.35 %
HYDROGEN INDEX
0
100
200
300
400
500
600
700
800
900
1000
380
400
420
440
460
480
500
520
T max °C

FIGURE 2




**VR ≈ 1.0 at 3500 m depth**

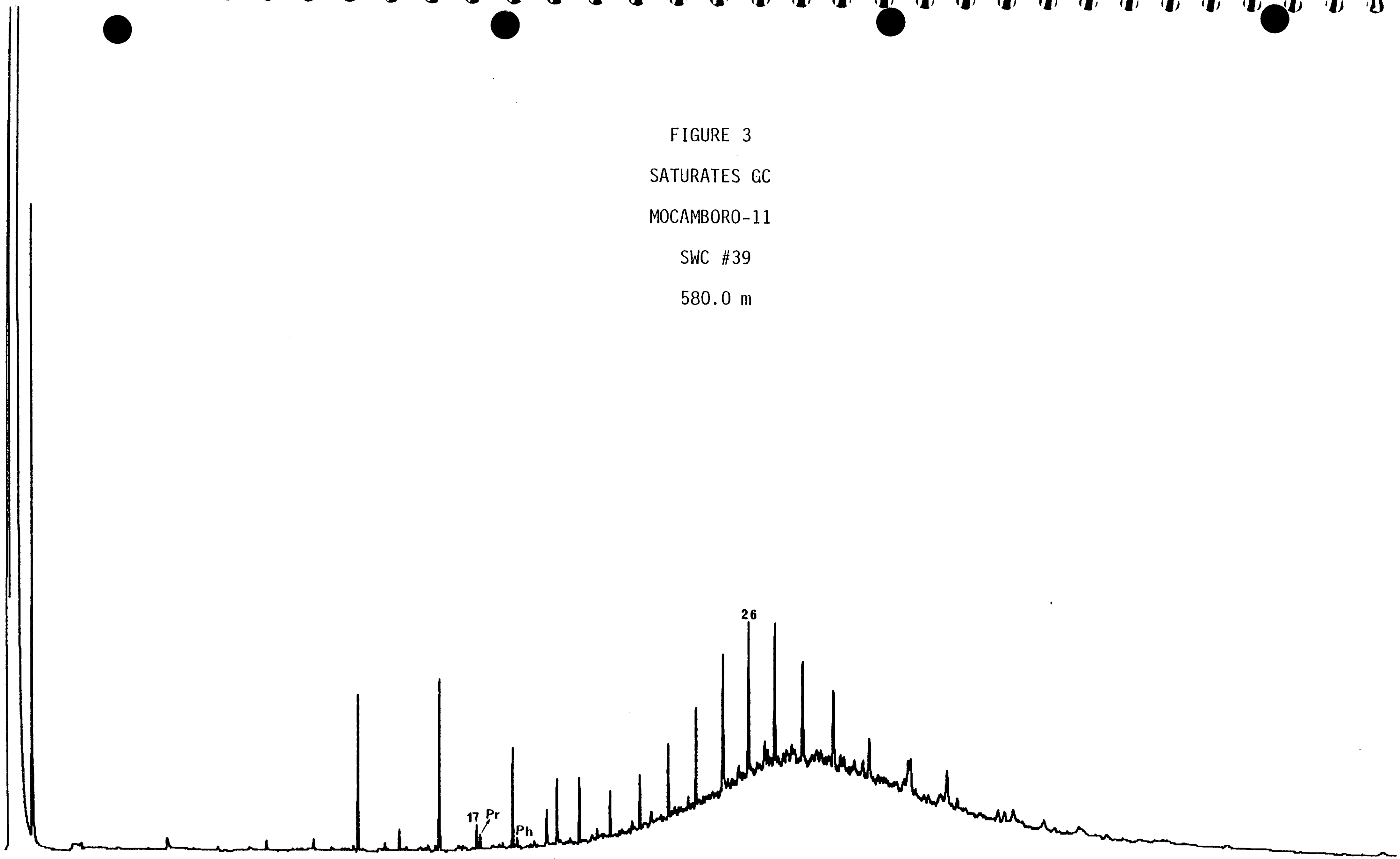
FIGURE 3

SATURATES GC

MOCAMBORO-11

SWC #39

580.0 m



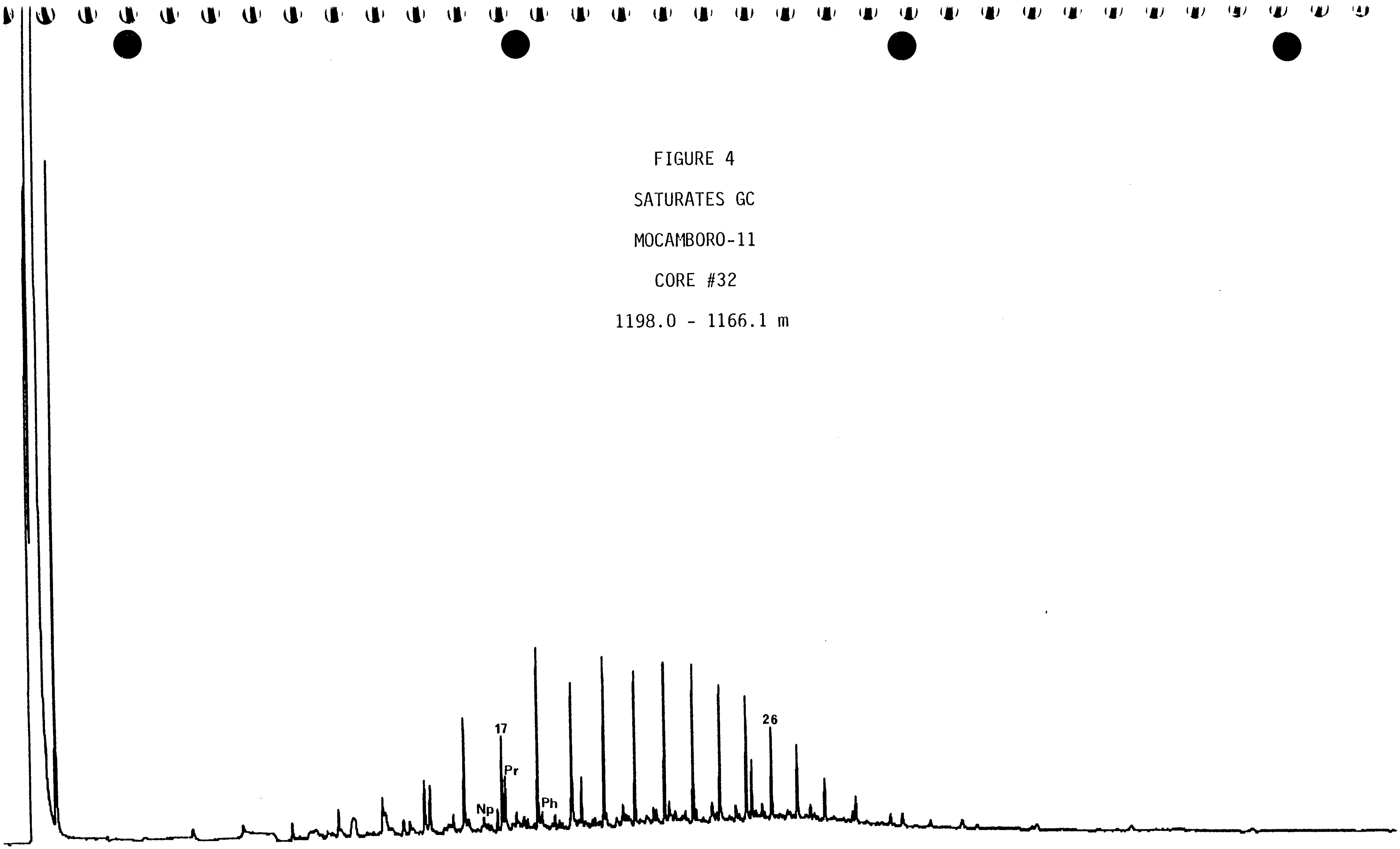



FIGURE 4

SATURATES GC

MOCAMBORO-11

CORE #32

1198.0 - 1166.1 m

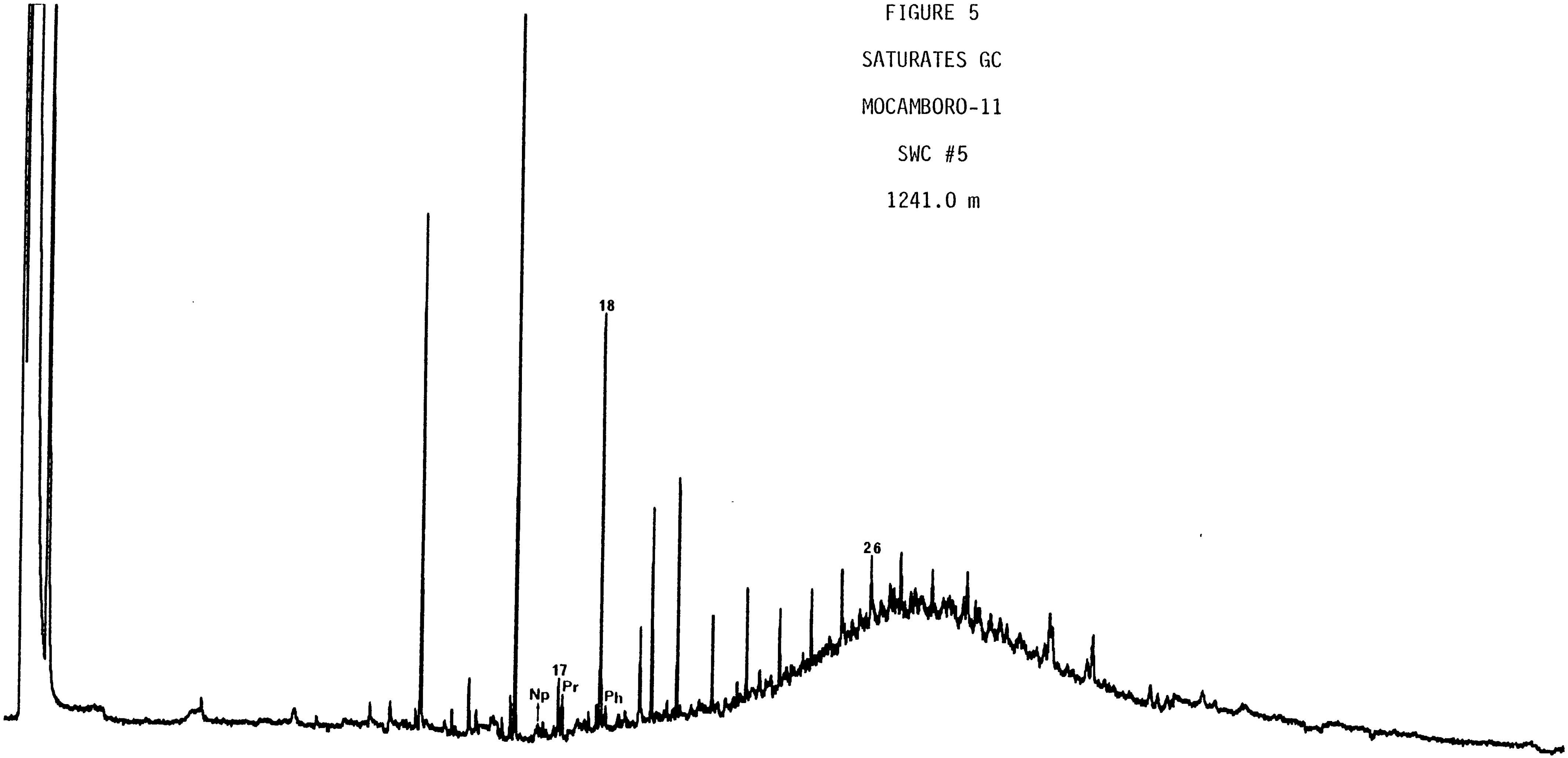
FIGURE 5

SATURATES GC

MOCAMBORO-11

SWC #5

1241.0 m



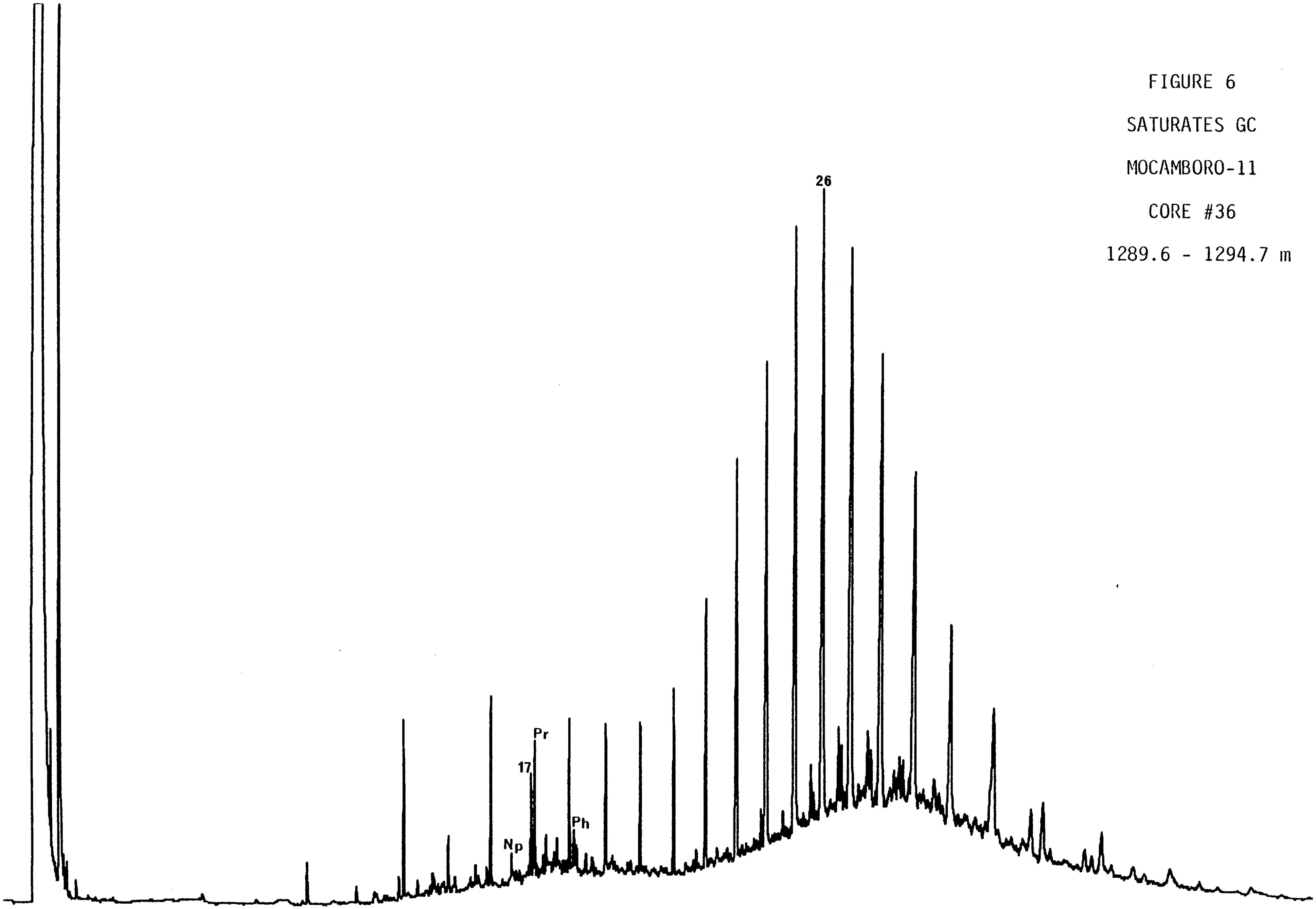



FIGURE 6

SATURATES GC

