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VIC/P31
MINERVA-1
WELL COMPLETION REPORT
INTERPRETATIVE

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VIC/P31, MINERVA-1

WELL COMPLETION REPORT

INTERPRETATIVE VOLUME

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GEOCHEMICAL EVALUATION OF MINERVA-1

OTWAY BASIN

OFFSHORE VICTORIA AUSTRALIA

PREPARED BY: J. PRESTON
SENIOR GEOCHEMIST

0538.rep

DATE: April, 1994

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1 INTRODUCTION

Following completion of the Minerva-1 well, a programme was undertaken to evaluate the source rock character and thermal maturity of the drilled sequence, and the fluids recovered from it.

The evaluation of source rock character firstly involved analysis of four sidewall cores for total organic carbon (TOC) content by Geotech, Perth. Three of the samples (including one coal) yielded a TOC greater than 1.0%, and were accordingly pyrolysed by the Rock-Eval method.

In an attempt to evaluate the thermal maturity of the Minerva-1 section, vitrinite reflectance measurements were made on eight SWCs from the well.

Two gas samples, recovered by RFT from 1649.8m and 1942.5m, were analysed by CSIRO, North Ryde, for their chemical and stable carbon isotopic compositions. In an attempt to gain more information relating to the source of the gases and their associated fluids, the RFT gas samples were subjected to cold-trapping by Petrolab, Adelaide. A condensate sample was obtained from the 1942.5m RFT gas sample; however, water was recovered from the 1649.8m RFT gas sample and was solvent-extracted for its dissolved hydrocarbons. The condensate and extract were then analysed by whole-oil and whole-extract GC, separated, and analysed by the saturate fraction GC, GC-MS (branched/cyclics) and GC-MS (aromatics) techniques.

This report provides a compilation of the petroleum geochemistry data obtained from the Minerva-1 well, together with an interpretation of these data.

2   SOURCE ROCK CHARACTERISATION

2.1   Screening Analyses

2.1.1   Total Organic Carbon (TOC)

Four samples analysed for total organic content (TOC) originated in the Late Cretaceous Sherbrook and Shipwreck Groups (Table 1-1, Table 2). Although 0.5% TOC is commonly used as the minimum requirement for a petroleum source rock, it is uncommon for sediments from the southern margin of Australia with less than 1.0% TOC to be significant petroleum sources. On the basis of four samples, it is clear that the Late Cretaceous section in Minerva-1 contains some potential petroleum source rocks, the TOC values of two samples ranging from 1.34-1.68% (Table 2, Figure 1 and Enclosure 1). Note that one sample, from 1837.1m, consisted of coal (TOC=40.50%).

2.1.2   Rock-Eval Pyrolysis

The three samples in which the TOC was found to exceed 1.0% were pyrolysed using the Rock-Eval method. Two of these samples from 1342-1747m, gave HI values of 94-102 and S1+S2 yields of 1.31-1.75 mg/g (Figures 2 and 3), indicating poor generative potential, chiefly for gas, with perhaps minor amounts of condensate. The data from the 1837.1m sample (HI=449) suggest that there is much greater potential for liquids generation in the coals.

It is clear from the S1+S2 yields of the Minerva-1 samples that expulsion, if any, would be possible only at relatively high levels of thermal maturity. At such levels of thermal maturity, considerable secondary cracking of liquids to gas would occur, such that these source rocks would perhaps be even more gas-prone than indicated by the source character data.

The Rock-Eval pyrolysis data listed in Table 2 are summarised in the form of crossplots in Figures 4 and 5. Figure 4 reflects the overall quality of the kerogen in the samples analysed, in terms of their oil-prone or gas-prone character: two samples plot in the gas/condensate-prone Type II/III and Type III areas of the diagram (HI < 150). The more liquids-prone character of the coal sample is reflected in its more obvious Type II affinity.

Figure 5 reflects the generative capacity of the samples, in terms of their overall quantitative potential; only the coal sample exceeds the threshold of significant hydrocarbon generation and expulsion, despite its thermal immaturity.

Maceral petrography associated with the vitrinite reflectance determinations shows that the organic matter in most of the samples is dominated by inertinite, followed by vitrinite (Figure 6). However, liptinitic/exinitic (Type II) macerals are identified in all samples except 2215m (described as 100% inertinite), confirming the presence of some liquids-prone components. In some samples, the Type II macerals appear to be supplemented by oil-prone alginitic (Type I) macerals.

2.2   Thermal Maturity

Rock-Eval parameters which are often used for maturity assessment are Tmax and Production Index (PI). A Tmax value of 435°C, and a PI value of 0.10, are regarded as marking the entrance to the oil-generative window.

As Table 2 and Figure 7 show, values of Tmax are 432°C in the case of two samples, with an anomalously low value of 424°C from the coal. Values of PI (Figure 8) are less than 0.10 in the 1342-1523m interval, but PI reaches 0.10 in the coal.

There is therefore broad agreement between the maturity estimates based on the PI and Tmax data, namely that the 1342-1523m section is thermally immature, and the coal-bearing section around 1837.1m marginally mature.

Vitrinite reflectance measurements on nine samples from the 1130-2392.5m interval range up to 0.75% (See Table 3/ 3A and Figures 9 and 10). Values for four samples in the 1130-1747m interval occupy the immature 0.42-0.53% range. Values of 0.62-0.63% at 1947.5-2215m indicate marginal maturity, though a value of 0.75% at 2392.5m suggests early oil-generative maturity at this depth. These data concur with the Tmax and PI values from the Rock-Eval data.

Because kerogens will generate products with markedly different compositions as thermal maturity progresses, it follows that certain analyses and the interpretation of their results will be fundamentally affected by maturity, in particular Rock-Eval pyrolysis data. The observation that the drilled interval has not attained thermal maturity means that this need not be a consideration in the interpretation of geochemical data from the Minerva-1 well. The poor source quality of parts of the drilled sequence cannot be attributed to advanced thermal maturity, but more to organic matter type and/or its preservation state.

3   **FLUIDS CHARACTERISATION**

3.1   **Whole-Oil GC Analysis**

One condensate sample, obtained by the cold-trapping of a gas sample from
1942.5m (Table 1-2), was analysed by the whole-oil GC method. The
whole-oil GC data for this sample are presented in Table 4; the
corresponding whole-oil GC trace is shown in Figure 11 (C_1-C_{33} range),
Figure 12 (C_1-C_8 gasoline range), and Figure 13 (normalised plot).

Paraffin Index data from the condensate are plotted in Figure 14, and
suggest (if taken at face value) that the condensate was expelled from its
source rock at about 135°C.

3.2   **Saturate Fraction GC Analyses**

Water was recovered from the cold-trapping of the 1649.8m RFT gas
sample, and was solvent-extracted for its dissolved hydrocarbons.

Both the 1942.5m condensate sample, and the 1649.8m water-extract, were
separated into their constituent fractions by liquid chromatography. The
1649.8m water-extract consisted of 96% saturates; however, no separation
data were reported by the laboratory for the 1942.5m condensate.

The saturate fractions of the condensate and water-extract were analysed by
the saturate fraction GC method. The resulting saturate GC traces are
shown in Figures 15 and 16; the n-alkane distribution data are reported in
Table 5, normalised in Figure 17, and compared in Figure 18; the n-alkane
compositional data for the condensate and water-extract are listed in Table
6, and summarised in Figure 19. Note that the value of Pr/Ph (9.03) and
the ratio of Pr/nC_{17} to Ph/n C_{18} (4.36) in the 1649.8m fluid are typical of
hydrocarbons generated from terrestrial (non-marine) sediments containing
higher land plant-derived organic matter. No value for Pr/Ph was reported
for the 1942.5m condensate.

3.3   **GC-MS (Branched/Cyclics) Analysis**

The branched and cyclic compounds were isolated from the saturate
fractions of the condensate and water-extract and analysed by the SIR
GC-MS technique. Selected m/z 191 (triterpane) and m/z 217 (sterane)
biomarker distributions are given in Figures 20-21; full suites of mass
fragmentograms are provided in this report as Appendices 1 and 3.

Detailed compound abundances and calculated parameters are listed in Tables 7 to 9; normalised compound abundances and values for calculated parameters for the m/z 191 ions (terpanes) are summarised in Figures 22a-23a, and for the m/z 217 ions (steranes) in Figures 22b-23b. Figures 24a-24b compare normalised compound abundances and values of calculated parameters for the condensate and water-extract. Note that these plots are based on compound abundances from the topped fluid in the case of 1942.5m condensate.

3.3.1   Terpane Parameters

The relative abundance of C_{27} triterpanes, $18\alpha(H)$-hopane (Ts) and $17\alpha(H)$-hopane (Tm), is theoretically useful for the maturity assessment of medium to high maturity oils. With increasing maturity, more of the maturable C_{27} triterpane (Tm) is converted to the stable C_{27} triterpane (Ts). The relative amounts of Ts and Tm in the condensate and water-extract show a predominance of stable (Ts) over maturable (Tm) (Ts/Ts+Tm = 58-61%), suggesting that they are thermally mature. Note that the Ts/Ts+Tm parameter is lithofacies-dependent, and should be used with some caution as an absolute indicator of thermal maturity (it is best used as a maturity indicator of oils from a common source of consistent organic facies).

Moretanes are diastereomers of the hopanes, and, being less stable than the latter, are destroyed more rapidly with increasing maturity. The moretane/hopane ratio decreases from about 0.80 in immature bitumens to values of 0.15-0.05 in mature source rocks and oils. The relative abundances of the C_{29} and C_{30} moretanes and hopanes in the condensate and water-extract reveal a predominance of hopanes (moretane/hopane = 0.08-0.10), implying that they are mature. (Note that, like Ts/Ts+Tm, the moretane/hopane parameter is to some extent lithofacies-dependent, its value, for example, being higher in Tertiary source rocks.)

The $C_{31}22S$-hopane/$C_{31}22R$-hopane ratio can be used to assess thermal maturity. As maturity increases, the proportion of the 22S isomer increases at the expense of the biologically produced 22R isomer, until equilibrium is reached, at which point the 22S isomer accounts for about 60% of the mixture. This is achieved soon after the onset of oil generation (at about 0.60% VR, before significant oil generation has occurred), limiting the use of this parameter at higher levels of maturity. In the water-extract and condensate, the 22S isomer accounts for 60-61% of the mixture, implying that isomeric equilibrium has been reached, and that the source rocks in both cases were thermally matured at least to the point of initial oil-generation. Note that the 22S isomer of the C_{32} hopanes forms 60% of the isomeric mixture, concurring with the C_{31} hopane data.

Note that the distributions of terpane compounds in the water-extract and condensate are very similar (figures 22a, 22b and 24a), minor differences being reported values for C_{28} 28,30-bisnorhopane and C_{29}-moretanes. The C_{28} 28,30-bisnorhopane (BNH) present in the 1649.8m water-extract is probably derived from the original (post-diagenetic) free bitumen (S_o) in thermally immature claystones around 1649.8m, and was present in the water recovered by the RFT at this depth. Hence the 1649.8m water-extract appears to consist of both gas-associated condensate (migrated) with minor amounts of free bitumen (indigenous).

3.3.2   Sterane Parameters

The relative proportion of the geological 20S and biological 20R isomers of the C_{28} and $C_{29}\alpha\alpha\alpha$ (normal) steranes, expressed as the 20S/20S+20R ratios, is perhaps the most reliable biomarker maturity parameter (it is not greatly influenced by lithofacies variations). Equilibrium, when the 20S isomer forms about 52-55% of the mixture, is reached at, or around, 0.80% vitrinite reflectance. In the Minerva-1 condensate and water-extract, the 20S isomer forms 51% of the C_{29} mixture, suggesting expulsion of these fluids from its source sediment at, or beyond, 0.80% vitrinite reflectance.