MOCAMBORO-11

CORE #36

1289.6 - 1294.7 m

FIGURE 7

SATURATES GC

MOCAMBORO-11

SWC #4

1304.5 m

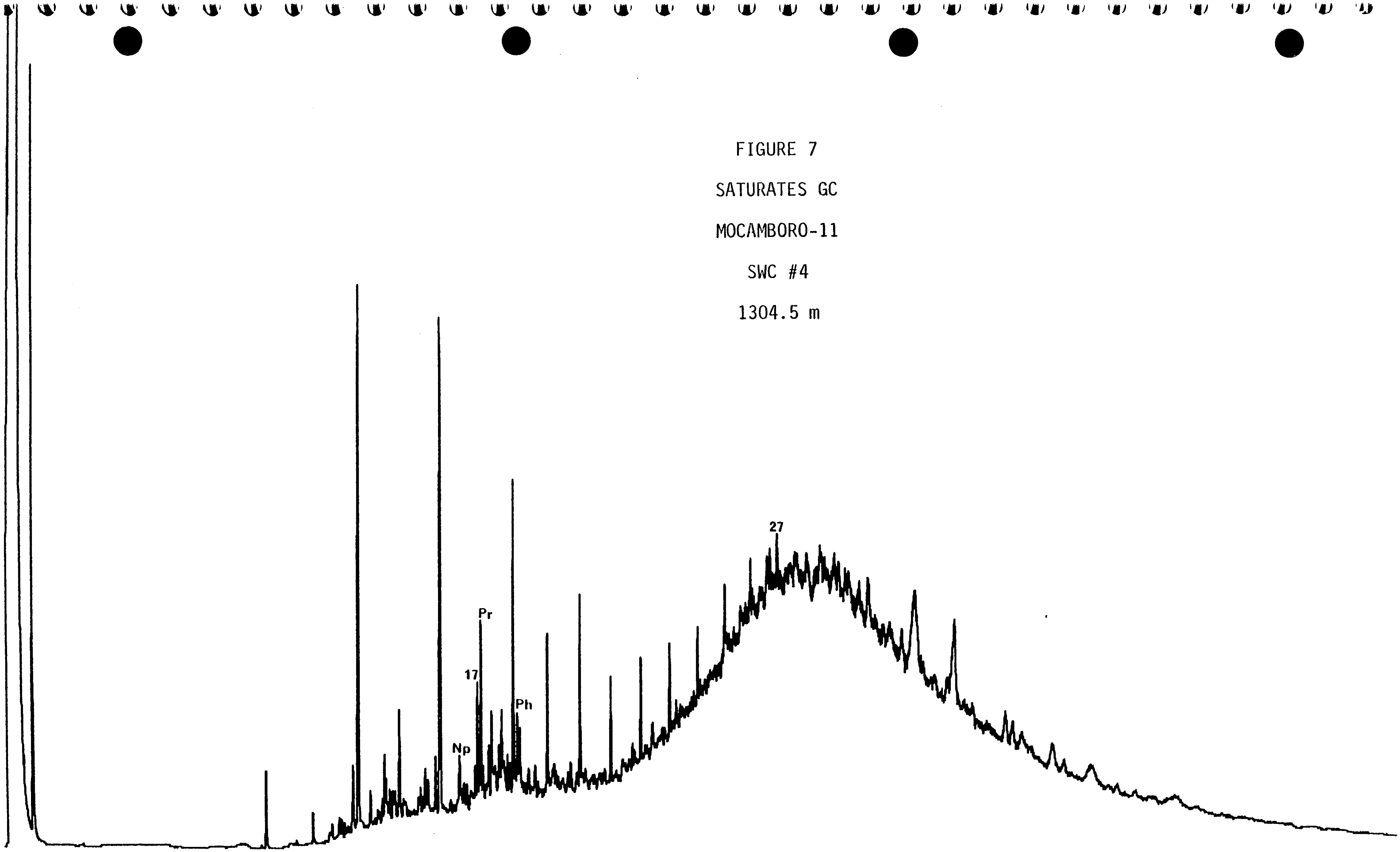


FIGURE 8

SATURATES GC

MOCAMBORO-11

CORE #37

1317.0 - 1323.1 m

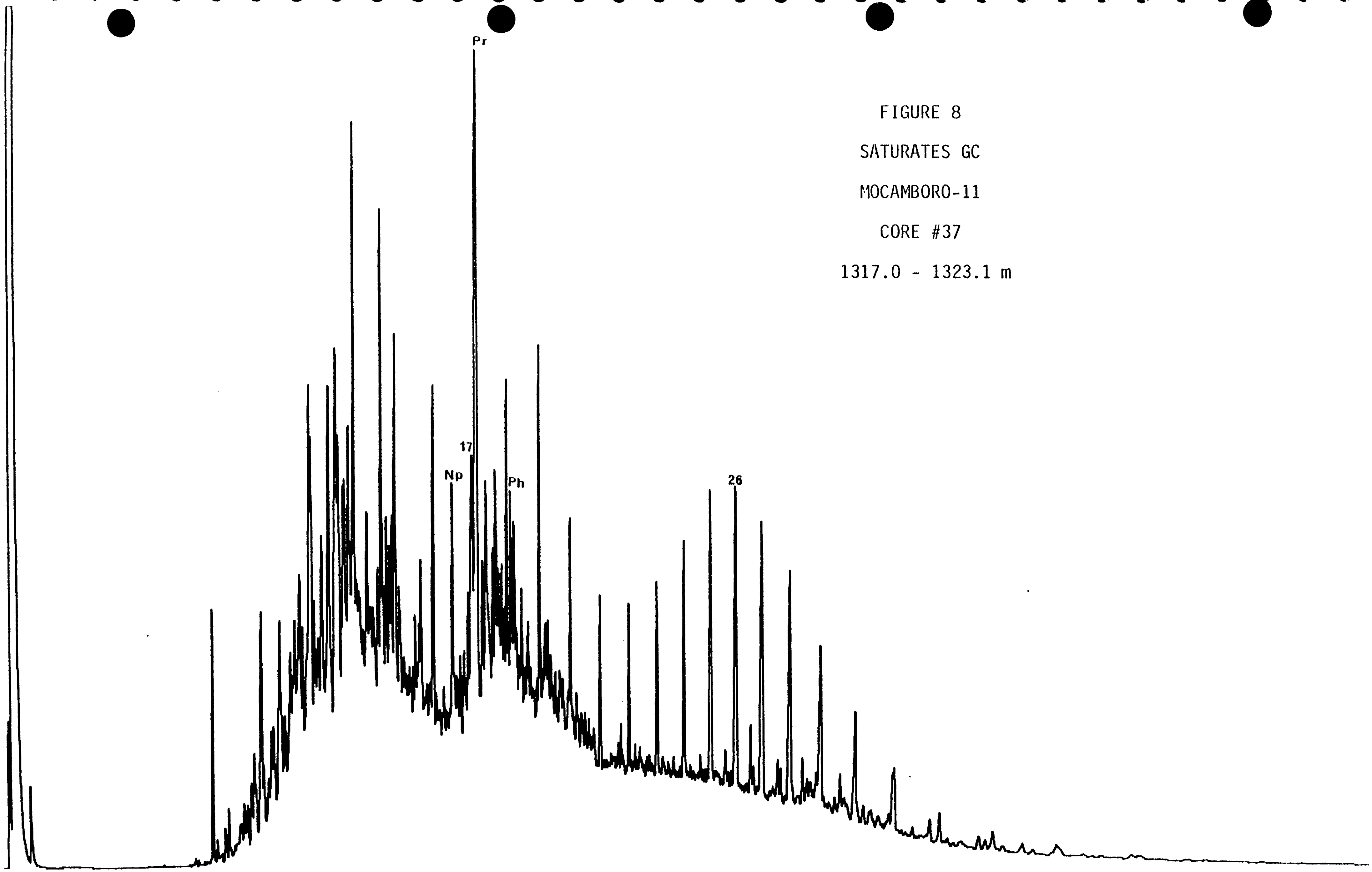


FIGURE 9

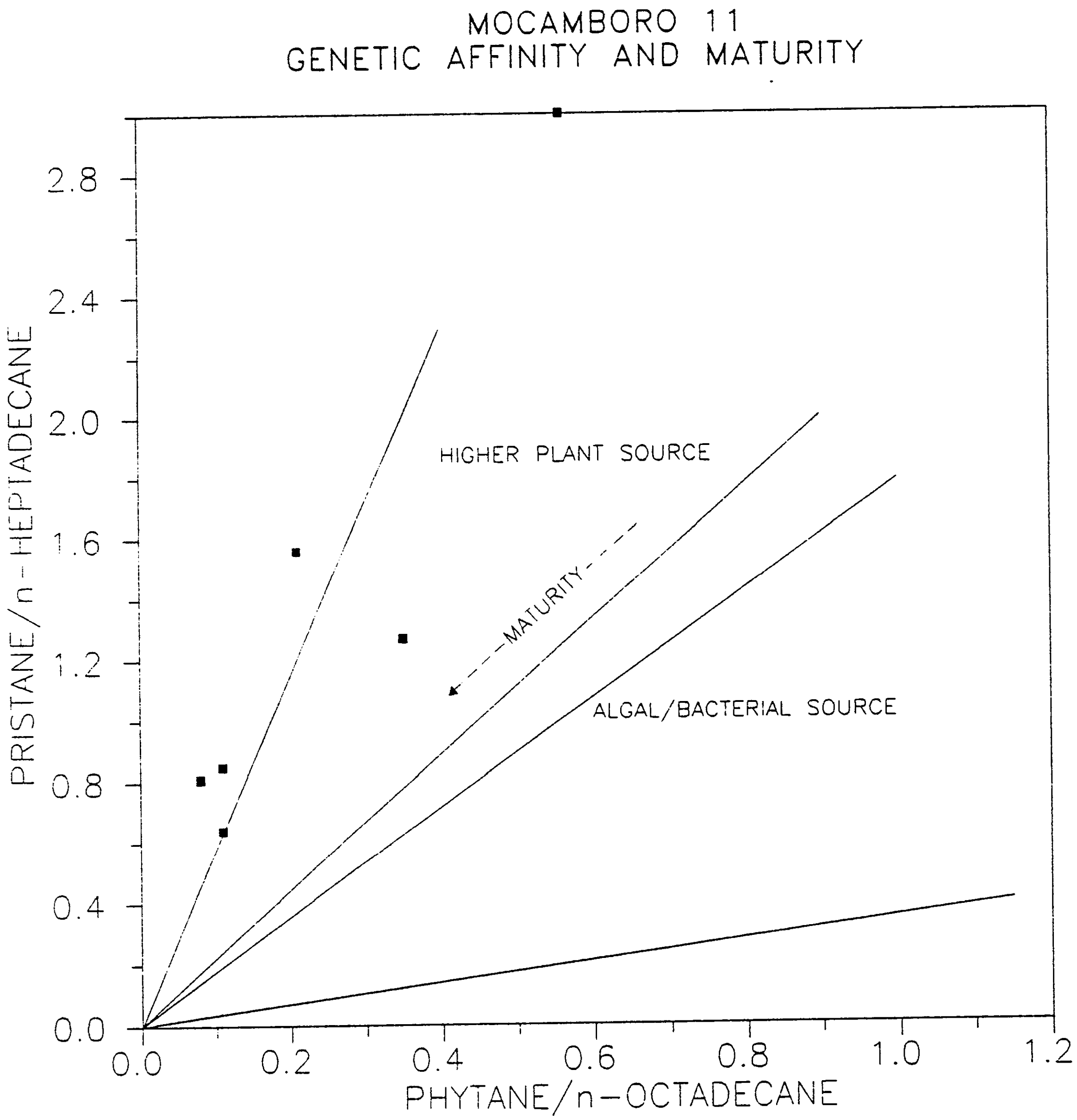

MOCAMBORO 11
GENETIC AFFINITY AND MATURITY
HIGHER PLANT SOURCE
MATURITY
ALGAL/BACTERIAL SOURCE
PRISTANE/n-HEPTADECANE
PHYTANE/n-OCTADECANE
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
0.0
0.2
0.4
0.6
0.8
1.0
1.2