The relative proportions of C_{29} normal ($\alpha\alpha\alpha$) and iso-($\beta\beta\alpha$) steranes can be effective in assessing the thermal maturity of source rocks and oils. The normal ($\alpha\alpha\alpha$) steranes, produced biologically, become less dominant relative to the iso-steranes ($\beta\beta\alpha$) with increasing maturity, until equilibrium is reached at a value of $\beta\beta\alpha/(\beta\beta\alpha+\alpha\alpha\alpha)$ of about 67-71% (VR=0.90%). In the Minerva-1 condensate and water-extract, the iso-steranes dominate the normal steranes ($\beta\beta\alpha/\alpha\alpha\alpha+\beta\beta\alpha$ = 57-60%), suggesting that the source rock was matured to 0.8-0.9% VR at the time they were expelled. This maturity estimate is inconsistent with that based on stable carbon isotope data derived from the gas with which the 1649.8m water-extract was intimately associated (see section 3.5.2).

Diasterane/sterane ratios are affected by both thermal maturity and inorganic (lithological) characteristics of the source rock. Conversion of steranes to diasteranes is catalysed by clay minerals, so that diasterane/sterane ratios are typically low (less than 0.30) in carbonate source rocks and derived oils. A high-Eh (oxidising) depositional environment and increasing thermal maturity can each result in a high diasterane/sterane ratio. C_{29} diasteranes constitute 44% of the C_{29} normal/iso-/diasterane mixture in the Minerva-1 condensate and water-extract, implying that these hydrocarbons were expelled from thermally mature clastic source rocks. It is difficult to make a better estimate of the absolute level of thermal maturity at which the condensate and water-extract were expelled from their sources (the proportion of diasteranes being partly dependent on lithofacies).

Note that the distributions of sterane compounds in the water-extract and condensate are, like the terpane distributions, very similar (Figure 23a, 23b and 24b). Perhaps the only conspicuous difference is the value of Ratio C (ratio of C_{30} hopanes and moretanes to C_{29} total steranes). The general assumption about triterpane/sterane ratios is that steranes are derived mainly from algae and higher plants, whereas triterpanes come mainly from bacteria. However, the relationship between organic facies and triterpane/sterane ratio is complex, and cannot always be used with confidence. When absolute concentrations of biomarkers are high, high triterpane/sterane ratios are taken to indicate a high degree of microbial input; where concentrations are low, high ratios are taken to indicate greater contribution from land-plants than from algae. Low triterpane/sterane ratios together with high absolute biomarker concentrations, are associated with coals, shales and oils (eg. South East Asia and New Zealand); low ratios in conjunction with low absolute abundances may indicate a dominance of higher-plant and fungal material (Waples et al., 1991). Triterpane/sterane ratios as expressed by Ratio C are low in the water-extract (0.36), and higher in the condensate (1.09), but each suggests generation from source sediments deposited in a relatively oxic, aquatic environment. (Note that Figure 25 shows data from the 1649.8m water-extract only, since a Pr/Ph value was not reported for the 1942.5m condensate - see also Figure 27).

Figure 26, a triangular plot of C_{27}, C_{28} and C_{29} normal steranes, shows a dominance of C_{27} compounds, the data plotting within the marginal marine field. Note that S isomers of the normal steranes were not reported for either the water-extract or the condensate, and Figure 26 is constructed accordingly (R isomers only).

Figure 27 shows a crossplot of Pr/Ph ratio versus $C_{29}R/C_{27}R$ for the 1942.5m condensate, further suggesting a relatively oxic, aquatic environment for deposition of the source sediments, based on the dominance of the $C_{27}R$ steranes relative to $C_{29}R$.

Plots of $\beta\beta/(\beta\beta+\alpha\alpha)$ versus $20S/(20S+20R)$ for the C_{29} steranes are effective in describing and comparing the thermal maturity of source rocks or oils; data for any oils which plot away from the maturity trend-line in such plots should be re-examined in the light of the disagreement between the two parameters (Peters and Moldowan, 1993). As Figure 28 shows, data for the condensate and water-extract plot together, suggesting that the two data sets are comparable and correlable.

A note of caution should be made regarding the use of biomarker data from condensates. Condensates are formed either from source rocks under high thermal stress or by phase-separation from an oil, and exist in the subsurface in the gas phase. These processes usually result in a significant variation in the values of important biomarker ratios and parameters in condensates

compared with co-genetic oils (Woodhouse, 1991). This means that the absolute values of such ratios and parameters may not be a true reflection of the nature of the source organic matter and its maturity. In addition, many of the maturity indicators based on biomarker abundances are only of value at lower levels of maturity because they reach isomeric equilibrium so early, rendering them less useful at the levels of maturity appropriate to the generation of gases and condensates. However, the biomarker data for the water-extract and condensate, notwithstanding these effects, can be used for comparative purposes; they are sufficiently similar to leave little doubt that the Minerva-1 fluids are co-genetic, and may be of further value in the correlation of the Minerva-1 hydrocarbons with those recovered from nearby wells.

3.4   GC-MS(Aromatics) Analysis

The aromatics fractions from the 1649.8m water-extract and 1942.5m condensate were analysed by the SIR GC-MS technique. Full suites of mass fragmentograms are provided in this report as Appendices 2 and 4. Detailed compound abundances, and parameters calculated from them, are listed in Tables 10 and 11.

The primary application of these data is for maturity assessment. Perhaps the most widely used parameter is the Methylphenanthrene Index (MPI-1), due to its better calibration against the vitrinite reflectance scale, equivalent values of which can be calculated (Radke et al, 1982). Figure 29 shows a plot of MPI-derived vitrinite reflectance values versus depth for the Minerva-1 condensate and water-extract. These fluids give values of $R_c(a)\%$ (1.07 and 0.84%) which are disparate, and approriate to moderate levels of thermal maturity in the oil-generative window (implying oil-associated gas). However, if the MPI-1 values are converted to $R_c(b)\%$, using an algorithm appropriate to thermal maturities greater than 1.35% VR, then values of 1.63% and 1.86% VR are obtained, consistent with the thermogenic gas indicated by the gas isotope data (see section 3.5.2).

The relative abundances of certain aromatic compounds can be applied to source input assessment, particularly the degraded diterpanes, such as 1,2,5-TMN, 1,7-DMP, 1-MP and retene, which are thought to be derived from resin precursors in conifers (such as Araucariaceae, Cupressaceae and Podocarpaceae in the Jurassic to Lower Cretaceous of Australia). Source sediments which pre-date the appearance of such conifers in the Late Triassic will display different distributions of degraded aromatic compounds, so that the data provide a useful correlation tool. Figures 30 and 31 show crossplots of ratios involving these compounds; while the latter shows a grouping of the condensate and water-extract data, implying a similar source, Figure 30 does not (the reason for this is not clear, but may relate to low concentrations of aromatic compounds in the analysed fluids).

3.5   Gas Analysis

Two gas samples, recovered by RFT from 1649.8m and 1931.0m in Minerva-1 were analysed by CSIRO, North Ryde for their chemical and stable carbon isotopic compositions. (The water-extract isolated by cold-trapping of the 1649.8m sample has already been discussed.)

3.5.1   Chemical Composition

The chemical compositions of the RFT gases are summarised in Tables 12 and 13, normalised in Figure 32. The gases are chemically very similar, containing 94% methane, though the 1931.0m gas contains slightly more carbon-dioxide than the 1649.8m gas.

3.5.2   Stable Carbon Isotopic Composition

The stable carbon isotope data for the two gases are listed in Table 14, and values for individual hydrocarbon species cross-plotted in Figures 33 and 34. As these figures show, the carbon isotope compositions of the gases are very similar, leaving their co-genetic origin in little doubt. Figure 33 indicates that the gases were expelled from their source rocks at thermal maturities equivalent to over 2.0% VR, early in the dry-gas-generative window, whereas Figure 34 suggests 1.5-1.6% VR, within the wet-gas window.

Figure 35 is an attempt to characterise the gases in terms of the isotopic compositions of their methane components and the relative amounts of their C_2+ components. This plot suggests that the gases are non-associated (ie. they were not generated along with oil, but produced by the thermal cracking of oils) and that they were migrated from depth.

4   CONCLUSIONS

Four SWC samples, from the Late Cretaceous Sherbrook and Shipwreck Groups, were analysed for their TOC content. Three samples (including one coal) yielded values greater than 1.0%, and were accordingly analysed by Rock-Eval pyrolysis. The resulting data revealed a predominance of Type II/III to Type III, mainly gas-prone organic matter with HI values less than 150, with the exception of the coal sample (1837.1m) characterised by more strongly liquids-prone organic matter. While liptinitic/exinitic (Type II) macerals were identified in most samples (supplemented by a sparse alginitic component), suggesting some liquids potential, it is clear from the S1+S2 yields that expulsion from these samples would be possible only at relatively advanced levels of thermal maturity; at such levels, secondary cracking of liquids to gas would occur, such that these source rocks would, in the event, become even more gas-prone than indicated by the source character data.

Thermal maturity data, namely Tmax, PI and vitrinite reflectance measurements, suggest that the 1130-1747m interval is thermally immature, the 1947.5-2215m interval marginally mature, and the interval down to 2392.5m early oil-generative mature. The generative potential of the sediments has therefore not been realised at the Minerva-1 location.

A further inference is that the quality of these source rocks can not be linked to advanced maturity, their relative leanness being more a function of the type and preservation state of their contained organic matter.

A condensate and a water-extract, acquired from the cold-trapping of the 1942.5m and 1649.8m RFT gases, were subjected to whole-oil GC and whole-extract GC (as appropriate), saturates-GC, GC-MS (branched/cyclics) and GC-MS (aromatics) analysis. Paraffin Index data from the condensate suggest that it was expelled from its source rock at about 135°C (close to peak-oil generation). Saturate fraction GC data from the water-extract suggest that it was generated from higher land-plant-derived organic matter within source sediments deposited under strongly oxic conditions. Biomarker data, from SIR GC-MS analysis of the saturates and aromatics fractions, suggest that the fluids were generated from aquatically derived organic matter incorporated into clastic source sediments deposited under relatively oxic conditions, possibly in a marine to marginally marine environment. Isomeric equilibria were found to be exceeded in the case of those biomarker indicators appropriate to lower levels of thermal maturity, others (such as the relative abundances of Ts/Tm, and moretanes/hopanes) indicating advanced maturities. Values of $R_c(b)\%$, calculated from MPI-1 using an algorithm appropriate to maturities greater than 1.35% VR, fall in

the 1.63-1.86% range, consistent with the 1.5-1.6% (or greater) values obtained from stable carbon isotope data from the 1649.8m and 1931.0m gases. These data further confirm that the gases were generated by the thermal cracking of liquids at depth rather than in association with liquids within the oil-generative window.

Caution should be exercised when biomarker data from condensates are used to make inferences regarding source organic matter type, provenance, and thermal maturity. The absolute values of compound abundances, and ratios based on them, may not be a true reflection of these source characteristics, in that they are either maturity- or phase-affected, or both. However, such data may still be useful for comparative purposes, being sufficiently similar to infer the co-genesis of the Minerva-1 gas/condensates, and being of potential value for correlation with hydrocarbons recovered from nearby wells.