FIGURE 10
PHENANTHRENE AND METHYLPHENANTHRENES
1289.6 m

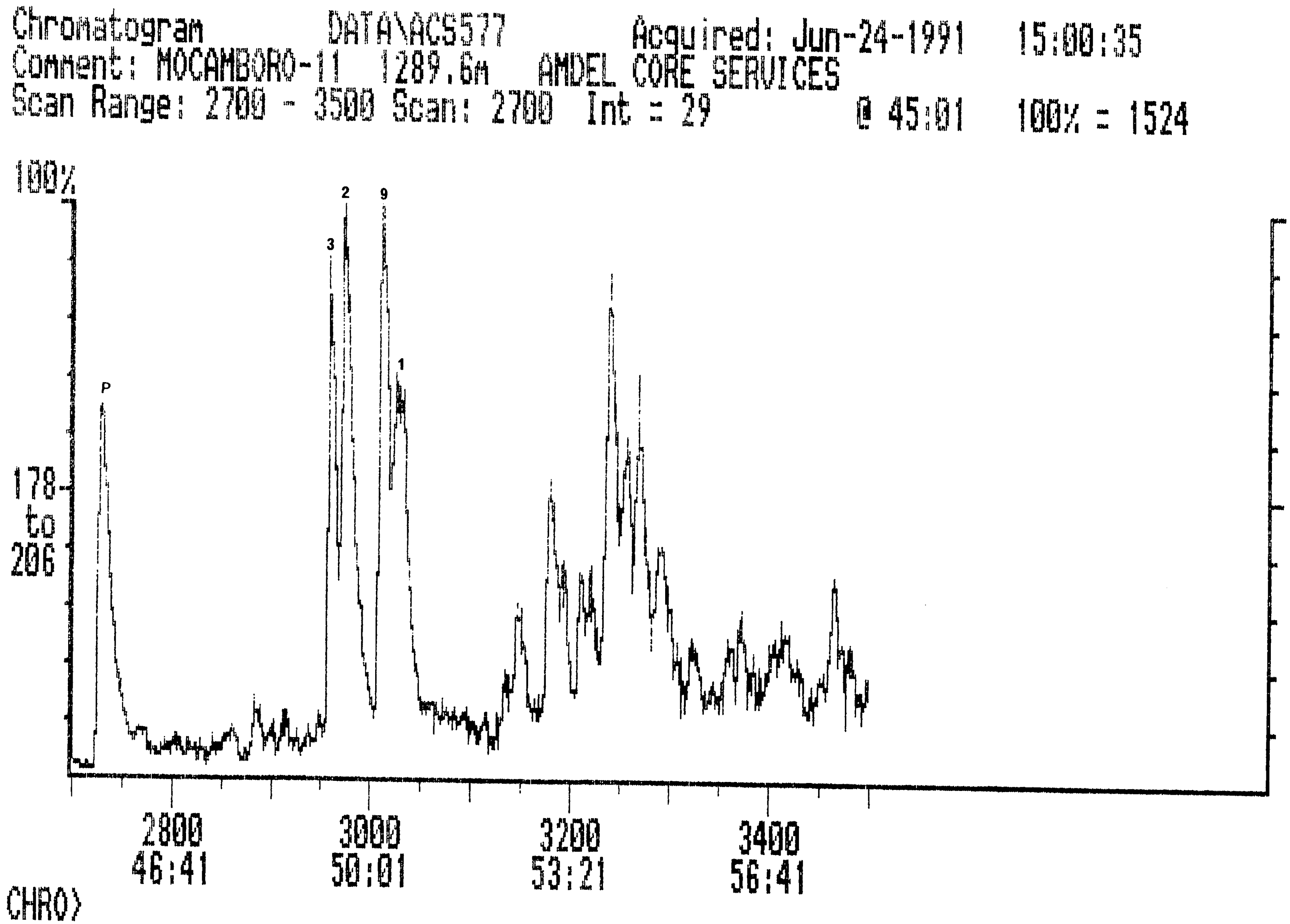


FIGURE 11
DI- AND TRIMETHYLNAPHTHALENES
1289.6 m

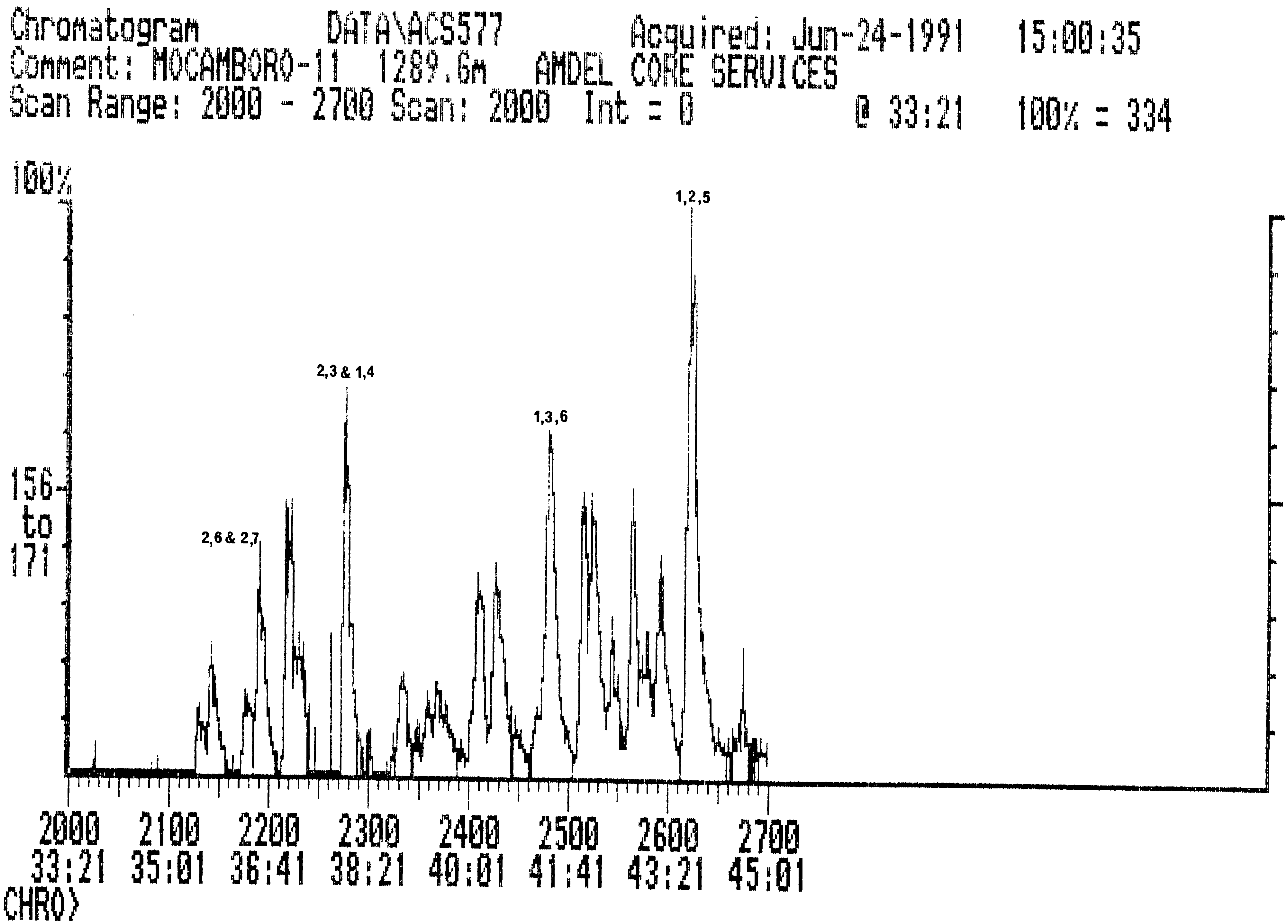
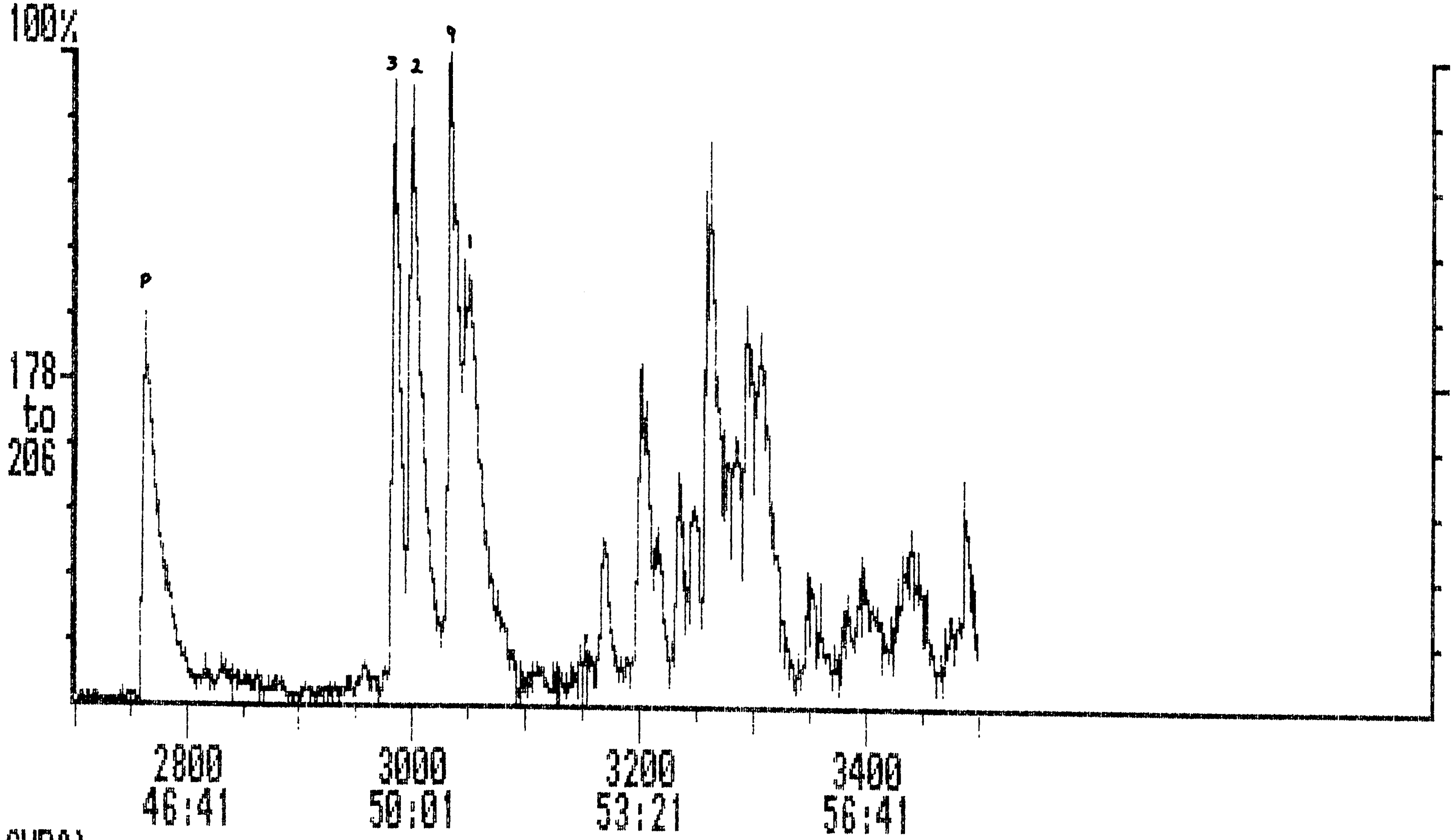


FIGURE 12
PHENANTHRENE AND METHYLPHENANTHRENES
1304 m

Chromatogram DATA\ACS576 Acquired: May-17-1991 19:25:52
Comment: MOCAMBORO-11 31 AMDEL CORE SERVICES
Scan Range: 2700 - 3500 Scan: 2700 Int = 0 @ 45:01 100% = 31598



CHRO>

FIGURE 13
P[illegible]NANTHRENE AND METHYLPHENANTHRENE
1317 m

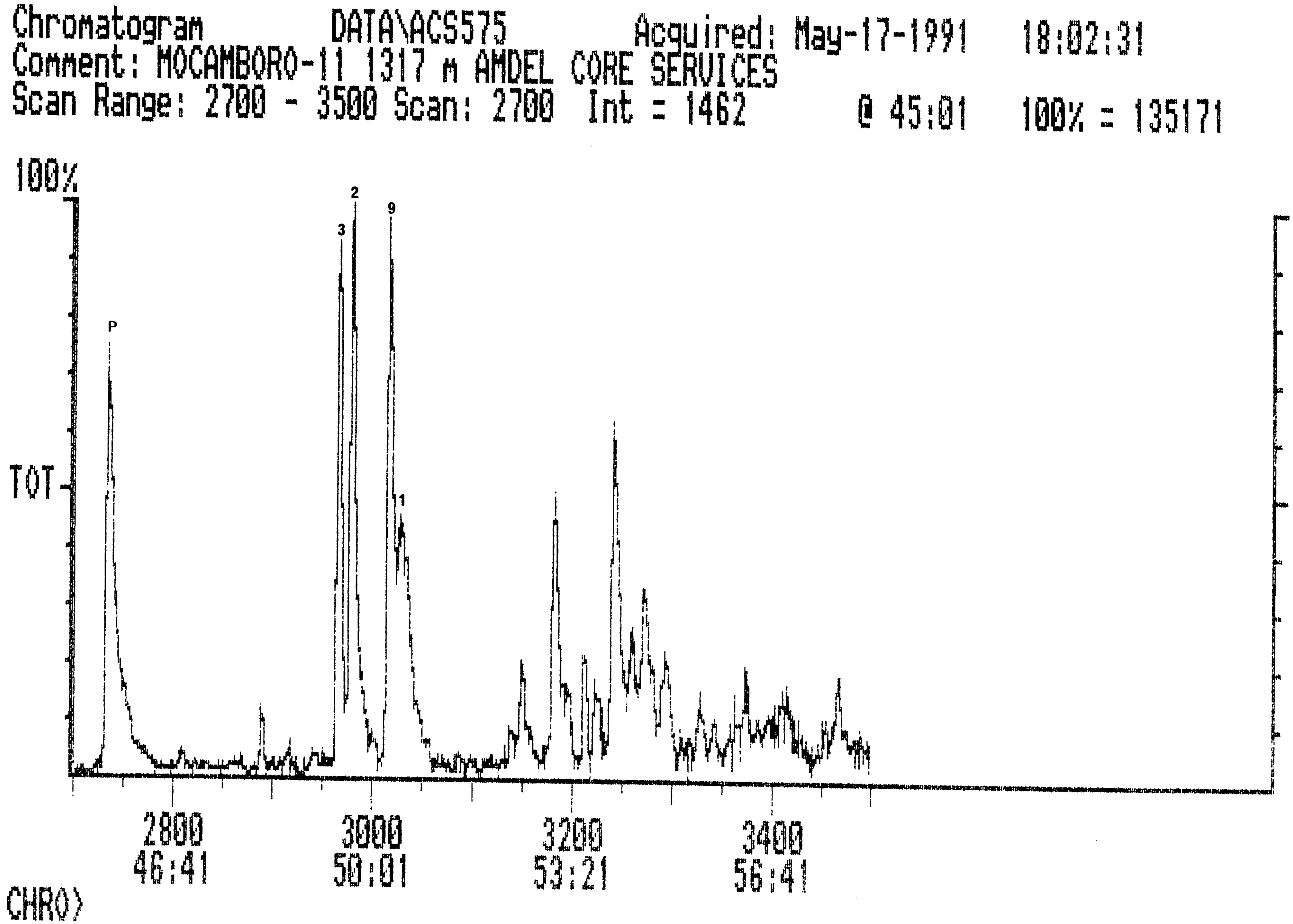
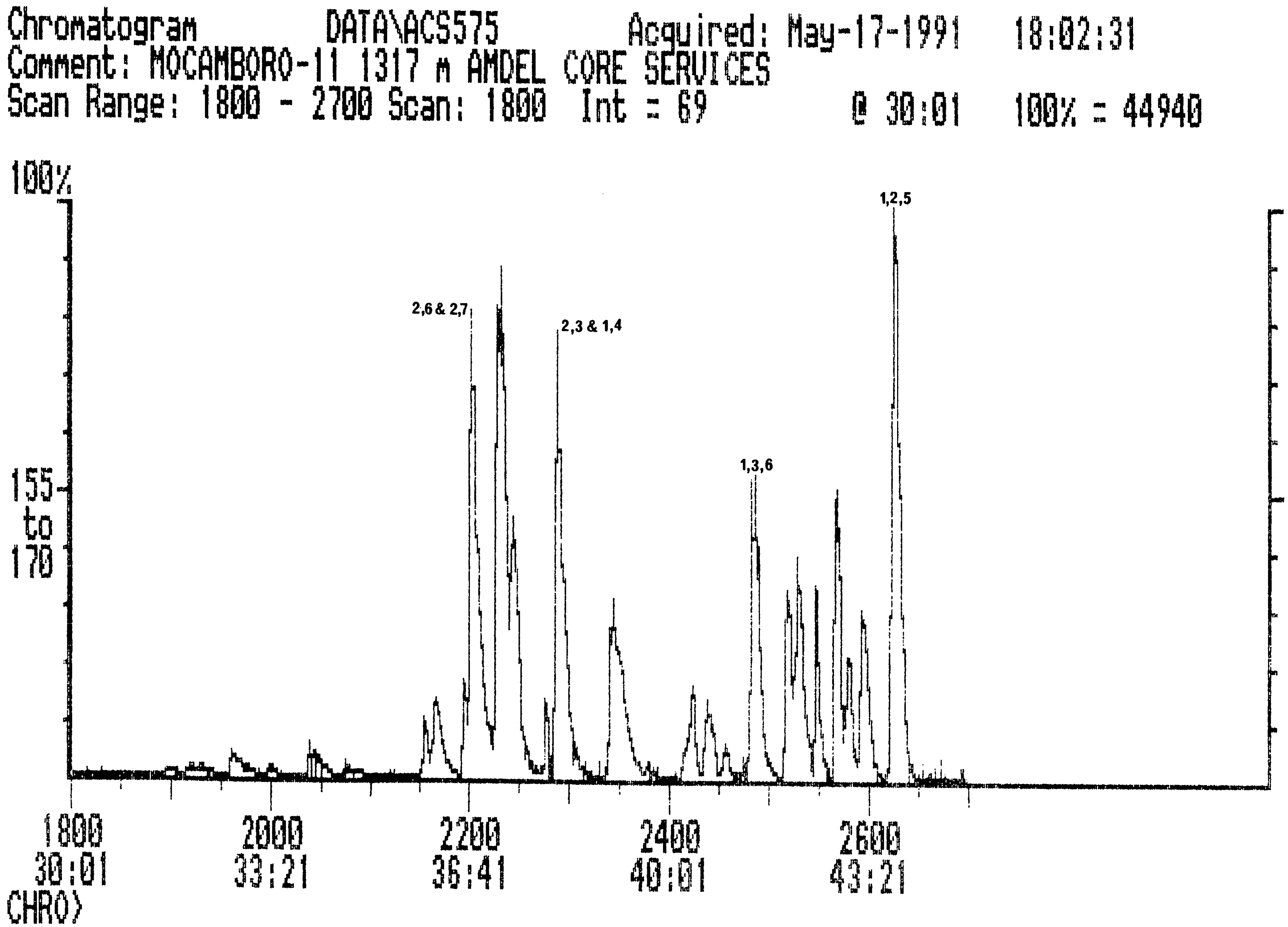


FIGURE 14
DI- AND TRIMETHYLNAPHTHALENES
1317 m



# APPENDIX 1

# ANALYTICAL METHODS

1. Total Organic Carbon (TOC)

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

2. 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).

3. Organic Petrology

Representative portions of the cuttings samples 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 on vitrinite phytoclasts 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 at 24±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.

4. Liquid Chromatography

Asphaltenes were not precipitated from the condensate prior to liquid chromatography. The condensate was 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 (50:50) 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) eluting in turn with petroleum ether and petroleum ether/dichloromethane (91:9).

5. Gas Chromatography

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

| | |
|---|---|
| Gas Chromatograph: | Carlo Erba 5140 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 |

6. 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.

7. 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 Finiga 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).

# APPENDIX 2

## HISTOGRAM PLOTS OF VITRINITE REFLECTANCE DATA

## MOCAMBORO-11

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 96.8-103.0m

Sorted List

| | | |
|---|---|---|
| 0.27 | 0.32 | 0.35 |
| 0.28 | 0.32 | 0.35 |
| 0.28 | 0.32 | 0.36 |
| 0.29 | 0.32 | 0.38 |
| 0.30 | 0.33 | |
| 0.31 | 0.33 | |
| 0.31 | 0.33 | |
| 0.31 | 0.33 | |
| 0.31 | 0.34 | |
| 0.31 | 0.34 | |

Number of values= 24

Mean of values 0.32
Standard Deviation 0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

27-29 ****
30-32 **********
33-35 ********
36-38 **

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 159.0m

Sorted List

| | |
|---|---|
| 0.30 | 0.40 |
| 0.30 | |
| 0.31 | |
| 0.32 | |
| 0.32 | |
| 0.33 | |
| 0.33 | |
| 0.33 | |
| 0.34 | |
| 0.36 | |

Number of values= 11

Mean of values 0.33
Standard Deviation 0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 30-32 | ***** |
| 33-35 | **** |
| 36-38 | * |
| 39-41 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 213.4-214.4m

Sorted List

| | | | |
|---|---|---|---|
| 0.25 | 0.32 | 0.36 | 0.45 |
| 0.26 | 0.33 | 0.36 | |
| 0.27 | 0.33 | 0.36 | |
| 0.28 | 0.34 | 0.37 | |
| 0.28 | 0.34 | 0.37 | |
| 0.28 | 0.34 | 0.37 | |
| 0.30 | 0.34 | 0.37 | |
| 0.30 | 0.35 | 0.38 | |
| 0.32 | 0.35 | 0.38 | |
| 0.32 | 0.35 | 0.42 | |

Number of values= 31

Mean of values 0.34
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 25-27 | ** |
| 28-30 | ****** |
| 31-33 | ***** |
| 34-36 | ********** |
| 37-39 | ****** |
| 40-42 | * |
| 43-45 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 260m

Sorted List

0.27
0.32
0.32
0.32
0.33
0.34
0.34
0.34
0.36

Number of values= 9

Mean of values 0.33
Standard Deviation 0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 27-29 | * |
| 30-32 | *** |
| 33-35 | **** |
| 36-38 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 307.5-313.4m

Sorted List

0.36
0.37
0.38
0.39
0.40
0.40

Number of values= 6

Mean of values 0.38
Standard Deviation 0.01

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

36-38 ***
39-41 ***

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 350m

Sorted List

0.33
0.41
0.41
0.42

Number of values= 4

Mean of values 0.39
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 33-35 | * |
| 36-38 | |
| 39-41 | ** |
| 42-44 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 400m

Sorted List

| | |
|---|---|
| 0.28 | 0.47 |
| 0.32 | 0.51 |
| 0.35 | |
| 0.35 | |
| 0.35 | |
| 0.36 | |
| 0.37 | |
| 0.37 | |
| 0.38 | |
| 0.40 | |

Number of values= 12

Mean of values 0.38
Standard Deviation 0.06

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 28-30 | * |
| 31-33 | * |
| 34-36 | **** |
| 37-39 | *** |
| 40-42 | * |
| 43-45 | |
| 46-48 | * |
| 49-51 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 426-429m

Sorted List

| | | |
|---|---|---|
| 0.31 | 0.38 | 0.41 |
| 0.34 | 0.39 | 0.41 |
| 0.36 | 0.39 | 0.41 |
| 0.36 | 0.39 | 0.42 |
| 0.37 | 0.39 | 0.42 |
| 0.38 | 0.39 | 0.43 |
| 0.38 | 0.40 | 0.43 |
| 0.38 | 0.40 | |
| 0.38 | 0.40 | |
| 0.38 | 0.41 | |

Number of values= 27

Mean of values 0.39
Standard Deviation 0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 31-33 | * |
| 34-36 | *** |
| 37-39 | ************ |
| 40-42 | ********* |
| 43-45 | ** |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 465m

Sorted List

0.36
0.37
0.38
0.40
0.40
0.40
0.43
0.43
0.48

Number of values= 9

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 | |
| 48-50 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 500m

Sorted List

0.38
0.39
0.39
0.39
0.44
0.48

Number of values= 6

Mean of values 0.41
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 38-40 | **** |
| 41-43 | |
| 44-46 | * |
| 47-49 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 550.0m

Sorted List

| | |
|---|---|
| 0.34 | 0.48 |
| 0.37 | 0.49 |
| 0.38 | 0.51 |
| 0.40 | 0.52 |
| 0.40 | |
| 0.41 | |
| 0.44 | |
| 0.44 | |
| 0.45 | |
| 0.47 | |

Number of values= 14

Mean of values 0.44
Standard Deviation 0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 34-36 | * |
| 37-39 | ** |
| 40-42 | *** |
| 43-45 | *** |
| 46-48 | ** |
| 49-51 | ** |
| 52-54 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 582.5m

Sorted List

0.41
0.43
0.46
0.49

Number of values= 4

Mean of values 0.45
Standard Deviation 0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

41-43 **
44-46 *
47-49 *

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 605.0m

Sorted List

| | |
|---|---|
| 0.40 | 0.48 |
| 0.41 | 0.48 |
| 0.42 | |
| 0.44 | |
| 0.44 | |
| 0.45 | |
| 0.45 | |
| 0.45 | |
| 0.46 | |
| 0.47 | |

Number of values= 12

Mean of values 0.45
Standard Deviation 0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

40-42 ***
43-45 *****
46-48 ****

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 626.0m

Sorted List

| | | |
|---|---|---|
| 0.36 | 0.41 | 0.46 |
| 0.36 | 0.41 | 0.46 |
| 0.37 | 0.41 | 0.46 |
| 0.37 | 0.42 | 0.47 |
| 0.38 | 0.42 | |
| 0.38 | 0.43 | |
| 0.39 | 0.43 | |
| 0.39 | 0.45 | |
| 0.39 | 0.45 | |
| 0.40 | 0.46 | |

Number of values= 24

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

Well Name: MOCAMBORO-11
Depth: 667.5m

Sorted List

| | | |
|---|---|---|
| 0.38 | 0.43 | 0.48 |
| 0.39 | 0.43 | 0.48 |
| 0.40 | 0.45 | 0.48 |
| 0.40 | 0.46 | 0.48 |
| 0.40 | 0.46 | 0.49 |
| 0.40 | 0.46 | 0.49 |
| 0.41 | 0.47 | 0.49 |
| 0.41 | 0.47 | |
| 0.41 | 0.48 | |
| 0.43 | 0.48 | |

Number of values= 27

Mean of values 0.44
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

38-40 ******
41-43 ******
44-46 ****
47-49 ***********

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 705.1-706.3m

Sorted List

0.39
0.44
0.47
0.47
0.48

Number of values= 5

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 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 759.3-763.3m

Sorted List

0.42
0.46
0.50
0.52

Number of values= 4

Mean of values 0.48
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 42-44 | * |
| 45-47 | * |
| 48-50 | * |
| 51-53 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 792.0m

Sorted List

| | | |
|---|---|---|
| 0.38 | 0.44 | 0.54 |
| 0.41 | 0.44 | |
| 0.41 | 0.44 | |
| 0.41 | 0.45 | |
| 0.41 | 0.45 | |
| 0.42 | 0.46 | |
| 0.42 | 0.46 | |
| 0.43 | 0.46 | |
| 0.43 | 0.50 | |
| 0.44 | 0.53 | |

Number of values= 21

Mean of values 0.44
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 38-40 | * |
| 41-43 | ******** |
| 44-46 | ********* |
| 47-49 | |
| 50-52 | * |
| 53-55 | ** |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 808.0m

Sorted List

0.39
0.40
0.43
0.44

Number of values= 4

Mean of values 0.42
Standard Deviation 0.02

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

39-41 **
42-44 **

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 861.0m

Sorted List

| | |
|---|---|
| 0.48 | 0.59 |
| 0.49 | 0.59 |
| 0.49 | 0.61 |
| 0.51 | |
| 0.54 | |
| 0.54 | |
| 0.55 | |
| 0.56 | |
| 0.57 | |
| 0.58 | |

Number of values= 13

Mean of values 0.55
Standard Deviation 0.04

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 48-50 | *** |
| 51-53 | * |
| 54-56 | *** |
| 57-59 | ***** |
| 60-62 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 933.0m

Sorted List

0.41
0.41
0.43
0.44
0.44
0.45
0.46
0.46
0.50
0.52

Number of values= 10

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

Well Name: MOCAMBORO-11
Depth: 997.5-1000.0M

Sorted List

| | | | |
|---|---|---|---|
| 0.40 | 0.50 | 0.57 | 0.60 |
| 0.41 | 0.51 | 0.57 | |
| 0.47 | 0.51 | 0.57 | |
| 0.47 | 0.51 | 0.58 | |
| 0.49 | 0.51 | 0.58 | |
| 0.49 | 0.52 | 0.59 | |
| 0.49 | 0.54 | 0.59 | |
| 0.49 | 0.56 | 0.59 | |
| 0.50 | 0.56 | 0.60 | |
| 0.50 | 0.56 | 0.60 | |

Number of values= 31

Mean of values 0.53
Standard Deviation 0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 40-42 | ** |
| 43-45 | |
| 46-48 | ** |
| 49-51 | *********** |
| 52-54 | * |
| 55-57 | ******* |
| 58-60 | ******** |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 1061.1-1066.7m

Sorted List

| | |
|---|---|
| 0.40 | 0.51 |
| 0.43 | 0.51 |
| 0.43 | 0.51 |
| 0.43 | 0.53 |
| 0.47 | 0.54 |
| 0.47 | 0.55 |
| 0.47 | 0.56 |
| 0.49 | 0.56 |
| 0.50 | 0.57 |
| 0.50 | 0.58 |

Number of values= 20

Mean of values 0.50
Standard Deviation 0.05

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 40-42 | * |
| 43-45 | *** |
| 46-48 | *** |
| 49-51 | ****** |
| 52-54 | * |
| 55-57 | ***** |
| 58-60 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 1161.8-1166.1m

Sorted List

0.47
0.49
0.51
0.54

Number of values= 4

Mean of values 0.50
Standard Deviation 0.03

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 47-49 | ** |
| 50-52 | * |
| 53-55 | * |

VITRINITE REFLECTANCE VALUES

Well Name: MOCAMBORO-11
Depth: 1346.0m

Sorted List

| | |
|---|---|
| 0.45 | 0.61 |
| 0.47 | 0.62 |
| 0.47 | 0.62 |
| 0.47 | 0.62 |
| 0.50 | 0.62 |
| 0.51 | 0.64 |
| 0.54 | 0.66 |
| 0.55 | |
| 0.56 | |
| 0.57 | |

Number of values= 17

Mean of values 0.56
Standard Deviation 0.07

HISTOGRAM OF VALUES
Reflectance values multiplied by 100

| | |
|---|---|
| 45-47 | **** |
| 48-50 | * |
| 51-53 | * |
| 54-56 | ** |
| 57-59 | ** |
| 60-62 | ***** |
| 63-65 | * |
| 66-68 | * |

# APPENDIX 8

## MACERAL ANALYSIS & VITRINITE REFLECTANCE DATA

# Maceral Analyses and Vitrinite Reflectance Data for Mocamboro-1, Otway Basin, Victoria

for

Geological Survey of Victoria

by

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University of Adelaide
February 1991

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## List of Plates

## 1. Introduction

A detailed petrographic examination was undertaken of five organic-rich sediments from the Eumeralla Formation in Mocamboro-1, Otway Basin, for Geological Survey of Victoria. The aim of the study was to determine their dispersed organic matter content.