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TABLE 1-1

GEOLOGIC & GENERAL DATA - SEDIMENTS
======================================

WELL NAME = MINERVA-1
COUNTRY   = Australia
BASIN   = Otway

DEPTH UNIT = Metres
DATE OF JOB = Apr 93

DEPTH 1	DEPTH 2	GEOLOGIC PERIOD/EPOCH	GEOLOGIC AGE	FORMATION	PRIMARY LITHOLOGY	PERCENT PRIMARY	SECONDARY LITHOLOGY	PERCENT SECONDARY	SAMPLE TYPE	SAMPLE QUALITY	CONTRACTOR	SAMPLE PICKED	TEMPERATURE (deg. C)
1130.00	1130.00	L.CRET	-	SHERGP	-	-	-	-	SWC	-	GTS	NO	-
1342.00	1342.00	L.CRET	-	SHERGP	-	-	-	-	SWC	-	GTS	NO	-
1523.00	1523.00	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
1747.00	1747.00	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
1837.10	1837.10	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
1947.50	1947.50	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
2157.50	2157.50	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
2215.00	2215.00	L.CRET	-	SHIPGP	-	-	-	-	SWC	-	GTS	NO	-
2392.50	2392.50	E.CRET	-	OTWAGP	-	-	-	-	SWC	-	GTS	NO	-

N.B. Code definitions at end of table
      - = No data

CODE DEFINITIONS FOR TABLE 1

GEOLOGICAL PERIOD CODES

E.CRET = Early Cretaceous
L.CRET = Late Cretaceous

GEOLOGICAL AGE CODES

FORMATION CODES

OTWAGP = Otway Group
SHERGP = Sherbrook Group
SHIPGP = Shipwreck Group

PRIMARY/SECONDARY LITHOLOGY CODES

SAMPLE TYPE CODES

SWC = Sidewall Core

SAMPLE QUALITY CODES

CONTRACTOR CODES

GTS = Geotechnical Services

TABLE 1-2

GEOLOGIC & GENERAL DATA - FLUIDS
===================================

WELL NAME = MINERVA-1   DEPTH UNIT = Metres
COUNTRY   = Australia   DATE OF JOB = Aug 93-Mar 94
BASIN   = Otway

DEPTH 1	DEPTH 2	SAMPLE DESCRIPTION	GEOLOGIC PERIOD/EPOCH	GEOLOGIC AGE	FORMATION	SAMPLE TYPE	SAMPLE QUALITY	CONTRACTOR	TEMPERATURE (deg. C)
1649.80	1649.80	GAS	L.CRET	-	SHIPGP	RFT	-	CSI	-
1649.80	1649.80	COLD-TRAPPED COND	L.CRET	-	SHIPGP	RFT	-	GTS	-
1649.80	1649.80	COLD-TRAPPED COND	L.CRET	-	SHIPGP	RFT	-	GTS	-
1931.00	1931.00	GAS	L.CRET	-	SHIPGP	RFT	-	CSI	-
1942.50	1942.50	COLD-TRAPPED COND	L.CRET	-	SHIPGP	RFT	-	GTS	-
1942.50	1942.50	TOPPED	L.CRET	-	SHIPGP	RFT	-	GTS	-

N.B. Code definitions at end of table
      - = No data

CODE DEFINITIONS FOR TABLE 1

GEOLOGICAL PERIOD CODES

L.CRET = Late Cretaceous

GEOLOGICAL AGE CODES

FORMATION CODES

SHIPGP = Shipwreck Group

SAMPLE TYPE CODES

RFT = Repeat Fm Test

SAMPLE QUALITY CODES

CONTRACTOR CODES

CSI = C.S.I.R.O
GTS = Geotechnical Service

TABLE 2

TOC AND ROCK-EVAL PYROLYSIS DATA - SEDIMENTS
==

WELL NAME = MINERVA-1
COUNTRY   = Australia
BASIN   = Otway

DEPTH UNIT = Metres
DATE OF JOB = Apr 93

DEPTH 1	DEPTH 2	TOC	TMAX	SO	S1	S2	S3	S1+S2	S2/S3	PI	PC	HI	OI	INSTRUMENT	SAMPLE TYPE	CONTRACTOR	PICKED
1342.00	1342.00	1.68	432	-	.04	1.71	.37	1.75	4.62	.02	.15	102	22	RE2	SWC	GTS	NO
1523.00	1523.00	1.34	432	-	.05	1.26	.81	1.31	1.56	.04	.11	94	60	RE2	SWC	GTS	NO
1747.00	1747.00	.37	-	-	-	-	-	-	-	-	-	-	-	RE2	SWC	GTS	NO
1837.10	1837.10	40.50	424	-	19.70	181.98	1.28	201.68	142.17	.10	16.74	449	3	RE2	SWC	GTS	NO

TOC	= Total organic carbon	TMAX	= Max. temperature S2	SO	= Volatile gaseous HC's
S2	= HC generating potential	S3	= Organic carbon dioxide	PI	= Production index
HI	= Hydrogen index	OI	= Oxygen index	-	= no data

S1 = Volatile hydrocarbons (HC's)
PC = Pyrolysable carbon
N.B. Code defn's at end of table.

CODE DEFINITIONS FOR TABLE 2

INSTRUMENT CODES

RE2 = Rock-Eval II

SAMPLE TYPE CODES

SWC = Sidewall Core

CONTRACTOR CODES

GTS = Geotechnical Services

Figure 1

MINERVA-1
TOC vs Hydrogen Index

MINERVA-1
TOC vs Hydrogen Index: inc. Coal

Figure 2

Left chart:

MINERVA-1
TOC vs S1+S2

S1 + S2 (y-axis: 0.0 to 5.0)
TOC (%) (x-axis: 0.0 to 3.0)

SHERGP   SHIPGP
●   ◈

Right chart:

MINERVA-1
TOC vs S1+S2: inc. Coal

S1 + S2 (y-axis: 0 to 250)
TOC (%) (x-axis: 0 to 50)
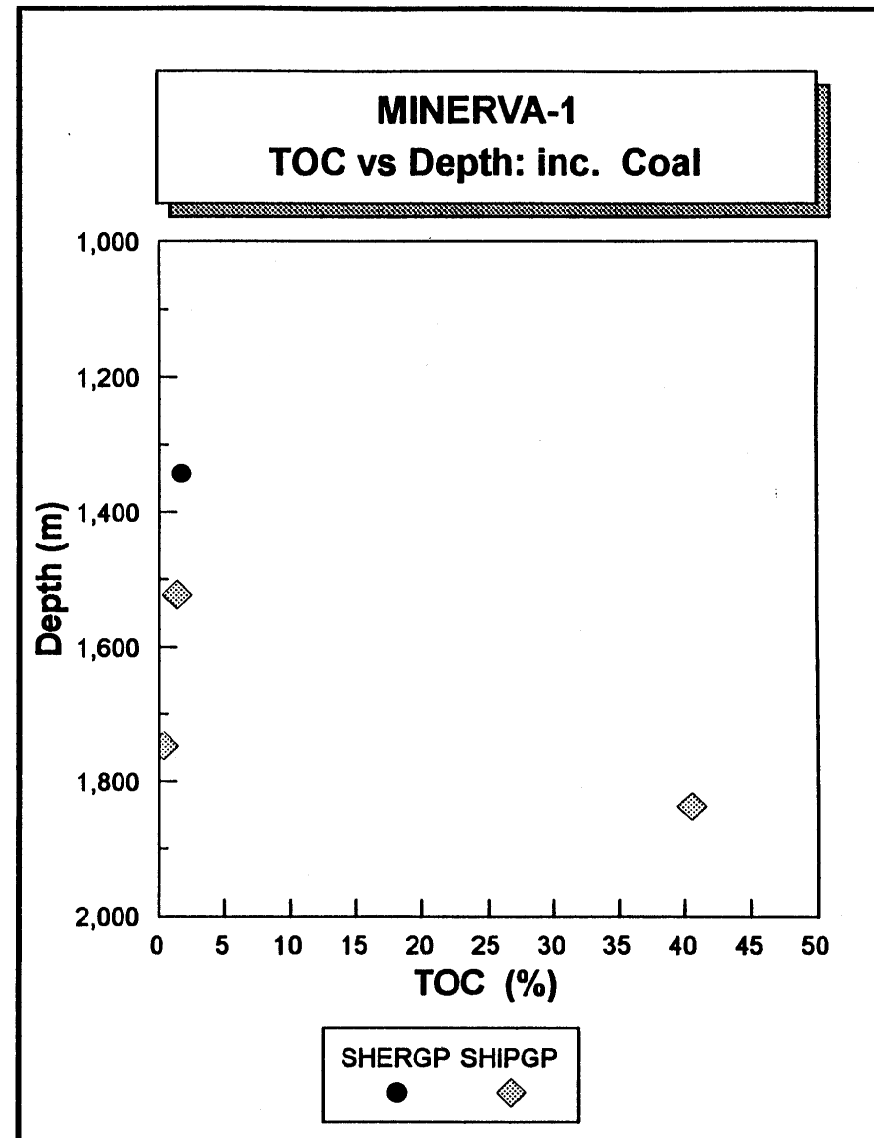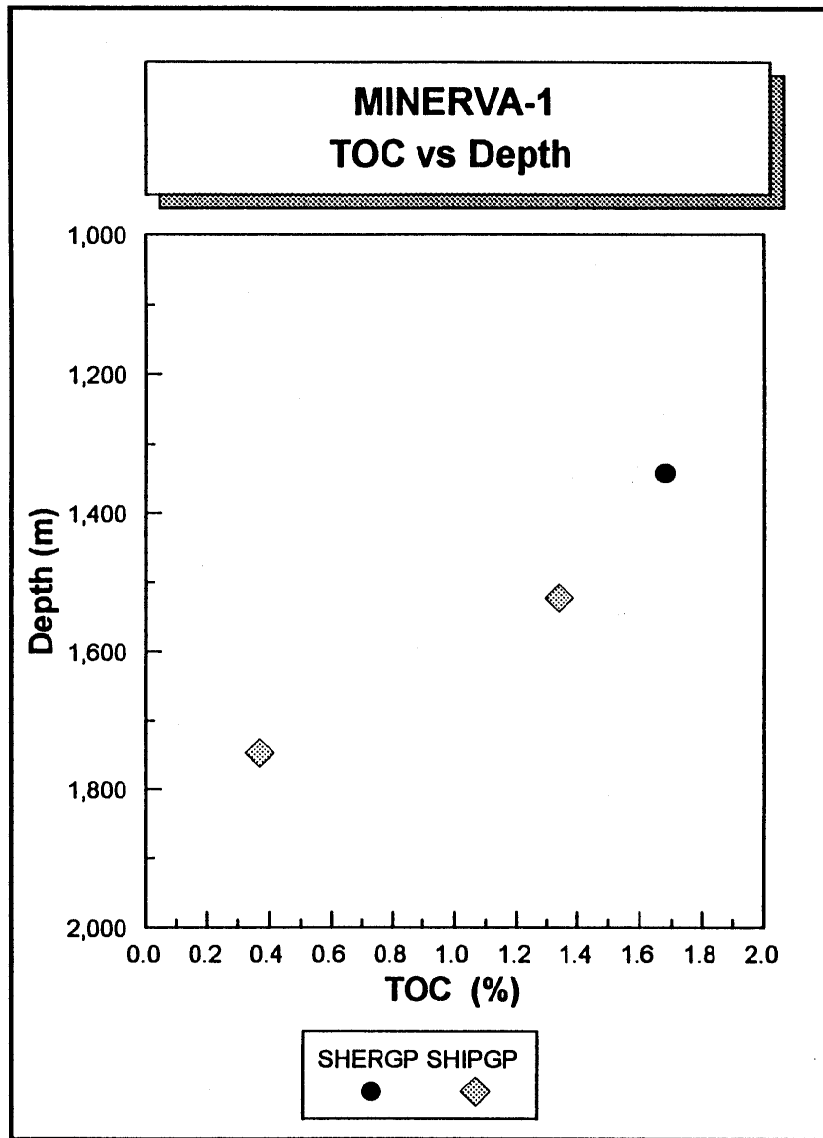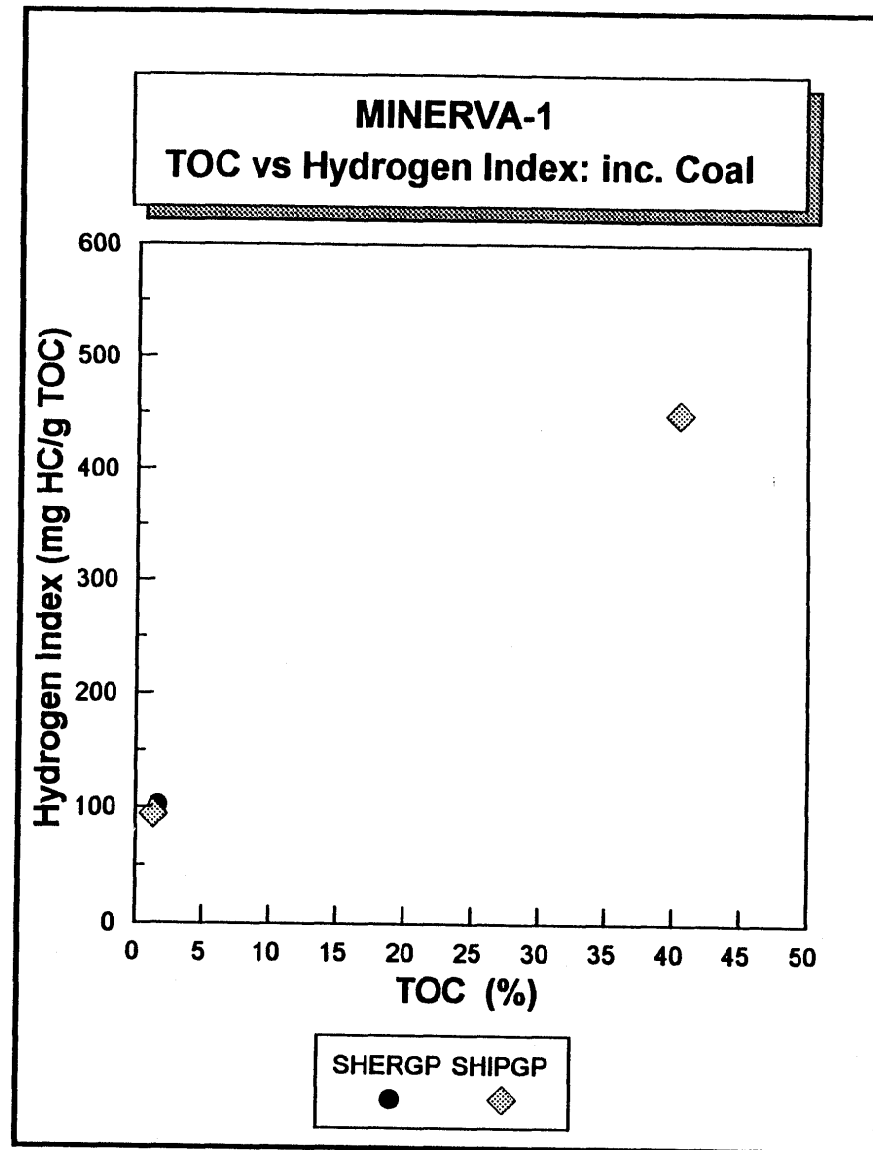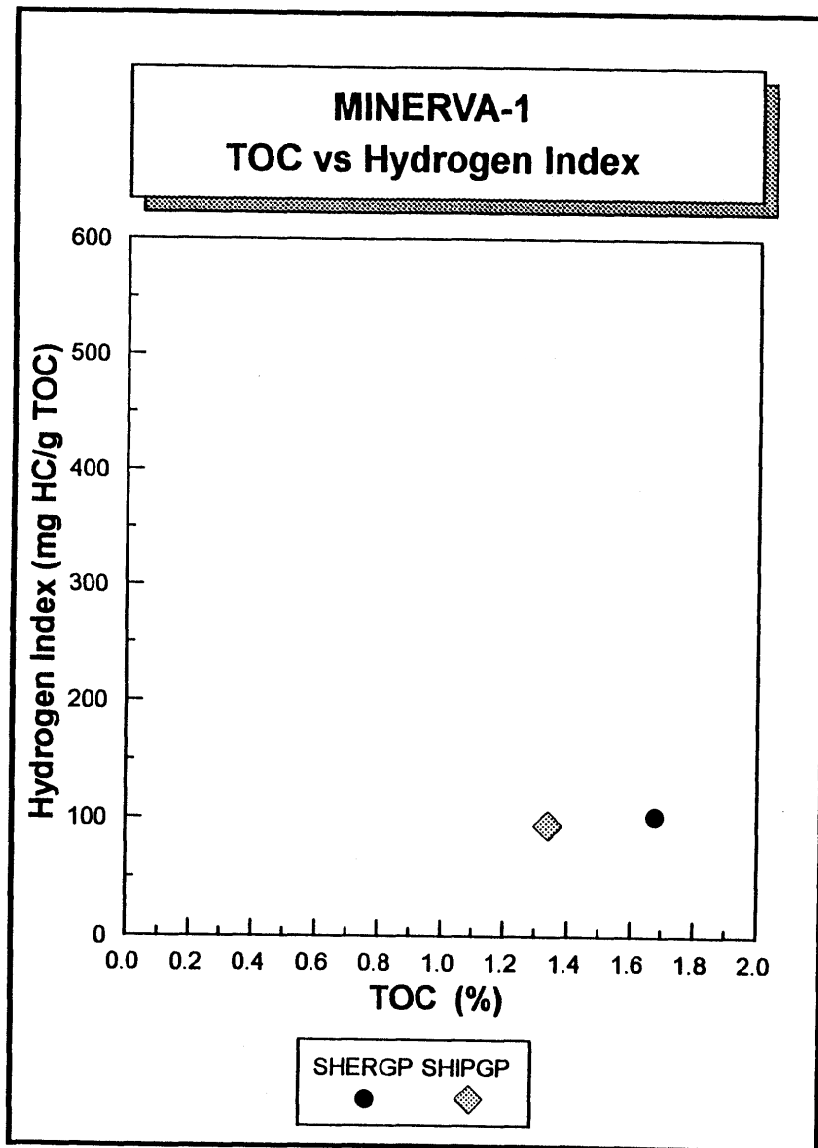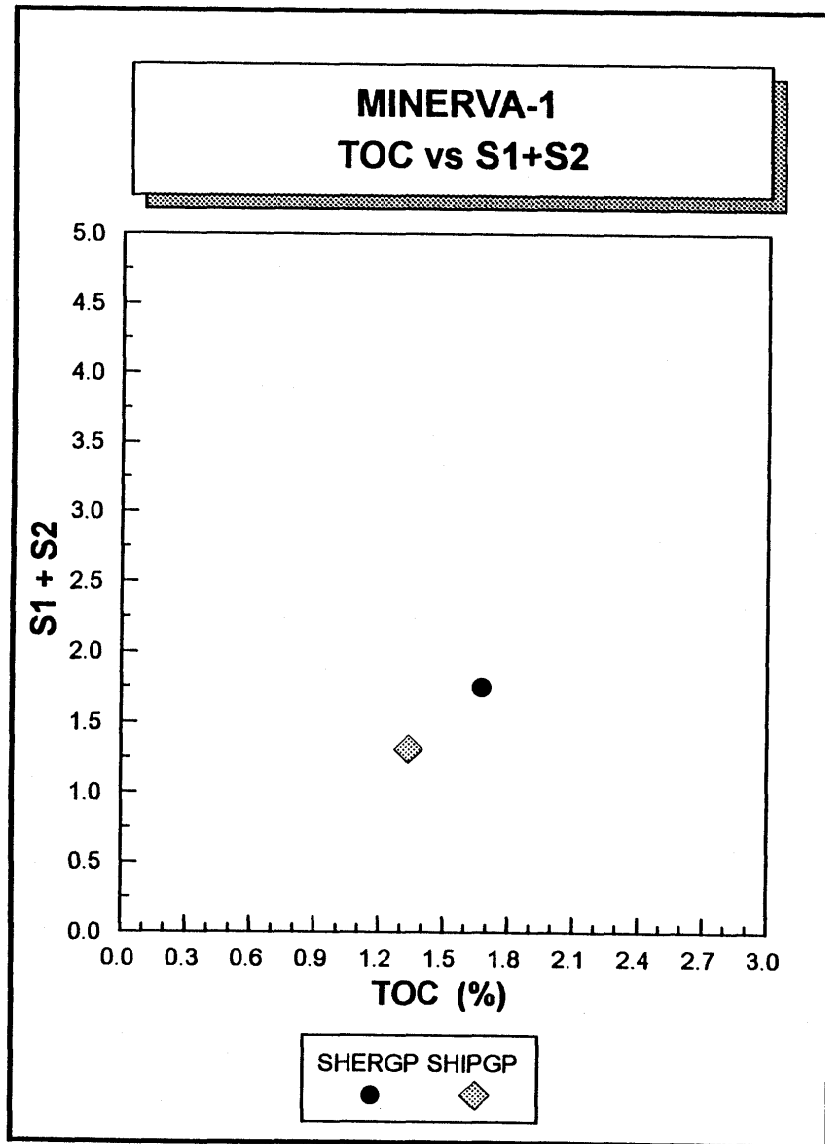
SHERGP   SHIPGP
●   ◈

Figure 3

MINERVA-1
Hydrogen Index vs Oxygen Index
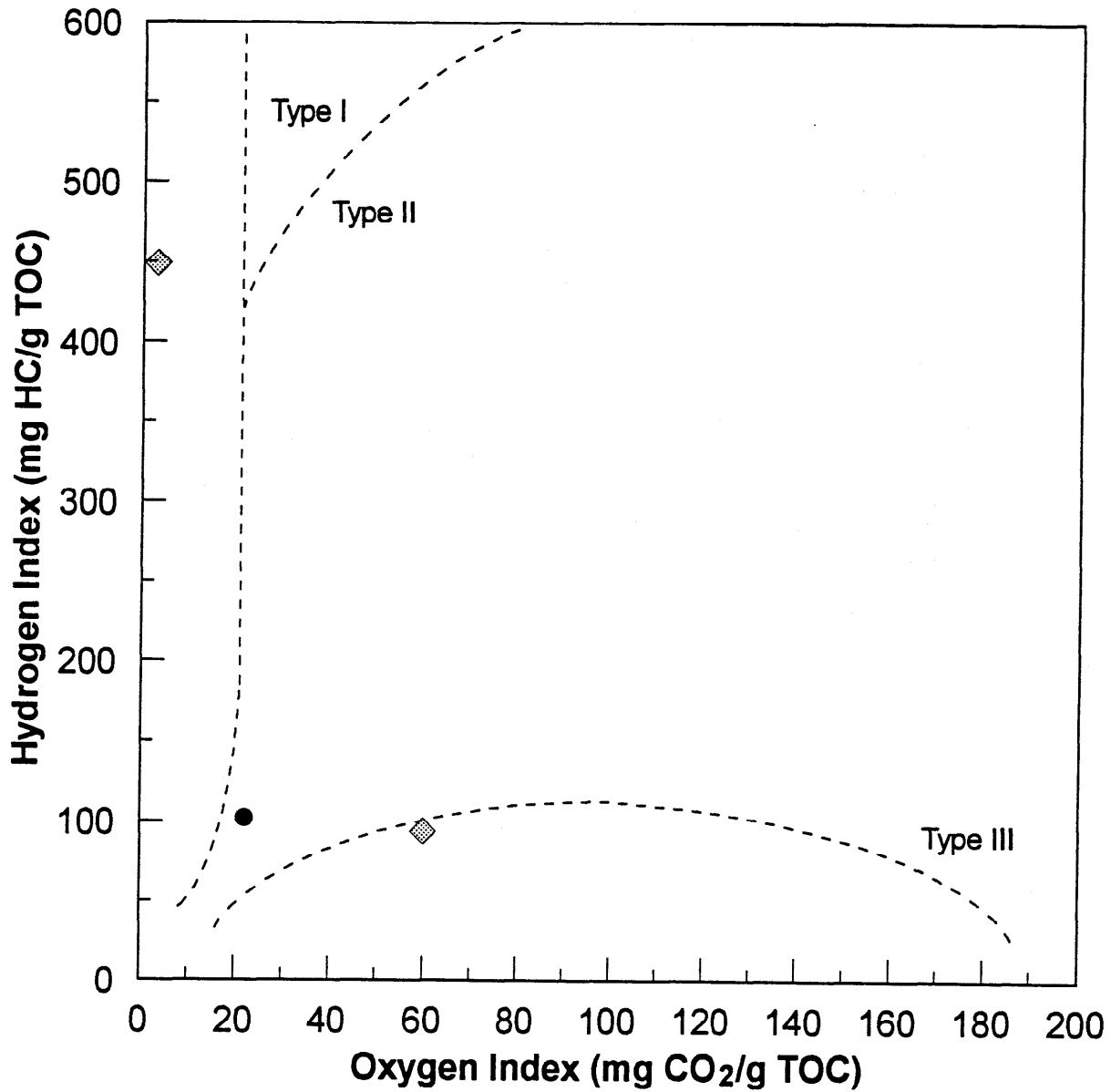
Figure 4