## 2. Petrographic Procedures

### 2.1 Samples

A total of 1 cuttings and 4 core samples, consisting of coals and dark-grey argillaceous sediments, were selected from Mocamboro-1 for organic petrographic analysis (Table 1). All samples were cleaned to remove any contaminants (*e.g.* drilling mud and ink). Vitrinite reflectance and petrographic analyses of the above samples were then carried out (Table 1).

### 2.2 Preparation

A representative portion of each sample was crushed and mounted in cold-setting epoxy resin using a 2.5 cm diameter mould. On hardening, the samples were ground flat using a diamond impregnated lap, followed by corundum paper (400 and 600 grades) with kerosene as the lubricant. The surface was polished on "Lamplan 450" microcloth using three grades of diamond paste (3µm, 1µm and 0.5µm, respectively) and kerosene as the lubricant.

### 2.3 Petrographic Analysis

Organic petrographic observations and assessment of sediment type were made with a Leitz Ortholux II reflectance microscope using Leitz oil immersion objectives (x50/0.85, x32/0.65) in incident white light and UV light. The maceral classification scheme is shown in Table 2, and the coal microlithotype classification in Table 3.

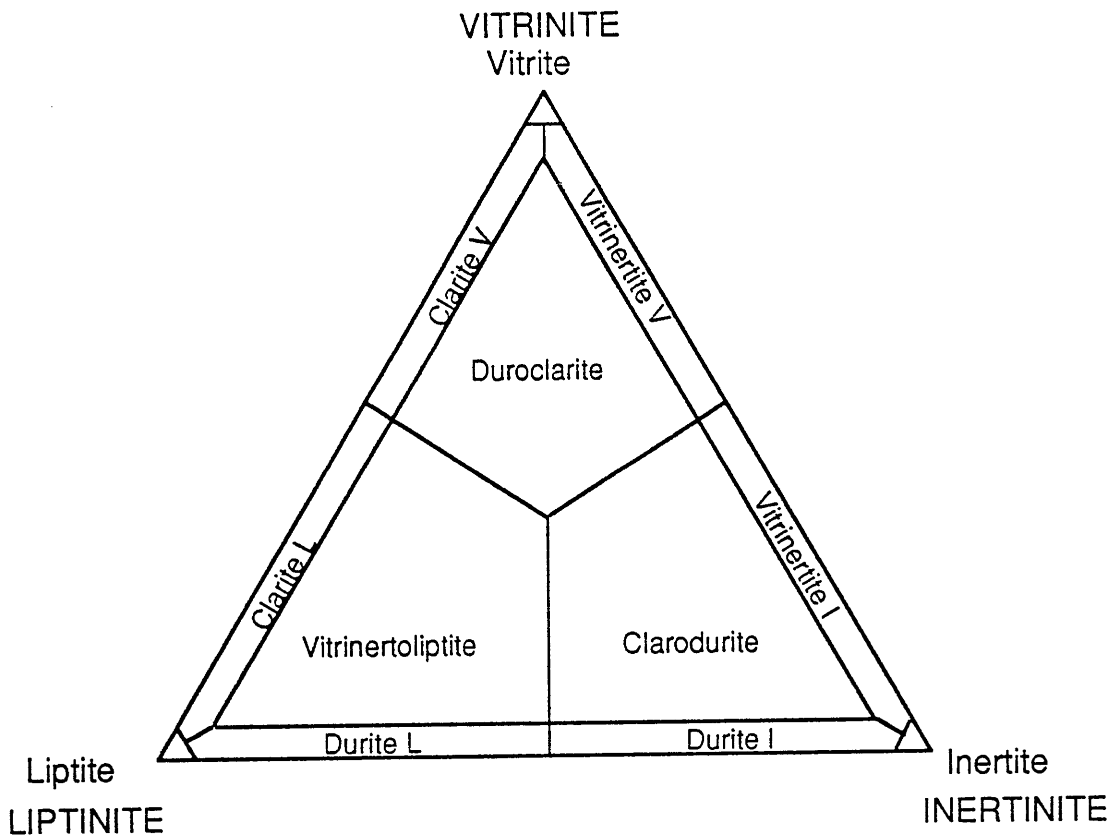
**TABLE 1: Samples Selected for Petrographic Descriptions and Vitrinite Reflectance Measurements, Mocamboro-1.**

| SAMPLE N° | Depth Range (m) | Sample Type | Lithology |
|---|---|---|---|
| A-923.184 | 64.2 | Core 4C | Shale; Coal |
| A-923.185 | 96.8 | Core 5A | Shale |
| A-923.186 | 213.6 | Core 7B | Coal; Shale |
| A-923.187 | 667 - 669 | Cuttings | Coal |
| A-923.188 | 706.0 | Core 13B | Shale |

**TABLE 2: Coal Maceral Classification** (modified from AS 2856-1986)

| MACERAL GROUP | MACERAL SUBGROUP | MACERAL |
|---|---|---|
| Vitrinite | Telovitrinite | Textinite<br>Texto-ulminite<br>Eu-ulminite<br>Telocollinite |
| | Detrovitrinite | Attrinite<br>Densinite<br>Desmocollinite |
| | Gelovitrinite | Corpogelinite<br>Porigelinite<br>Eugelinite |
| Liptinite | | Sporinite<br>Cutinite<br>Resinite<br>Liptodetrinite<br>Alginite<br>Suberinite<br>Fluorinite<br>Exsudatinite<br>Bituminite |
| Inertinite | Telo-inertinite | Fusinite<br>Semifusinite<br>Sclerotinite |
| | Detro-inertinite | Inertodetrinite<br>Micrinite |
| | Gelo-inertinite | Macrinite |

**TABLE 3: Coal Microlithotype Classification**



## 2.4 Reflected Light Microscopy

Vitrinite reflectances were measured in accordance with the guidelines published by the Australian Standard AS 2486 (Standards Association of Australia, 1989).

The analyses were made using a Leitz Ortholux II petrographic microscope connected to a Leitz MPV compact microphotometer with a digital display unit. Linearity of the microphotometer was established by calibrating against the synthetic standards, spinel, yttrium aluminium garnet and gadolinium gallium garnet with reflectance values of 0.421%, 0.924% and 1.726%, respectively. The microscope was fitted with a Leitz oil immersion (x50/0.85) objective. The immersion oil has a refractive index of 1.5180 at 23°C in sodium light (589.3nm). Reflectance was measured in normal incident white light. A Berek prism was used as the vertical illuminator. The aperture diaphram to the microphotometer had an area of $2\mu m^2$ and the monochromatic interference filter had a fixed central wavelength of 546nm. Measurements were made, wherever possible, on telovitrinite (vitrinite A). Maximum vitrinite reflectance ($R_V$max) was measured by rotating the microscope stage through 360° and recording the two maxima. If the two $R_V$max values differed by no more than 2%, the readings were summed and the arithmetic mean recorded as $R_V$max. A minimum of 30 reflectance measurements were made on each sample unless otherwise stated. Due to the small size of the vitrinite phytoclasts in sample A-923.185, only average vitrinite reflectance ($R_V$av) was measurable, (*i.e.* there was no rotation of the stage).

## 3. Results and Discussion

Photomicrographs of the samples examined in this study are given in Appendix A. The organic petrographic descriptions of the samples, which include both coals and clastic sediments with dispersed organic matter (d.o.m.), are summarised in Appendix B. The vitrinite reflectance data for each sample is presented both in a table and as a histogram in Appendix C.

This report assesses the maturity and organic matter content of the Eumeralla Formation from the interval 64.2 - 706.0 metres depth in Mocamboro-1.

## 3.1 Organic Petrology of Coal and Shale

### Sample A-923.184, depth 64.2m

This sample consists of two different lithologies, shale and coal.

The shale contains a moderate amount (5% - 10% by volume) of dispersed organic matter (d.o.m.), comprising inertinite as the most abundant maceral and minor amounts of vitrinite and liptinite. Vitrinite occurs as wisps and stringers which are commonly associated with dark-brown matrix bituminite; as small reworked phytoclasts; and more rarely as large coaly fragments with cellular structures (*viz.* texto-ulminite and eu-ulminite). Inertinite is present as detro-inertinite and to a lesser extent as telo-inertinite, with semifusinite predominating over fusinite. The liptinite macerals include sporinite, resinite and liptodetrinite with minor amounts of cutinite. The resinite usually occurs within vitrinite, as opposed to discrete isolated globules (Plate 1). In addition, there is the rare maceral telalginite which appears as small bodies (30µm) with an intense yellow fluorescence under ultraviolet light (Plate 2a).

The coal consists entirely of vitrinite, represented by the macerals texto-ulminite, eu-ulminite and telocollinite and hence can be classified as the microlithotype vitrite.

### Sample A-923.185, depth 96.8m

The shale contains a very low amount (<1% by volume) of dispersed organic matter (d.o.m.). Inertinite makes up the largest portion of the d.o.m. with inertodetrinite as the dominant maceral and subordinate semifusinite. There are only minor amounts of vitrinite and liptinite (Plate 2b).

### Sample A-923.186, depth 213.6m

The lithologies represented in this sample grade from shale through to coal.

The shale is rich in d o.m. (10% - 50% by volume). Inertinite (semifusinite and fusinite) is the dominant maceral group with lesser amounts of vitrinite and liptinite. Vitrinite is present as wisps and stringers of poorly gelified telovitrinite. Sporinite and liptodetrinite dominate the liptinites with only minor amounts of resinite and cutinite (Plate 3).

In the coal, inertinite is the dominant maceral group with subordinate vitrinite and liptinite. Hence it is classified as the microlithotype clarodurite (Plate 4). The inertinite occurs mainly as telo-inertinite, although a considerable quantity of detro-inertinite is also present. Semifusinite is the most abundant maceral, although fusinite and sclerotinite were also observed. Vitrinite occurs in pure bands as telovitrinite, and as the granular matrix detrovitrinite. Sporinite and resinite are the dominant liptinites although lesser amounts of liptodetrinite, and more rarely cutinite and suberinite, are also present. In addition, there is a minor amount of the microlithotype vitrite. The vitrinite occurs as texto-ulminite, eu-ulminite and telocollinite (Plate 5a).

**Sample A-923.187, depth 667 - 669m**

This coal is composed largely of vitrinite and is classified as the microlithotype vitrite. Due to increasing maturity and gelification the most common maceral is now telocollinite (Plate 5b). In addition, the microlithotype duroclarite is also present (Plate 6). Detrovitrinite (desmocollinite) is more abundant than telovitrinite (texto-ulminite, eu-ulminite and telocollinite). The gelovitrinite maceral corpogelinite is also present in this sample. The liptinites are dominated by sporinite, resinite and liptodetrinite with minor amounts of cutinite. The inertinites are represented by inertodetrinite and lesser amounts of semifusinite and fusinite.

**Sample A-923.188, depth 706m**

The shale is rich in d.o.m. (5% - 10% by volume). Inertinite, as inertodetrinite, makes up the largest proportion of the d.o.m. although significant amounts of very well preserved liptinite, notably sporinite were seen (Plate 7). Vitrinite is rare, occurring as reworked phytoclasts and wisps.

## 3.2 Vitrinite Reflectance Measurements

The results of the vitrinite reflectance measurements are shown in Table 4. The samples from the depths 64.2m, 213.6m and 667m (A-923-184, A-923-186 and A-923.187) are rich in the maceral subgroup telovitrinite, and hence reliable vitrinite reflectance measurements were obtained. Due to the paucity and small size of the vitrinite phytoclasts in the shales from 96.8m and 706m (A-923.185 and A-923.188) the reflectance data for these two samples are less accurate.

**Table 4: Summary of Vitrinite Reflectance Measurements, Mocamboro-1**

| Sample N° | Depth (m) | Mean Average Reflectance | Mean Max Reflectance | Range $R_V max$ | SD | Number of readings |
|---|---|---|---|---|---|---|
| A-923.184 | 64.2 | - | 0.27 | 0.23 - 0.35 | 0.03 | 30 |
| A-923.185 | 96.8 | 0.48 | - | - | 0.08 | 7 |
| A-923.186 | 213.6 | - | 0.28 | 0.22 - 0.47 | 0.05 | 30 |
| A-923.187 | 667.0 | - | 0.44 | 0.36 - 0.49 | 0.03 | 30 |
| A-923.188 | 706.0 | - | 0.55 | 0.46 - 0.64 | 0.05 | 17 |

## 4. Summary

The d.o.m. content of the shales examined is typically inertinite-rich with variable, but lesser quantities, of vitrinite and liptinite. The preferential presence of the resistant oxidised woody fragments and their small size in sample A-923.185 would imply that they were deposited distally from their source in an oxic-suboxic aqueous environment. In contrast, the assemblage of inertinite with well preserved liptinite macerals in sample A-923.188 would suggest an input of water and wind-borne inertinite and sporinite into a lacustrine environment with more anoxic bottom waters.