MINERVA-1
Hydrogen Index vs Tmax
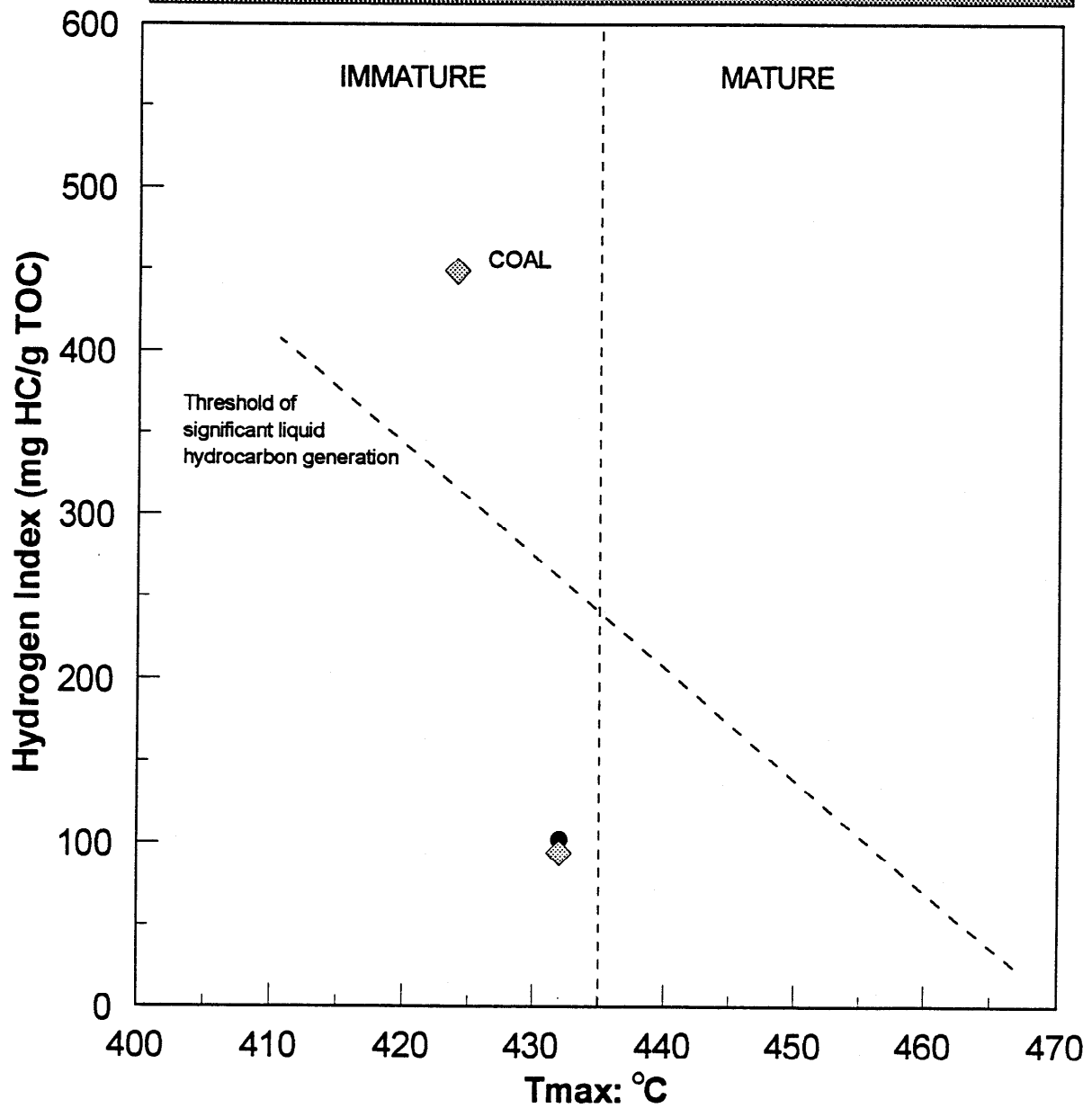
Figure 5

MINERVA-1
Maceral Composition Data
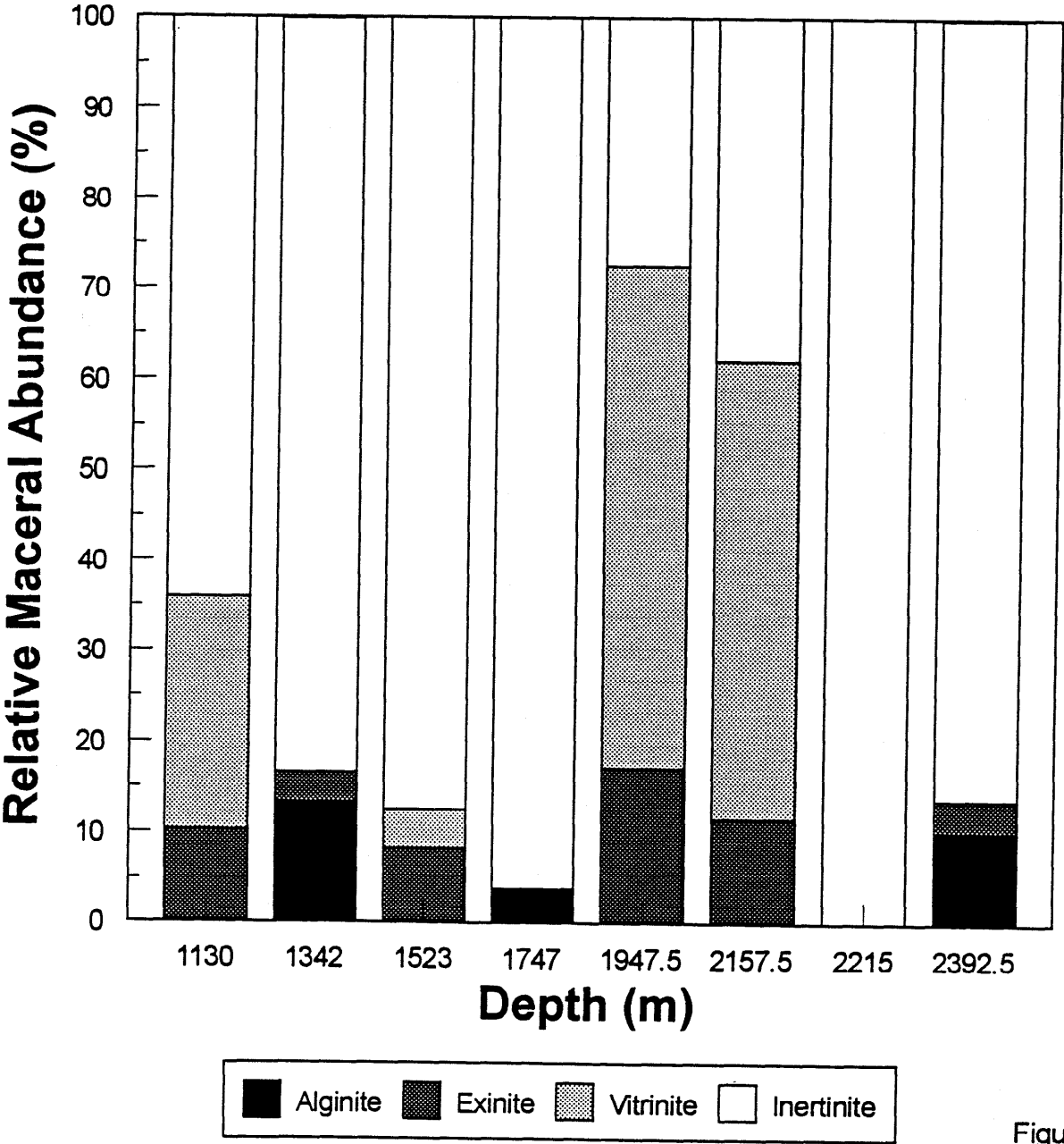
Figure 6

MINERVA-1
Tmax vs Depth

IMMATURE   MATURE

COAL

Tmax: °C
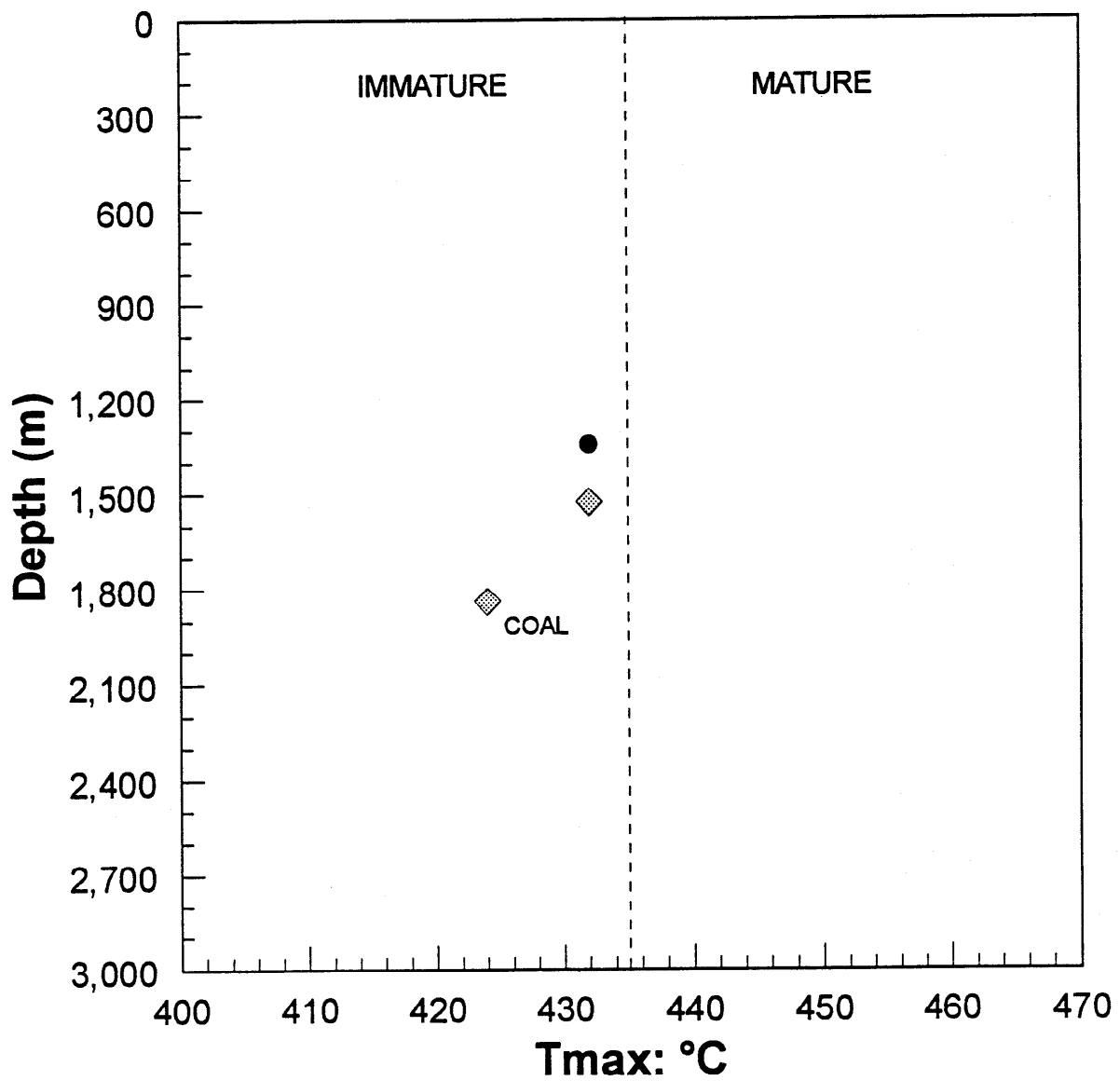
SHERGP   SHIPGP

Figure 7

MINERVA-1
PI vs Depth
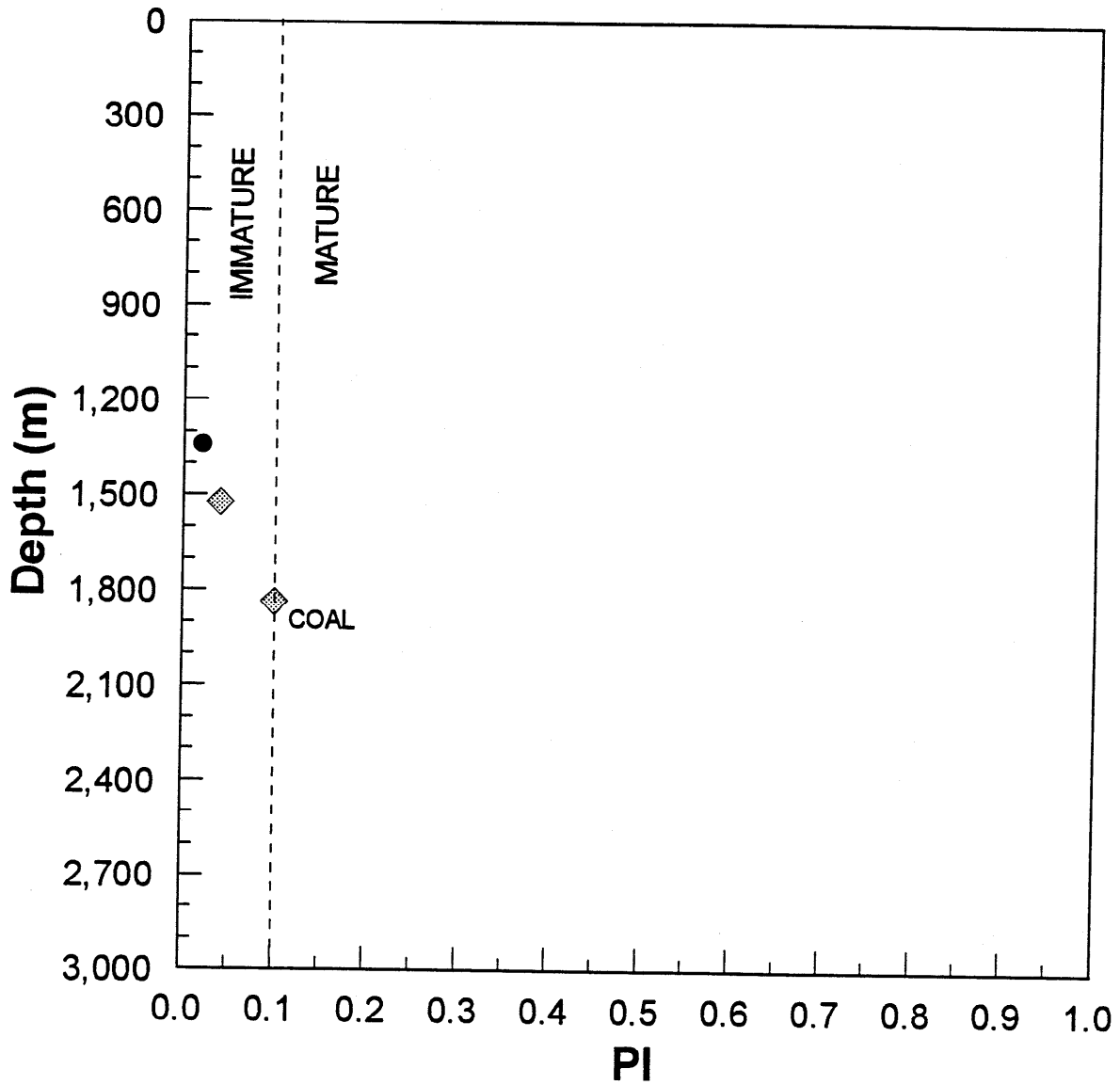
Figure 8

TABLE 3

VITRINITE REFLECTANCE AND COAL MACERAL DATA - SEDIMENTS
ALL MACERAL POPULATIONS

WELL NAME = MINERVA-1
COUNTRY = Australia
BASIN   = Otway

DEPTH UNIT = Metres
DATE OF JOB = June 93

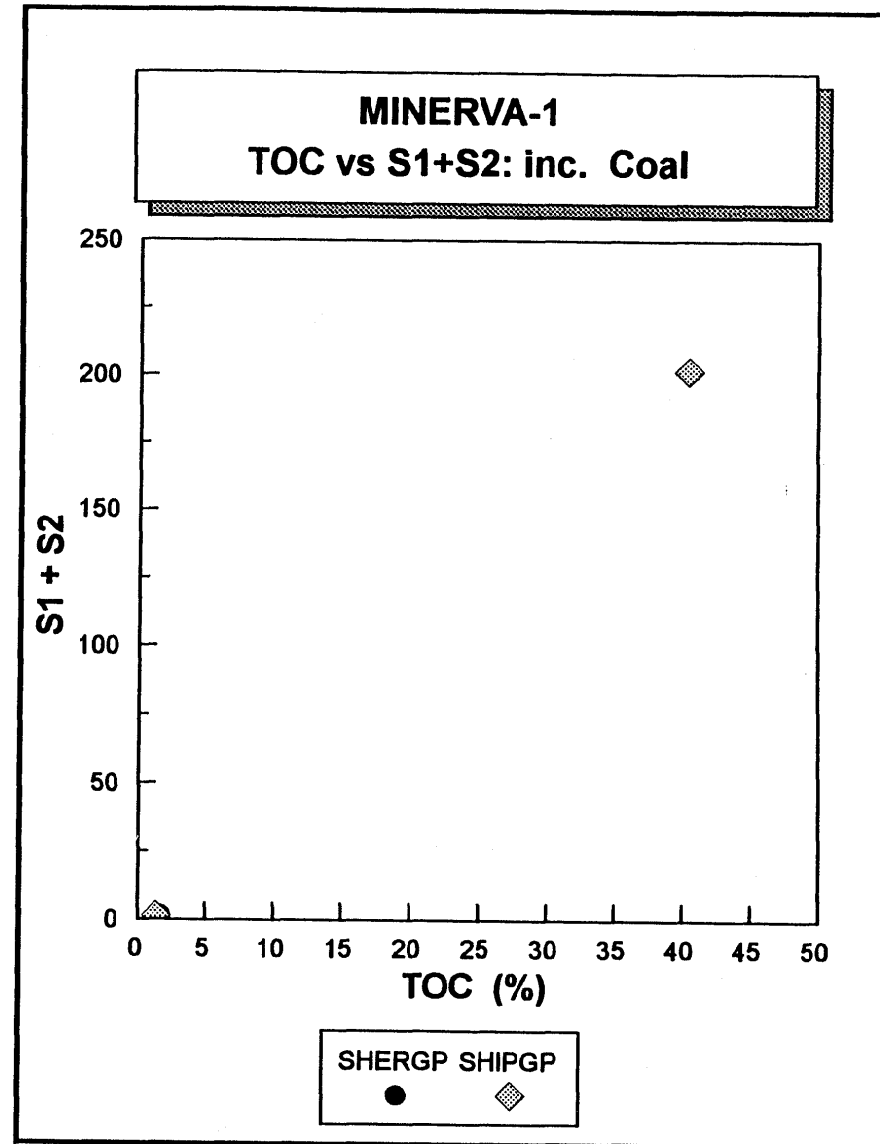| DEPTH 1	DEPTH 2	POPULATION TYPE	MEAN % REFL.	MINIMUM % REFL.	MAXIMUM % REFL.	NUMBER READINGS	STANDARD DEVIATION	% ALGINITE	% EXINITE	% VITRINITE	% INERTINITE	SOURCE OF DATA
1130.00	1130.00	V	.42	.29	.57	29	.09	0.00	10.30	25.60	64.10	GTS
1342.00	1342.00	V	.50	.42	.57	12	.04	13.30	3.30	0.00	83.30	GTS
1523.00	1523.00	V	.53	.41	.64	28	.06	0.00	8.30	4.20	87.50	GTS
1747.00	1747.00	V	.53	.40	.74	15	.09	3.80	0.00	0.00	96.20	GTS
1947.50	1947.50	V	.63	.53	.71	26	.05	0.00	17.20	55.40	27.40	GTS
2157.50	2157.50	V	.62	.57	.71	27	.03	0.00	11.60	50.50	37.90	GTS
2215.00	2215.00	V	.62	.57	.67	2	.07	0.00	0.00	0.00	100.00	GTS
		I	1.70	1.38	1.90	8	.19					
2392.50	2392.50	V	.75	.60	.94	9	.12	10.30	3.40	0.00	86.20	GTS

N.B. Code definitions at end of table
      - = no data

CODE DEFINITIONS FOR TABLE 3

POPULATION TYPE CODES

I = INERTINITE
V = VITRINITE

CONTRACTOR CODES

GTS = Geotechnical Servics

JOB NO. 1933A, MINERVA-1, OTWAY BASIN

Sample No(s)	Depth(m)/ Sample type	R max V (%)	Range (%)	N	Description Including Liptinite Fluorescence Characteristics
v7853	1130 SWC10	0.42	0.29-0.57	29	Sparse sporinite, bright yellow to orange, sparse cutinite, yellow to orange, rare resinite, greenish yellow, rare lamalginite and liptodetrinite, yellow to orange. (Siltstone>> coal. Coal rare, V only. Vitrite. Dom abundant, I>V>L. Inertinite abundant, vitrinite common, liptinite sparse. Oil drops rare, greenish yellow. Mineral fluorescence pervasive, faint green. Iron oxides common. Pyrite sparse.)
v7854	1342.0 SWC99	0.50	0.42-0.57	12	Sparse lamalginite and cutinite, yellow to orange, rare sporinite and liptodetrinite, yellow to orange. Rare tasmanitid-derived telalginite, bright yellow. (Silty claystone. Dom abundant, I>L>V. Inertinite abundant, liptinite sparse, vitrinite rare. Mineral fluorescence pervasive, weak yellow to orange. Iron oxides sparse. Pyrite abundant.)
v7855	1523 SWC89	0.53	0.41-0.64	28	Sparse sporinite, yellow to orange, rare cutinite, yellow to orange, rare lamalginite, bright greenish yellow to yellow, rare liptodetrinite, greenish yellow to orange. (Clayey siltstone. Dom abundant, I>L>V. Inertinite abundant, liptinite and vitrinite sparse. Oil drops rare, greenish yellow. Mineral fluorescence pervasive, weak green. Glauconite rare. Fossil fragments rare. Iron oxides sparse. Pyrite abundant.)
v7856	1747.0 SWC75	0.53	0.40-0.74	15	Sparse lamalginite, yellow to dull orange, rare liptodetrinite, yellow to dull orange. (Sandstone. Dom abundant, I>L>V. Inertinite abundant, liptinite sparse, vitrinite rare. Bitumen rare, dull orange to brown. Oil drops rare, yellow. Mineral fluorescence pervasive, weak yellow to orange. Iron oxides sparse. Glauconite sparse. Pyrite abundant.)
v7857	1947.5 SWC65	0.63	0.53-0.71	26	Major sporinite, greenish yellow to orange, abundant cutinite, yellow to orange, sparse resinite, bright greenish yellow, sparse liptodetrinite, greenish yellow to orange. (Coal>>shaly coal. Coal dominant, V>I>L. Vitrite>duroclarite>clarite> inertite. Mineral-free maceral group composition of the coal: vitrinite - 55%, inertinite - 28%, liptinite - 17%. Shaly coal abundant, V>L>I. Duroclarite>clarite. Mineral-free maceral group composition of the shaly coal: vitrinite - 50%, inertinite - 17%, liptinite - 33%. Iron oxides rare. Pyrite sparse.)
v7858	2157.5 SWC123	0.62	0.57-0.71	27	Abundant sporinite, yellow to dull orange, common resinite, yellow to orange, sparse cutinite, orange to dull orange, rare liptodetrinite, yellow to dull orange. (Coal dominant. Duroclarite>clarodurite>vitrite>inertite>clarite. Mineral-free maceral group composition of the coal: vitrinite - 50%, inertinite - 38%, liptinite - 12%. Vitrinite fluorescence common. Pyrite abundant.)