All the coal samples examined are humic - composed of land plants which were predominantly deposited as peats. They are either monomaceralic (*i.e.* vitrite or inertite), or a mixture of all three maceral groups, with duroclarite (vitrinite > inertinite and liptinite) or clarodurite (inertinite > vitrinite and liptinite) as the characteristic microlithotypes. Their liptinite content is restricted to higher plant derived macerals where sporinite and resinite are the dominant constituents, although subordinate amounts of cutinite and suberinite are also present.

The vitrinite reflectance data obtained indicate that the Lower Cretaceous Eumeralla Formation from 64.2 - 706.0 metres depth in Mocamboro-1 are thermally immature ($R_{V}max < 0.5\%$).

## 5. References

Standards Association of Australia, 1982. Glossary of terms relating to solid mineral fuels. Part 5 - Terms relating to the petrographic analysis of bituminous coal and anthracite (hard coal). Australian Standard AS 2418.

Standards Association of Australia, 1986. Coal maceral analysis. Australian Standard AS 2856.

Standards Association of Australia, 1989. Methods for microscopical determination of the reflectance of coal macerals. Australian Standard AS 2486.

## 7. Acknowledgements

I would like to thank Mr. B. Watson (Amdel Core Services) for access to their microscope for the vitrinite reflectance work.

## 6. Glossary

The coal maceral terms used in this report are briefly defined below. These definitions are an abbreviated version of those published in AS 2418, Part 5 - 1982 and AS 2856 - 1986.

| | | |
|---|---|---|
| MACERAL | : | The microscopically recognisable organic components of coal. |
| MACERAL GROUP | : | Three maceral groups are distinguished on the basis of their optical properties, *viz* vitrinite, liptinite (exinite) and inertinite. The macerals in each group have broadly similar properties in a single coal of specific rank. |
| <u>VITRINITE</u> | : | Generally this is the major component of most coal seams. Vitrinite macerals are derived from plant tissues (*e.g.* stem, root, bark, leaf) which have undergone only vitrinite diagenesis. It appears grey in reflected light. The vitrinite macerals are organised into subgroups according to their origin *viz* telovitrinite, detrovitrinite, gelovitrinite. |
| 1) TELOVITRINITE | : | Intact plant tissue phytoclasts, which include both cell wall and cell contents, that are larger than 0.02 mm in greatest dimension. |
| 1a) Texto-ulminite | : | Telovitrinite with well preserved and distinct cell walls which show no significant effects of compaction, but have undergone minor vitrinite diagenesis so that internal wall structures are not evident. |
| 1b) Eu-ulminite | : | Telovitrinite with distinct cell walls and no open or partly filled cell lumens due to compaction of the cell walls or complete infilling of the cell lumens. |
| 1c) Telocollinite | : | Telovitrinite which is internally structureless. |
| 2) DETROVITRINITE | : | Fine-grained (less than 0.02 mm greatest dimension) fragmented clasts of tissue which commonly forms a groundmass for all the other coal macerals. |
| 2a) Desmocollinite | : | Detrovitrinite groundmass which is compacted and cemented, internally structureless or massive, and without significant intergranular porosity. |
| 3) GELOVITRINITE | : | Consists of massive or submicroscopic granular vitrinite gel larger than 0.02 mm and not clearly part of telo- of detrovitrinite. |
| 3a) Corpogelinite | : | Massive gelovitrinite occurring as rounded or oval grains or fragments. |

| | | |
|---|---|---|
| <u>LIPTINITE</u> | : | Formed from substances rich in volatiles and hydrogen and resistant to decay and decomposition. |
| Sporinite | : | Originates from pollen grains, spores and sporangia. |
| Cutinite | : | Originates from the cuticle and associated tissue of needles, shoots, stalks, leaves, roots and thin stems. |
| Resinite | : | Lensoid masses, cell fillings or isolated bodies which originate from plant resins, fats, waxes and oils. |
| Liptodetrinite | : | Small fragments, typically less than 0.01 mm, that are formed from mechanically or biodegraded liptinite. |
| ALGINITE | : | Derived from some (lipidic or aliphatic walled) algae, including dinoflagellates and acritarchs. In UV light it is intense to bright, green/yellow, yellow, orange or brown. |
| Telalginite | : | Consists of discrete structured algal bodies (both colonial and unicellular) which are spherical to disc-shaped and > 0.005 mm thickness in sections perpendicular to bedding. In reflected light it is commonly translucent, black or dark-grey. |
| Bituminite | : | Specific botanical origins are unknown, it may result from the anaerobic degradation of higher plants or algae. It exhibits no specific form but can be present as a fine-grained groundmass, irregular laminae or as pod-like masses. It commonly appears dark-grey in reflected light and fluoresces weakly. |
| <u>INERTINITE</u> | : | Formed from woody tissues which have undergone mouldering or incomplete combustion; alternatively it maybe produced from the coalification of humic or liptinitic macerals. |
| 1) TELO-INERTINITE | : | Shows distinctive cell structure and exceeds 0.03 mm in its minimum dimension. |
| 1a) Fusinite | : | Most common colour is yellowish-white in reflected light. |
| 1b) Semifusinite | : | In reflected light it is pale-grey to white in colour, with reflectance values ranging between those of co-existing vitrinite and fusinite. |
| 1c) Sclerotinite | : | Consists of fungal remains. |
| 2) DETRO-INERTINITE | : | Includes all inertinite less than 0.03 mm in longest dimension. |
| 2a) Inertodetrinite | : | Inertinite which is < 0.03 mm but is > 0.002 mm. |

| | | |
|---|---|---|
| MICROLITHOTYPE | : | Naturally occurring macerals or associations of macerals with minimum band widths of 0.05 mm. Microlithotypes are classified into one of three categories, *viz* monomaceral, bimaceral or trimaceral, according to whether they contain components of one, two or three maceral groups. |
| ORGANOCLAST | : | A discrete particle of organic matter in a sedimentary rock. |
| PHYTOCLAST | : | Any piece of organic material that is derived from plants occurring within a clastic matrix. |

# KEY TO PETROLOGICAL DESCRIPTIONS

**Maceral Group**

| | |
|---|---|
| V | Vitrinite |
| I | Inertinite |
| L | Liptinite |

**Colour in UV Light (F)**

| | |
|---|---|
| G | Green |
| G/Y | Green/yellow |
| LY | Lemon-yellow |
| Y | Yellow |
| Y/O | Yellow/orange |
| LO | Light-orange |
| MO | Mid-orange |
| DO | Dark-orange |
| Br | Brown |

**Colour in Reflected Light (R)**

| | |
|---|---|
| PBr | Pale-brown |
| DBr | Dark-brown |
| R/Br | Red/brown |
| B | Black |

**Liptinite Abundance Category**

| ABUNDANCE | RANGE (vol %) |
|---|---|
| Major | > 10.0 |
| Abundant | 2.0 -10.0 |
| Common | 0.5 - 2.0 |
| Sparse | 0.1 - 0.5 |
| Rare | < 0.1 |

# APPENDIX B

## Organic Petrographic Descriptions: Mocamboro-1

| | | | |
|---|---|---|---|
| **Sample N°** | : A-923.184 | **Group** | : Otway |
| **Depth (m)** | : 64.2 | **Formation** | : Eumeralla |
| **Sample** | : Core 4C | **D.O.M.** | : Moderate/Rich 5 - 10% |

Lithology : Shale >> Coal (90:10) The folowing is the maceral description for the shale
Ratio V:I:L : I > V ≥ L (80:10:5)
Vitrinite : The texto-ulminite, eu-ulminite and telocollinite phytoclasts are surrounded by black matrix bituminite. Some coal fragments occur in the shale, vitrinite is present as eu-ulminite and telocollinite both are associated with resinite.
Inertinite : Detro-inertinite (inertodetrinite) > telo-inertinite (semifusinite > fusinite).
Liptinite :

| **Maceral** | **Colour** | **Intensity** | **Abundance** |
|---|---|---|---|
| Sporinite | Y | Bright-Dull | Abundant |
| Resinite | Y | Bright | Common |
| Liptodetrinite | G/Y-Y | Intense | Sparse |
| Cutinite | Y | Intense | Rare |

Bituminite :

| **Staining** | **Colour (F)** | **Colour (R)** | **Abundance** |
|---|---|---|---|
| Matrix | None | R/Br - B | Moderate |
| Wisps/Patches | None | DBr | Common |

Mineralogy : Pyrite; common, unoxidised framboids and specks.
Comments : Occasionally there are small (30µm) intensely yellow fluorescing forms, possibly planktonic algae.

---

| | | | |
|---|---|---|---|
| **Sample N°** | : A-923.184 | **Group** | : Otway |
| **Depth (m)** | : 64.2 | **Formation** | : Eumeralla |
| **Sample** | : Core 4C | **Microlithotype** | : Vitrite |

Lithology : Coal.
Ratio V:I:L : V >> I (95:<5)
Vitrinite : Telovitrinite is present as texto-ulminite grading through to telocollinite. Eu-ulminite is the dominant maceral.
Inertinite : Telo-inertinte is present as rare phytoclasts of cellular semifusinite.
Liptinite : None.
Mineralogy : No pyrite.
Comments : The coal is poorly gelified.

---

| | | | | | |
|---|---|---|---|---|---|
| **Sample N°** | : | A-923.185 | **Group** | : | Otway |
| **Depth (m)** | : | 96.8 | **Formation** | : | Eumeralla |
| **Sample** | : | Core 5A | **D.O.M.** | : | Poor <1% |

Lithology : Shale
Ratio V:I:L : I >> V > L [99:1: <1]
Vitrinite : Texto-ulminite phytoclasts are surrounded by black matrix bituminite.
Inertinite : Detro-inertinite (inertodetrinite) > telo-inertinite (semifusinite) are also commonly surrounded by matrix bituminite.

| Liptinite | **Maceral** | **Colour (F)** | **Intensity** | **Abundance** |
|---|---|---|---|---|
| | Sporinite | Y/O | Dull | Rare |

| Bituminite | **Staining** | **Colour (F)** | **Colour (R)** | **Abundance** |
|---|---|---|---|---|
| | Matrix | None | O | Light |
| | Wisps | None | B | Sparse |

Mineralogy : Pyrite: rare, unoxidised crystals.
Comments :

---

| | | | | | |
|---|---|---|---|---|---|
| **Sample N°** | : | A-923.186 | **Group** | : | Otway |
| **Depth (m)** | : | 213.6 | **Formation** | : | Eumeralla |
| **Sample** | : | Core 7B | **Microlithotype** | : | Clarodurite & vitrite |

Lithology : Coal > shale The folowing is the maceral description for the coal.
Ratio V:I:L : I > V > L 70:20:10
Vitrinite : Telovitrinite (texto-ulminite to telocollinite with texto-ulminite and eu-ulminite most abundant) = detrovitirnite (densinite to desmocollinite), poorly gelified.
Inertinite : Telo-inertinite (semifusinite > fusinite>> sclerotinite) > detro-inertinite (inertodetrinite).

| Liptinite | **Maceral** | **Colour (F)** | **Intensity** | **Abundance** |
|---|---|---|---|---|
| | Sporinite | Y/O | Bright-Dull | Abundant |
| | Resinite | Y | Intense/Bright | Abundant |
| | Liptodetrinite | LO | Dull | Common |
| | Cutinite | LO | Dull | Common |
| | Suberinite | LO | Dull | Sparse |

Mineralogy : Pyrite; none.
Comments : The coal is banded, the microlithotypes clarodurite alternate with vitrite and inertite. Occasionally sclerotinite and also thick walled megaspores (400µm diameter) with a resinite filling are present.

---

| | | | | |
|---|---|---|---|---|
| **Sample N°** | : A-923.186 | **Group** | : | Otway |
| **Depth (m)** | : 213.6 | **Formation** | : | Eumeralla |
| **Sample** | : Core 7B | **D.O.M.** | : | Rich 10% - 50% |

Lithology : Coaly shale

Ratio V:I:L : I > V ≥ L [60:30:10]

Vitrinite : Wisps and stringers of poorly gelified texto-ulminite, eu-ulminite and telocollinite are surrounded by black matrix bituminite.

Inertinite : Telo-inertinite (semifusinite > fusinite) > detro-inertinite (inertodetrinite).

Liptinite :

| **Maceral** | **Colour (F)** | **Intensity** | **Abundance** |
|---|---|---|---|
| Sporinite | Y/O | Moderate-Dull | Common |
| Liptodetrinite | Y?o | Moderate-Dull | Common |
| Resinite | Y | Bright | Common |
| Cutinite | DO | Dull | Sparse |

Bituminite :

| **Staining** | **Colour (F)** | **Colour (R)** | **Abundance** |
|---|---|---|---|
| Background | DB | O-B | Light-dark |

Mineralogy : Pyrite; as sparse unoxidised crystals and also replacing woody tissues.

Comments :

---

| | | | | |
|---|---|---|---|---|
| **Sample N°** | : A-923.187 | **Group** | : | Otway |
| **Depth (m)** | : 667 - 669 | **Formation** | : | Eumeralla |
| **Sample** | : Cuttings | **Microlithotype** | : | Vitrite & duroclarite |

Lithology : Coal

Ratio V:I:L : V >> I > L [80: 15 :5]

Vitrinite : Detrovitrinite (desmocollinite) >> telovitrinite (eu-ulminite and telocollinite).

Inertinite : Detro-inertinite (inertodetrinite) > telo-inertinte (semifusinite)

Liptinite :

| **Maceral** | **Colour (F)** | **Intensity** | **Abundance** |
|---|---|---|---|
| Sporinite | Y/O | Moderate - Dull | Abundant |
| Resinite | Y-B | Bright-Dull | Common |
| Liptodetrinite | Y/O | Moderate | Common |
| Cutinite | Y/O-LO | Bright-Dull | Rare |

Mineralogy : Pyrite: none.

---

| | | | | | |
|---|---|---|---|---|---|
| **Sample N°** | : A-923.188 | | **Group** | : | Otway |
| **Depth (m)** | : 706.0 | | **Formation** | : | Eumeralla |
| **Sample** | : Core 13B | | **D.O.M.** | : | Rich 5% - 10% |

| | | | | | |
|---|---|---|---|---|---|
| Lithology | : | Shale | | | |
| Ratio V:I:L | : | I >> L > V | [90:10:<1] | | |
| Vitrinite | : | Reworked phytoclasts < 20 µm, some wisps with dark matrix bituminite staining around the edges and as minor woody fragments (texto-ulminite). | | | |
| Inertinite | : | Detro-inertinite (inertodetrinite) = telo-inertinite (semifusinite). | | | |
| Liptinite | : | **Maceral** | **Colour (F)** | **Intensity** | **Abundance** |
| | | Sporinite | MO | Moderate - None | Common |
| | | Liptodetrinite | LO | Moderate | Sparse |
| | | Cutinite | MO | Bright-Dull | Rare |
| Bituminite | : | **Staining** | **Colour (F)** | **Colour (R)** | **Abundance** |
| | : | Matrix | None | Br | Light |
| | : | Wisps | None | O-Br | Rich |
| Mineralogy | : | Pyrite; rare, unoxidised crystals. | | | |
| Comments | : | Very occasionally there are small ( mm) planktonic cysts, possibly dinoflagellates. | | | |

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# APPENDIX C
## Vitrinite Reflectance Measurements

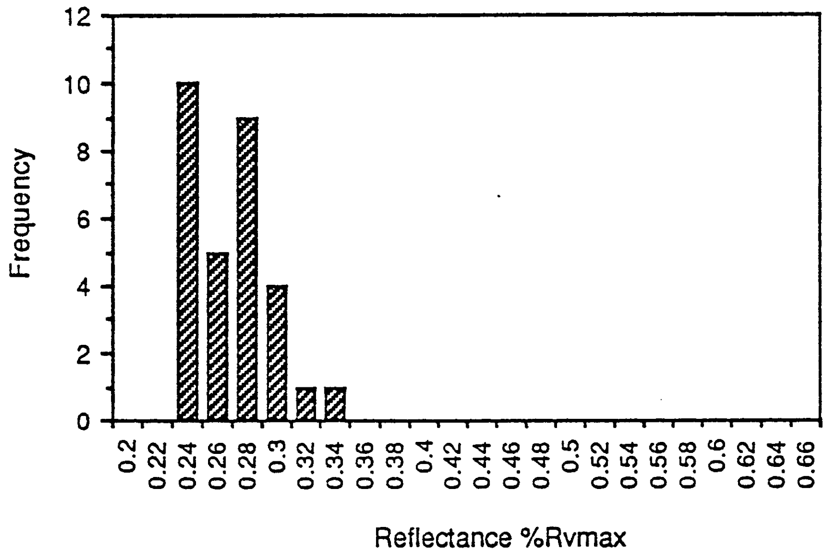
Sample Number: A-923-184
Depth: 64.2 m
Reflectance Measured: Maximum
Client: SADME

Vitrinite Reflectance Values

| | | |
|---|---|---|
| 0.24 | 0.26 | 0.29 |
| 0.24 | 0.27 | 0.29 |
| 0.24 | 0.27 | 0.29 |
| 0.24 | 0.27 | 0.29 |
| 0.24 | 0.27 | 0.30 |
| 0.25 | 0.28 | 0.30 |
| 0.25 | 0.28 | 0.30 |
| 0.25 | 0.28 | 0.31 |
| 0.25 | 0.28 | 0.33 |
| 0.25 | 0.29 | 0.35 |

Number of Measurements = 30
Mean Maximum Reflectance = 0.27
Standard Deviation = 0.03
Range = 0.23 - 0.35

Vitrinite Reflectance Values Mocamboro-1, 64.2 m



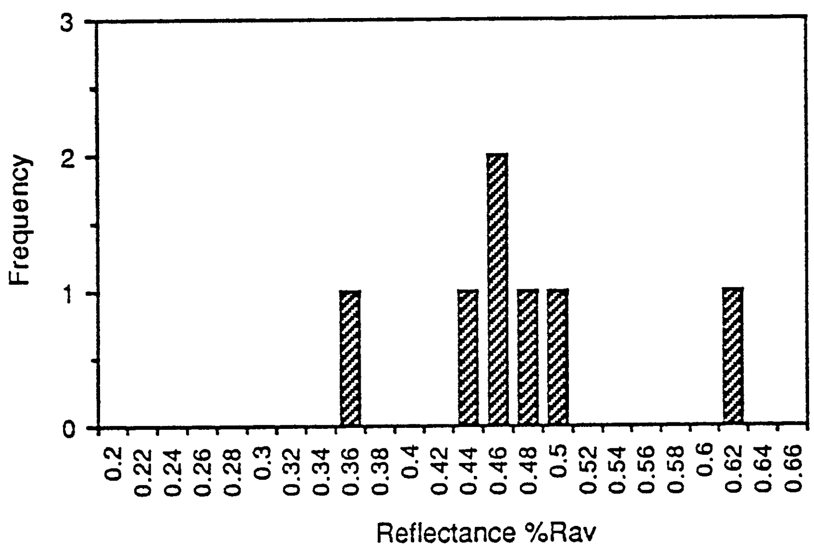
Sample Number: A-923-185
Depth: 96.8 m
Reflectance Measured: Average
Client: SADME

Vitrinite Reflectance Values

| | |
|---|---|
| 0.36 | 0.49 |
| 0.44 | 0.51 |
| 0.45 | 0.62 |
| 0.46 | |

Number of Measurements = 7
Mean Average Reflectance = 0.48
Standard Deviation = 0.08
Range = 0.36 - 0.62

Vitrinite Reflectance Values Mocamboro-1, 96.8m



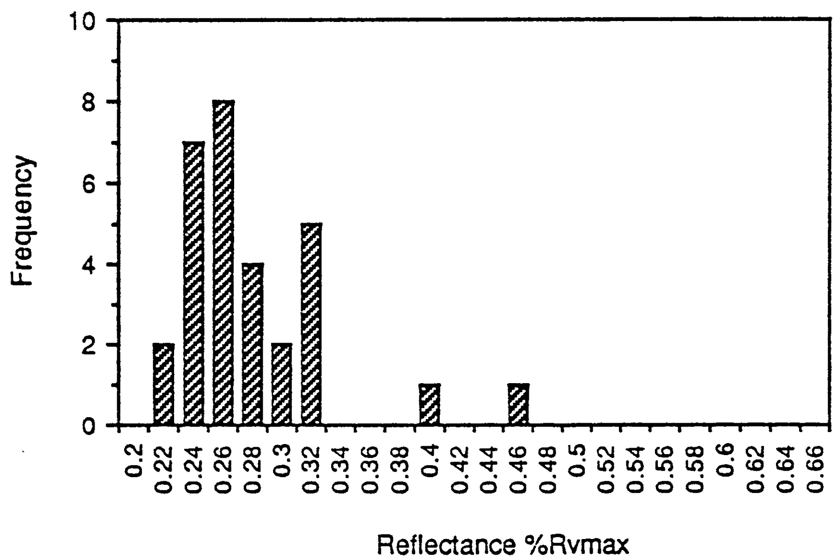
Sample Number: A-923-186
Depth: 213.6 m
Reflectance Measured: Maximum
Client: SADME

Vitrinite Reflectance Values

| | | |
|---|---|---|
| 0.22 | 0.26 | 0.29 |
| 0.22 | 0.26 | 0.30 |
| 0.24 | 0.26 | 0.31 |
| 0.24 | 0.26 | 0.32 |
| 0.25 | 0.26 | 0.32 |
| 0.25 | 0.27 | 0.32 |
| 0.25 | 0.27 | 0.32 |
| 0.25 | 0.28 | 0.33 |
| 0.25 | 0.28 | 0.40 |
| 0.26 | 0.29 | 0.47 |

Number of Measurements = 30
Mean Maximum Reflectance = 0.28
Standard Deviation = 0.05
Range = 0.22 - 0.47

Vitrinite Reflectance Values Mocamboro-1, 213.6 m



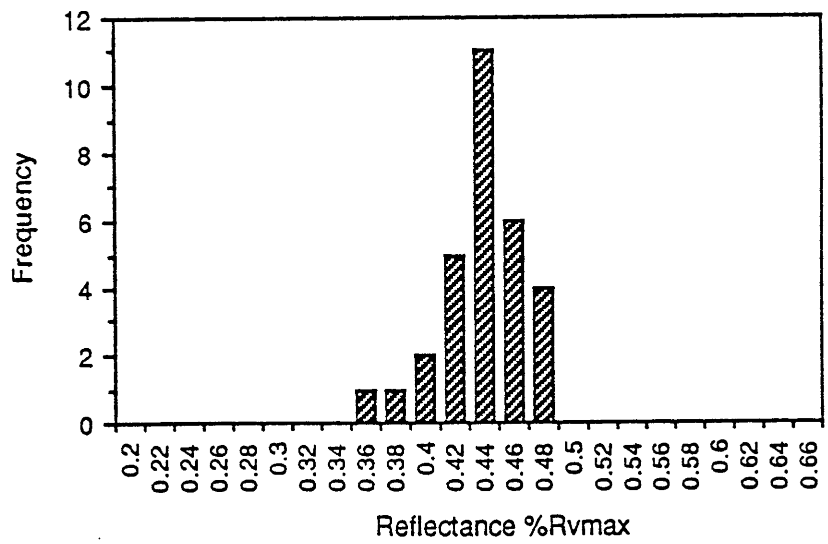
Sample Number: A-923-187
Depth: 667- 669 m
Reflectance Measured: Maximum
Client: SADME

Vitrinite Reflectance Values

| | | |
|---|---|---|
| 0.36 | 0.44 | 0.46 |
| 0.38 | 0.44 | 0.46 |
| 0.40 | 0.44 | 0.47 |
| 0.41 | 0.44 | 0.47 |
| 0.42 | 0.44 | 0.47 |
| 0.43 | 0.44 | 0.47 |
| 0.43 | 0.44 | 0.48 |
| 0.43 | 0.45 | 0.48 |
| 0.43 | 0.45 | 0.49 |
| 0.44 | 0.45 | 0.49 |

Number of Measurements = 30
Mean Maximum Reflectance = 0.44
Standard Deviation = 0.03
Range = 0.36 - 0.49

Vitrinite Reflectance Values Mocamboro-1, 667 m



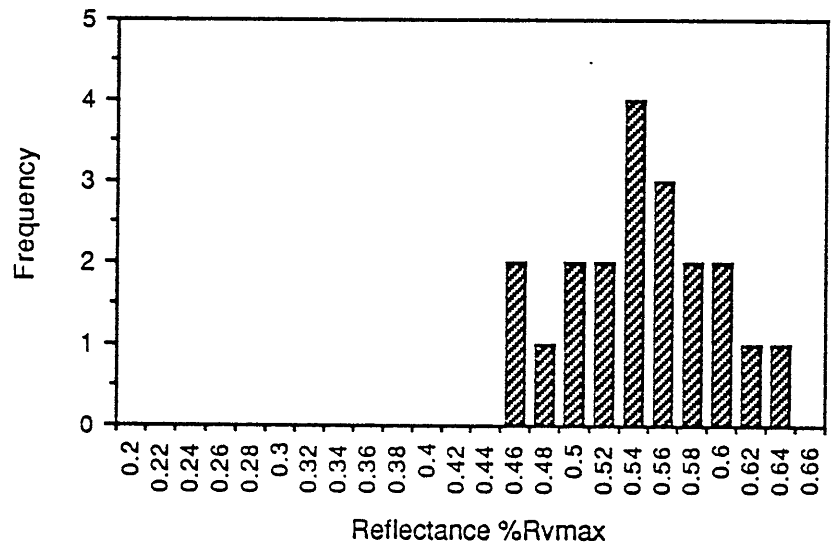
Sample Number: A-923-188
Depth: 706.0 m
Reflectance Measured: Maximum
Client: SADME

Vitrinite Reflectance Values

| | | |
|---|---|---|
| 0.46 | 0.54 | 0.58 |
| 0.47 | 0.55 | 0.59 |
| 0.49 | 0.55 | 0.60 |
| 0.50 | 0.55 | 0.61 |
| 0.51 | 0.56 | 0.62 |
| 0.52 | 0.56 | 0.64 |
| 0.52 | 0.57 | |

Number of Measurements = 20
Mean Maximum Reflectance = 0.55
Standard Deviation = 0.05
Range = 0.46 - 0.64

Vitrinite Reflectance Values Mocamboro-1, 706.0 m



# APPENDIX 10

## CORE ANALYSIS
## &
## PETROLOGICAL REPORT

AMDEL
CORE
SERVICES

28 August 1990

SA Department of Mines & Energy
Oil, Gas and Coal Division
PO Box 151
EASTWOOD SA 5063

Attention: The Director-General

**REPORT: 008/055**

| | |
|---|---|
| **CLIENT REFERENCE:** | NERDDC Project 1424 |
| **MATERIAL:** | Core Plugs |
| **LOCALITY:** | Victoria |
| **WORK REQUIRED:** | Core Analysis |

Please direct technical enquiries regarding this work to the signatory below under whose supervision the work was carried out.

**RUSSELL R MARTIN**
Laboratory Supervisor
Core Analysis/Special Core Analysis
on behalf of Amdel Core Services Pty Ltd

28 August 1990

SA Department of Mines & Energy
Oil, Gas and Coal Division
PO Box 151
EASTWOOD SA 5063

Attention: The Director-General

**FINAL DATA REPORT - CONVENTIONAL CORE ANALYSIS**

**REPORT: 008/055 - MOCAMBORO NO 11**

Sections of core from Mocamboro No 11 were delivered to Amdel Core Services, Adelaide on the 10th of August.

The following report includes tabular data of permeability to air, helium injection porosity, and density determinations. Data presented graphically includes a porosity versus permeability to air plot.

The data contained in this report has been derived by the following methods:

## 1. PLUG CUTTING & DRYING

One inch diameter plugs were taken from the sections of core where indicated by the SA Department of Mines. Tap water is used as the bit lubricant. Samples are trimmed square and the offcuts retained. Residual hydrocarbons are extracted from the plugs using a 3:1 chloroform/methanol mix in a Soxhlet extractor.

After cleaning, the plugs were air dried before measurements of helium injection porosity and air permeability were taken.

## 2. PERMEABILITY TO AIR

A plug sample is used for this measurement and is placed in a Hassler cell to which a confining pressure of 250 psig (1725 kPa) is applied; this pressure is used to prevent bypassing of air around the sides of the sample when the measurement is made. A known pressure is then applied to the upstream sample face and the differential pressure (between the upstream and downstream faces) is monitored at the downstream face. Permeability is then calculated using Darcy's Law.