TABLE 3A

*JOB NO. 1933A, MINERVA-1, OTWAY BASIN

Sample No(s)	Depth(m)/ Sample type	$\bar{R}_v$ max (%)	Range (%)	N	Description Including Liptinite Fluorescence Characteristics
v7859	2215 SWC121 R_I	0.62 1.70	0.57-0.67 1.38-1.90	2 8	Rare lamalginite and liptodetrinite yellow to orange. (Silty claystone>>coal. Coal rare, V only. Vitrite. Dom sparse, I>L. Inertinite sparse, liptinite rare, vitrinite absent. Mineral fluorescence pervasive, moderate orange. Iron oxides sparse. Pyrite rare.)
v7860	2392.5 SWC109	0.75	0.60-0.94	9	Sparse lamalginite, orange to dull orange, sparse liptodetrinite, yellow to dull orange, rare cutinite and sporinite, orange to dull orange. (Calcareous siltstone>>coal. Coal rare, inertinite only. Inertite only. Dom abundant, I>L>V. Inertinite abundant, liptinite sparse, vitrinite rare. Bitumen sparse, dull orange to brown. Oil drops sparse, yellow. Mineral fluorescence pervasive, weak yellow to orange. Rare glauconite. Iron oxides sparse. Pyrite sparse.)

FIGURE 9

VITRINITE REFLECTANCE AND COAL MACERAL INDENTIFICATION

WELL: MINERVA-1   CLIENT: BHP PETROLEUM   SAMPLE TYPE: SWC
SAMPLE ID: 1130.0 METRES   DATE: JUNE 1993

(Total No. of Readings=29)   0.29 0.30 0.31 0.32 0.32 0.33 0.33 0.35 0.36 0.36 0.37 0.38 0.38 0.39 0.41 0.41 0.41
0.44 0.44 0.45 0.47 0.47 0.50 0.52 0.54 0.55 0.56 0.57 0.57

——————— VITRINITE REFLECTANCE ———————   —— MACERAL IDENTIFICATION ——

POPULATION Number	%	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1	100.0	29	0.42	0.29	0.57	0.09	INDIGENOUS(+)	25.60	64.10	10.30	0.00
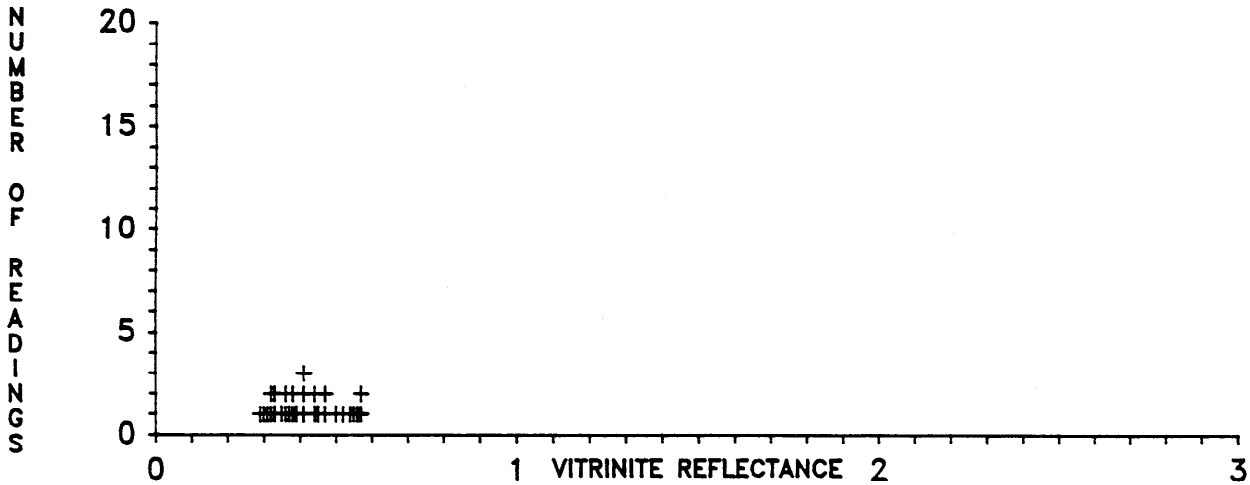
SAMPLE ID: 1342.0 METRES   SAMPLE TYPE: SWC

(Total No. of Readings=12)   0.42 0.45 0.47 0.47 0.49 0.50 0.51 0.51 0.53 0.53 0.55 0.57

——————— VITRINITE REFLECTANCE ———————   —— MACERAL IDENTIFICATION ——

POPULATION Number	%	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1	100.0	12	0.50	0.42	0.57	0.04	INDIGENOUS(+)	3.20	80.60	16.20	0.00

GEOTECH

FIGURE 9 (cont'd)

VITRINITE REFLECTANCE AND COAL MACERAL INDENTIFICATION
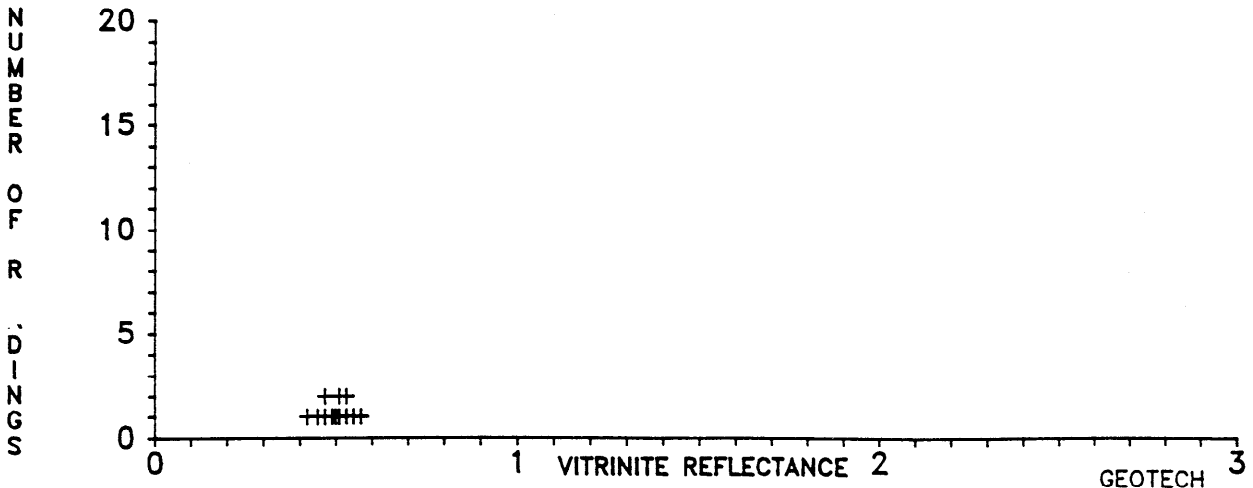
WELL: MINERVA—1 CLIENT: BHP PETROLEUM SAMPLE TYPE: SWC
SAMPLE ID: 1523.0 METRES DATE: JUNE 1993

(Total No. of Readings=28) 0.41 0.43 0.45 0.46 0.47 0.48 0.48 0.48 0.49 0.49 0.50 0.50 0.50 0.54 0.54 0.54 0.55
0.56 0.56 0.58 0.58 0.60 0.61 0.61 0.61 0.62 0.62 0.64

————— VITRINITE REFLECTANCE ————— —— MACERAL IDENTIFICATION ——

POPULATION Number %	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1 100.0	28	0.53	0.41	0.64	0.06	INDIGENOUS(+)	4.20	87.50	8.30	0.00
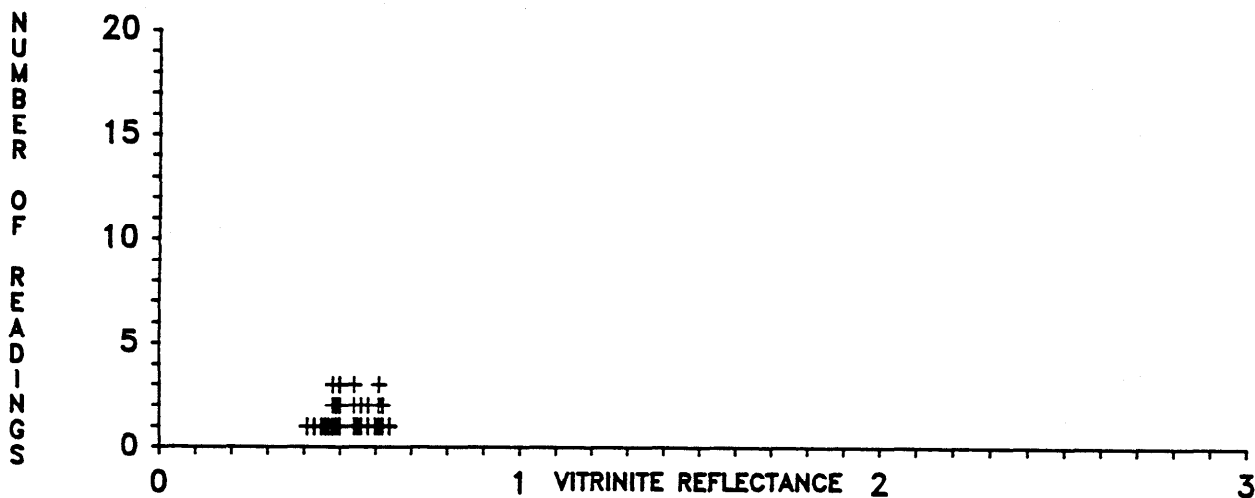
SAMPLE ID: 1747.0 METRES SAMPLE TYPE: SWC

(Total No. of Readings=15) 0.40 0.47 0.47 0.48 0.48 0.49 0.49 0.50 0.51 0.51 0.56 0.57 0.60 0.69 0.74

————— VITRINITE REFLECTANCE ————— —— MACERAL IDENTIFICATION ——

POPULATION Number %	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1 100.0	15	0.53	0.40	0.74	0.09	INDIGENOUS(+)	3.60	89.30	3.60	0.00

GEOTECH

FIGURE 9 (cont'd)

VITRINITE REFLECTANCE AND COAL MACERAL INDENTIFICATION

WELL: MINERVA—1
SAMPLE ID: 1947.5 METRES

CLIENT: BHP PETROLEUM
DATE: JUNE 1993

SAMPLE TYPE: SWC

(Total No. of Readings=26) 0.53 0.53 0.57 0.58 0.58 0.60 0.60 0.60 0.60 0.61 0.61 0.61 0.62 0.62 0.62 0.64 0.64 0.64 0.65 0.66 0.66 0.69 0.69 0.70 0.70 0.71