## 3. HELIUM INJECTION POROSITY

The porosity of a clean dry core plug is determined as follows: it is first placed in a matrix cup where the grain volume is measured by helium injection: a known volume of helium at a known pressure is expanded into the matrix cup which contains the core plug; the resulting pressure is recorded and the unknown volume (that is, the volume of the grains) is determined using Boyle's Law. The bulk volume is determined by mercury immersion. The difference between the grain volume and the bulk volume is the pore volume and from this the porosity is calculated as the volume percentage of pores with respect to the bulk volume.

## 4. APPARENT GRAIN DENSITY

The apparent grain density is derived from the measurements described in Section 3, above, and is the ratio of the weight of the core plug divided by the grain volume determined as in paragraph 4.

## 5. POROSITY AND PERMEABILITY AT OVERBURDEN PRESSURE

To determine the porosity and permeability of the core plug at overburden pressure, the sample is first placed in a cylindrical neoprene sheath and this assembly is loaded into a triaxial hydrostatic cell. The pore volume is then determined at "ambient" pressure. The overburden pressure (the value as supplied by the client) is then applied to the sample in the cell and the pore volume reduction caused by this increase in pressure, is measured. By this means the actual overburden pore volume and the bulk volume can be determined and are used to derive a value for the porosity at the applied overburden pressure. The permeability at overburden pressure is then measured in the hydrostatic cell exactly as described in paragraph 3.

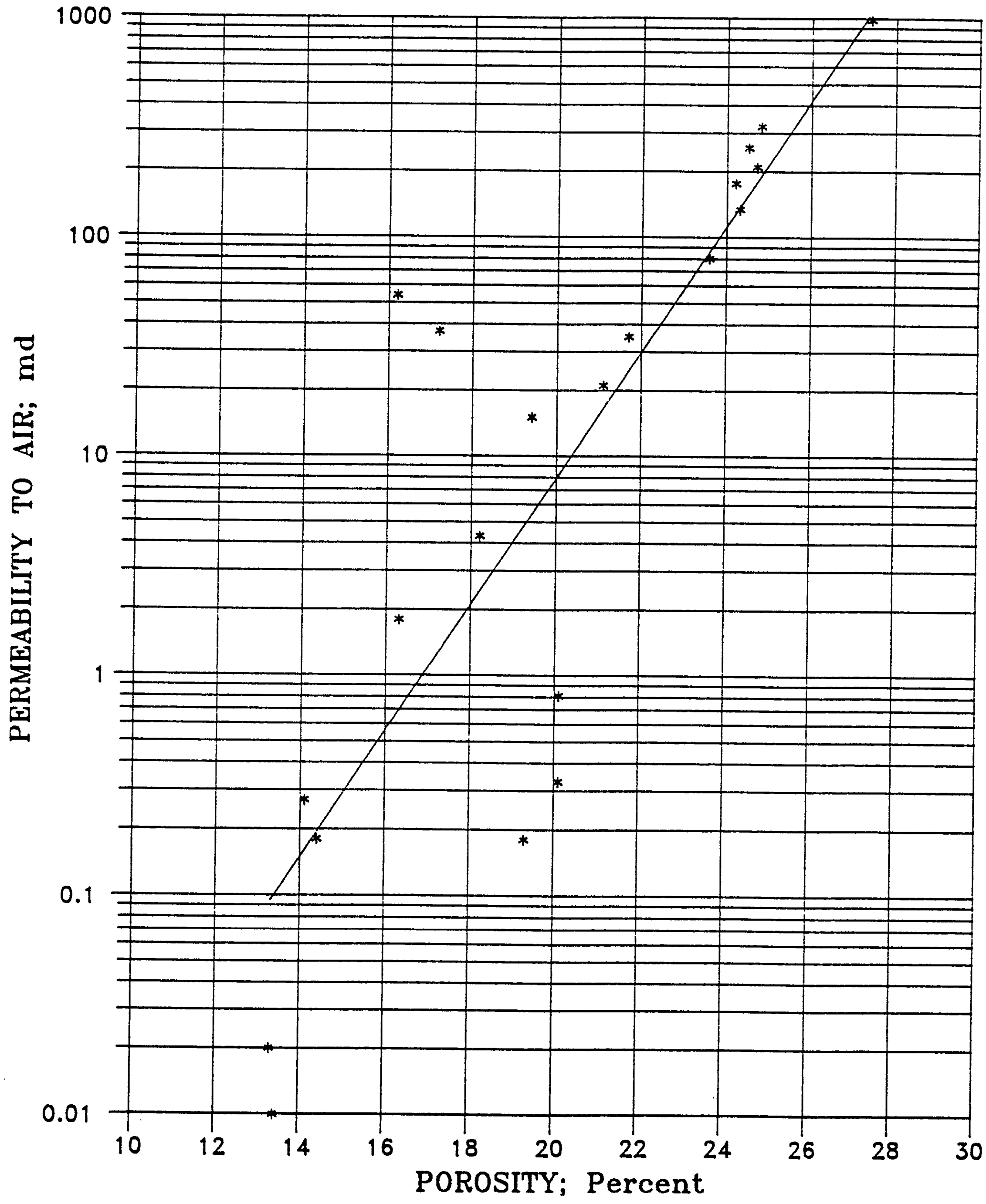
## 6. ABSOLUTE GRAIN DENSITY

An irregular fragment of sample which has been dried is used for this determination; the sample is coarsely crushed to approximately grain size or a little coarser and the granular material is then weighed. The volume of the grains is determined by conventional pycnometry and by this means the actual density of the grains is determined.

# POROSITY vs PERMEABILITY

Company: S.A. Department Mines & Energy
Well : Mocamboro No. 11

Ambient Y = EXP(0.6616X) * 1.421E-005



# CONVENTIONAL CORE ANALYSIS

Company: S.A. DEPARTMENT OF MINES
Well: MOCAMBORO No. 11
Field: MOCAMBORO
Location: OTWAY BASIN
Country: AUSTRALIA

File: 008-055
Date: 23/08/90
Core Intervals:

| Sample Number | Depth (m) | Porosity (%) | | Density | | Permeability (md) | | Summation of Fluids | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | He Inj | Roll Av | ABS | Grain | Ka | Roll Av Ka | Por % | Oil % | Water % | |
| 1 | 984.96 | 17.2 | | 2.66 | 2.67 | 37 | | | | | |
| 2 | 983.40 | 23.6 | | 2.66 | 2.66 | 80 | | | | | |
| 3 | 982.78 | 24.3 | | 2.65 | 2.66 | 134 | | | | | SP |
| 4 | 982.40 | 24.2 | | 2.65 | 2.66 | 176 | | | | | |
| 5 | 981.98 | 21.7 | | 2.65 | 2.65 | 35 | | | | | |
| 6 | 981.70 | 24.8 | | 2.65 | 2.66 | 321 | | | | | |
| 7 | 981.50 | 24.5 | | 2.65 | 2.65 | 256 | | | | | |
| 8 | 980.96 | 21.1 | | 2.64 | 2.66 | 21 | | | | | |
| 9 | 980.50 | 24.7 | | 2.65 | 2.66 | 209 | | | | | |
| 10 | 1021.10 | 27.4 | | 2.64 | 2.65 | 980 | | | | | |
| 11 | 1020.28 | 19.3 | | 2.65 | 2.66 | 0.18 | | | | | |
| 12 | 1019.27 | 13.3 | | 2.65 | 2.64 | 0.02 | | | | | |
| 13 | 1018.25 | 14.4 | | 2.66 | 2.66 | 0.18 | | | | | |
| 14 | 1017.45 | 20.1 | | 2.64 | 2.64 | 0.33 | | | | | |
| 15 | 1017.10 | 13.4 | | 2.60 | 2.61 | 0.01 | | | | | |
| 16 | 1016.38 | 19.4 | | 2.66 | 2.67 | 15 | | | | | |
| 17 | 1066.64 | 16.3 | | 2.65 | 2.66 | 1.8 | | | | | |
| 18 | 1065.90 | 16.2 | | 2.60 | 2.60 | 54 | | | | | SP/VF |
| 19 | 1065.05 | 18.2 | | 2.65 | 2.65 | 4.3 | | | | | SP/VF |
| 20 | 1064.15 | 20.1 | | 2.66 | 2.68 | 0.81 | | | | | SP |
| 21 | 1063.50 | 14.1 | | 2.65 | 2.68 | 0.27 | | | | | |

VF = Vertical Fracture; HF = Horizontal Fracture; MP = Mounted plug; SP = Short plug
C# = Top of Core; B# = Bottom of Core; OWC = Probable Oil/Water Content;
Tr = Probable Transition Zone; GC = Probable Gas Cap

# OVERBURDEN CORE ANALYSIS

Company: S.A. DEPARTMENT OF MINES

Well: MOCAMBORO NO 11 Date: 23/08/90

Field: MOCAMBORO Core Interval:

Location: OTWAY BASIN

Country: AUSTRALIA

| Sample Number | Depth | Porosity (%) at Overburden Pressure | | | | Roll Av | Permeability (md) at Overburden Pressure | | | | Roll Av |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ambient | 1500 | | | | Ambient | 1500 | | | |
| 1 | 984.96 | 17.2 | 16.1 | | | | 37 | 30 | | | |
| 2 | 983.40 | 23.6 | 22.7 | | | | 80 | 69 | | | |
| 3 | 982.78 | 24.3 | 23.4 | | | | 134 | 118 | | | |
| 4 | 982.40 | 24.2 | 22.8 | | | | 176 | 151 | | | |
| 5 | 981.98 | 21.7 | 20.8 | | | | 35 | 29 | | | |
| 6 | 981.70 | 24.8 | 23.8 | | | | 321 | 283 | | | |
| 7 | 981.50 | 24.5 | 23.4 | | | | 256 | 221 | | | |
| 8 | 980.96 | 21.1 | 20.1 | | | | 21 | 17 | | | |
| 9 | 980.50 | 24.7 | 23.8 | | | | 209 | 184 | | | |
| 10 | 1021.10 | 27.4 | 26.3 | | | | 980 | 854 | | | |
| 11 | 1020.28 | 19.3 | 18.4 | | | | 0.18 | 0.11 | | | |
| 12 | 1019.27 | 13.3 | 13.0 | | | | 0.02 | 0.02 | | | |
| 13 | 1018.25 | 14.4 | 13.9 | | | | 0.18 | 0.09 | | | |
| 14 | 1017.45 | 20.1 | 19.4 | | | | 0.33 | 0.22 | | | |
| 15 | 1017.10 | 13.4 | 13.2 | | | | 0.01 | 0.01 | | | |
| 16 | 1016.38 | 19.4 | 18.6 | | | | 15 | 12 | | | |
| 17 | 1066.64 | 16.3 | 13.6 | | | | 1.8 | 0.58 | | | |
| 18 | 1065.90 | 16.2 | 11.2 | | | | 54 | 1.2 | | | |
| 19 | 1065.05 | 18.2 | 16.1 | | | | 4.3 | 1.5 | | | |
| 20 | 1064.15 | 20.1 | 19.1 | | | | 0.81 | 0.40 | | | |
| 21 | 1063.50 | 14.1 | 13.3 | | | | 0.27 | 0.10 | | | |



Amdel Core Services Pty Limited
Incorporated in South Australia

# CORE PLUG DESCRIPTION

Well: S.A. DEPARTMENT OF MINES

Field: MOCAMBORO    Date: 23/08/90

Location: OTWAY BASIN    Core Interval:

Country: AUSTRALIA

| Sample Number | Depth | Description |
|---|---|---|
| 1 | 984.96 | Sst: lt gry, med-crs gr, p-mod srt, sbang-sbrnd, mod wl cmt, tr mic - Biot, tr carb spk, abd Cl-Chlor? cotd gn and mtrx, rr qtz o'gth, wh bnd thru which is calc rest of plug non calc |
| 2 | 983.40 | Sst: lt gry/gnsh, med gr, w/ srt, sbang-rr sbrnd, mod wl cmt, tr mic-Biot, tr carb spk, abd Cl-Chlor, mnr cotd gr, rr qtz o'gth, mnr calc cmt i/p |
| 3 | 982.78 | Sst: a/a but w/ rr tr Garnett and rr calc incl |
| 4 | 982.40 | Sst: a/a |
| 5 | 981.98 | Sst: lt gry/gnsh, med gr, wl srt, sbang-rr sbrnd, mod wl cmt, tr mic-Biot, rr carb incl, abd Cl-Chlor, mnr cotd gn, rr qtz o'gth, rr calc incl, abd Cl poss Kaolin? rr slty clas. rr tr Garnett |
| 6 | 981.70 | Sst: a/a |
| 7 | 981.50 | Sst: a/a |
| 8 | 980.96 | Sst: a/a but w/ cmt |
| 9 | 980.50 | Sst: a/a |
| 10 | 1021.10 | Sst: lt gry, med gr, wl srt, ang i/p - rr sbrnd, mod-p cmt, tr mic-Biot, rr carb spk, mnr Cl mtrx, mainly Cl cotd gn, abd Garnett thru, non calc, mnr filled frac |
| 11 | 1020.28 | Sst: lt gry/gnsh, fn gr, wl srt, sbang, wl cmt, tr mic-Biot, rr carb incl, abd Cl-Chlor, tr Garnett, non calc |
| 12 | 1019.27 | Sst: a/a |
| 13 | 1018.25 | Sst: a/a |

| Sample Number | Depth | Description |
|---|---|---|
| 14 | 1017.45 | Sst: a/a but w/ rr med gr thru |
| 15 | 1017.10 | Sst: a/a but w/ carb and mica lam thru |
| 16 | 1016.38 | Sst: a/a but w/ occ med gr thru |
| 17 | 1066.64 | Sst: lt gry, med-occ v crs gr thru, sbang, mod-p cmt, tr mic - Biot, carb spk, abd Cl both Chlor and Kaolin? which ap as Agg thru, abd calc incl thru poss part of cmt? tr Garnett (irregular plug) |
| 18 | 1065.90 | Sst: a/a but also abd slty clas thru, poss infill, mnr frac, (irregular plug) |
| 19 | 1065.05 | Sst: a/a for 17 |
| 20 | 1064.15 | Sst: lt gry/gnsh, fn-med gr, mod wl srt, sbang, mod wl cmt, tr Biot mic thru, rr carb incl, abd Cl - Chlor, tr Garnett, mnr calc incl through part of cmt or poss shell frags? |
| 21 | 1063.50 | Sst: a/a |