————— VITRINITE REFLECTANCE —————   ——— MACERAL IDENTIFICATION ———

POPULATION Number	%	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1	100.0	26	0.63	0.53	0.71	0.05	INDIGENOUS(+)	55.40	27.40	17.20	0.00
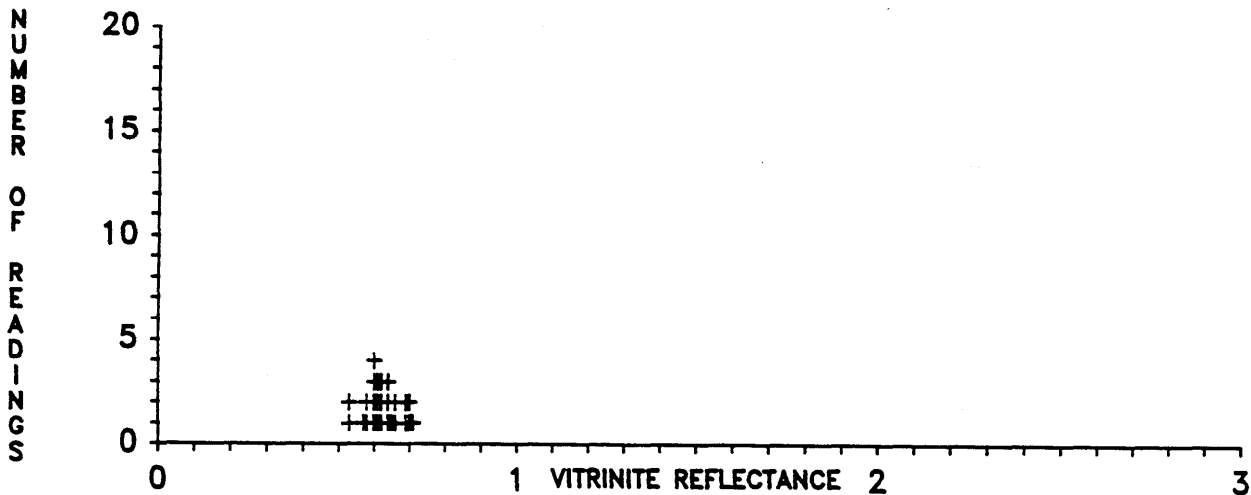
SAMPLE ID: 2157.5 METRES   SAMPLE TYPE: SWC

(Total No. of Readings=27) 0.57 0.58 0.58 0.59 0.59 0.59 0.60 0.61 0.61 0.61 0.62 0.62 0.63 0.63 0.63 0.63 0.63 0.63 0.63 0.64 0.64 0.64 0.65 0.65 0.65 0.66 0.71

————— VITRINITE REFLECTANCE —————   ——— MACERAL IDENTIFICATION ———

POPULATION Number	%	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments	% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1	100.0	27	0.62	0.57	0.71	0.03	INDIGENOUS(+)	50.50	37.90	11.60	0.00

GEOTECH

FIGURE 9 (cont'd)

VITRINITE REFLECTANCE AND COAL MACERAL INDENTIFICATION
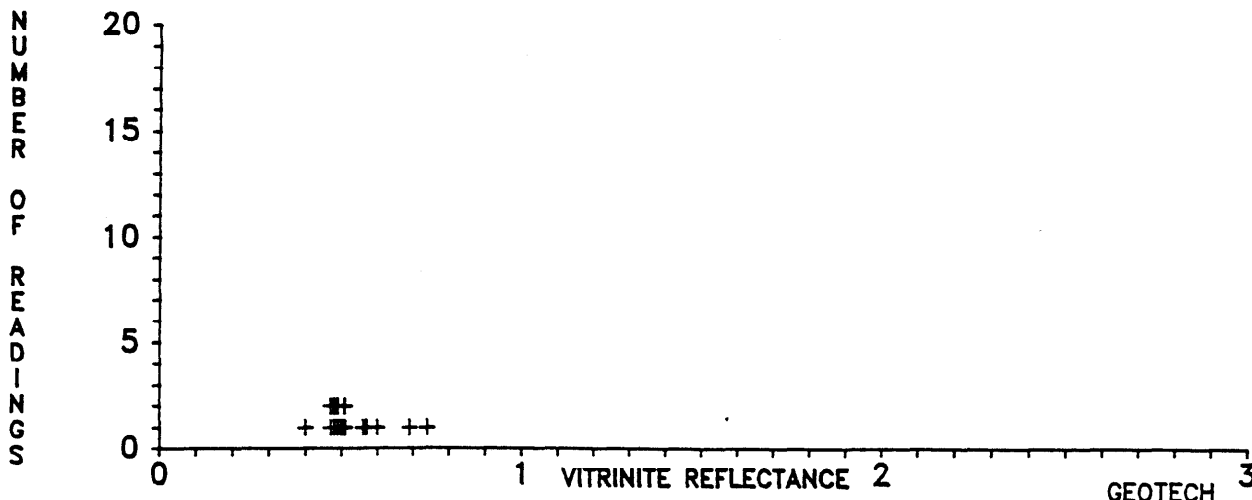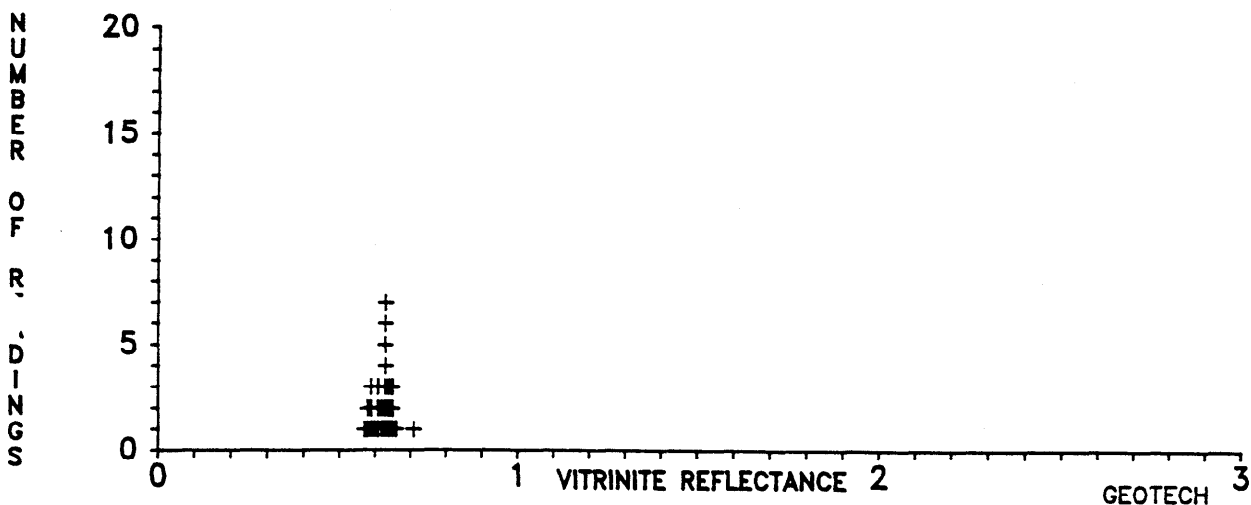
WELL: MINERVA-1   CLIENT: BHP PETROLEUM   SAMPLE TYPE: SWC
SAMPLE ID: 2215.0 METRES   DATE: JUNE 1993

(Total No. of Readings=10)   0.57 0.67 1.38 1.49 1.60 1.71 1.82 1.82 1.88 1.90

——— VITRINITE REFLECTANCE ———								**— MACERAL IDENTIFICATION —**			
POPULATION Number %	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments		% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1 20.0	2	0.62	0.57	0.67	0.08	INDIGENOUS(+)		33.30	33.40	33.30	0.00
2 80.0	8	1.70	1.38	1.90	0.19	INERTINITE(X)					
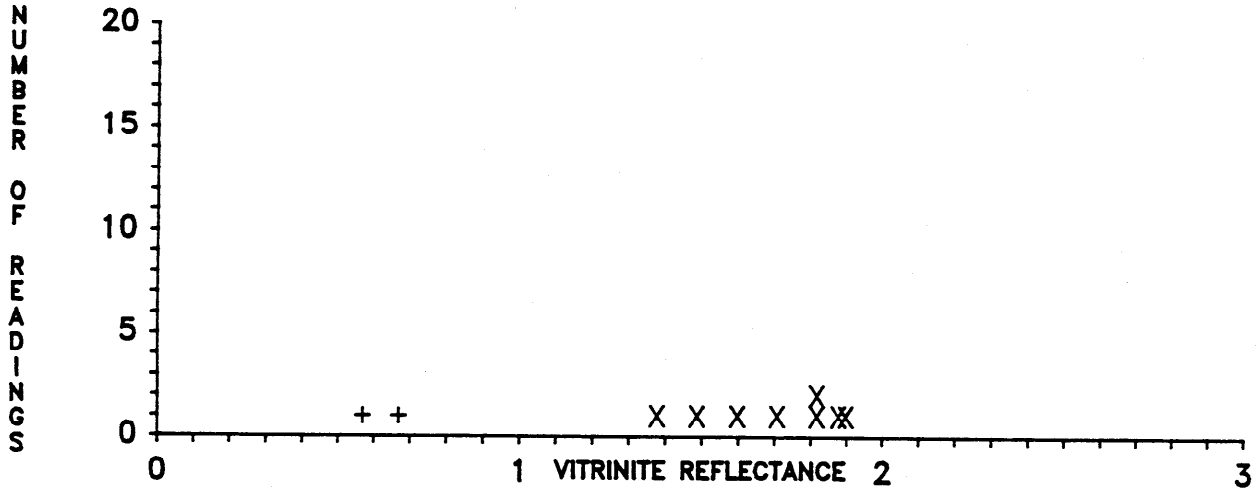
SAMPLE ID: 2392.5 METRES   SAMPLE TYPE: SWC

(Total No. of Readings=9)   0.60 0.62 0.66 0.70 0.76 0.78 0.84 0.86 0.94

——— VITRINITE REFLECTANCE ———								**— MACERAL IDENTIFICATION —**			
POPULATION Number %	No. of Readings	Mean Ro (%)	Min Ro (%)	Max Ro (%)	STD Dev (%)	Comments		% Vitrinite	% Inertinite	% Liptinite	% Bitumen
1 100.0	9	0.75	0.60	0.94	0.11	INDIGENOUS(+)		3.20	80.60	12.90	3.30

GEOTECH
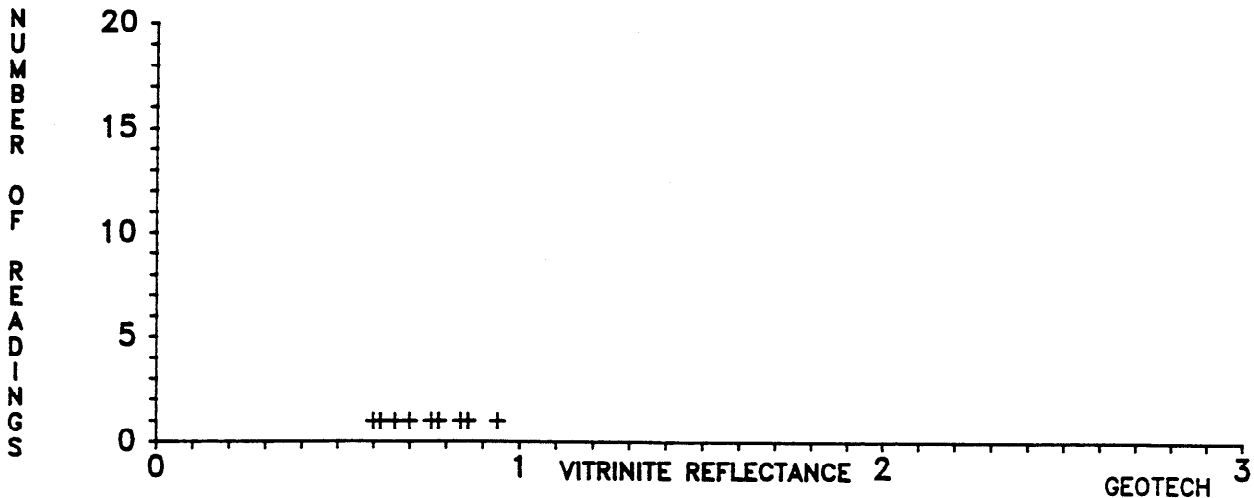
MINERVA-1
Vitrinite Reflectance vs Depth
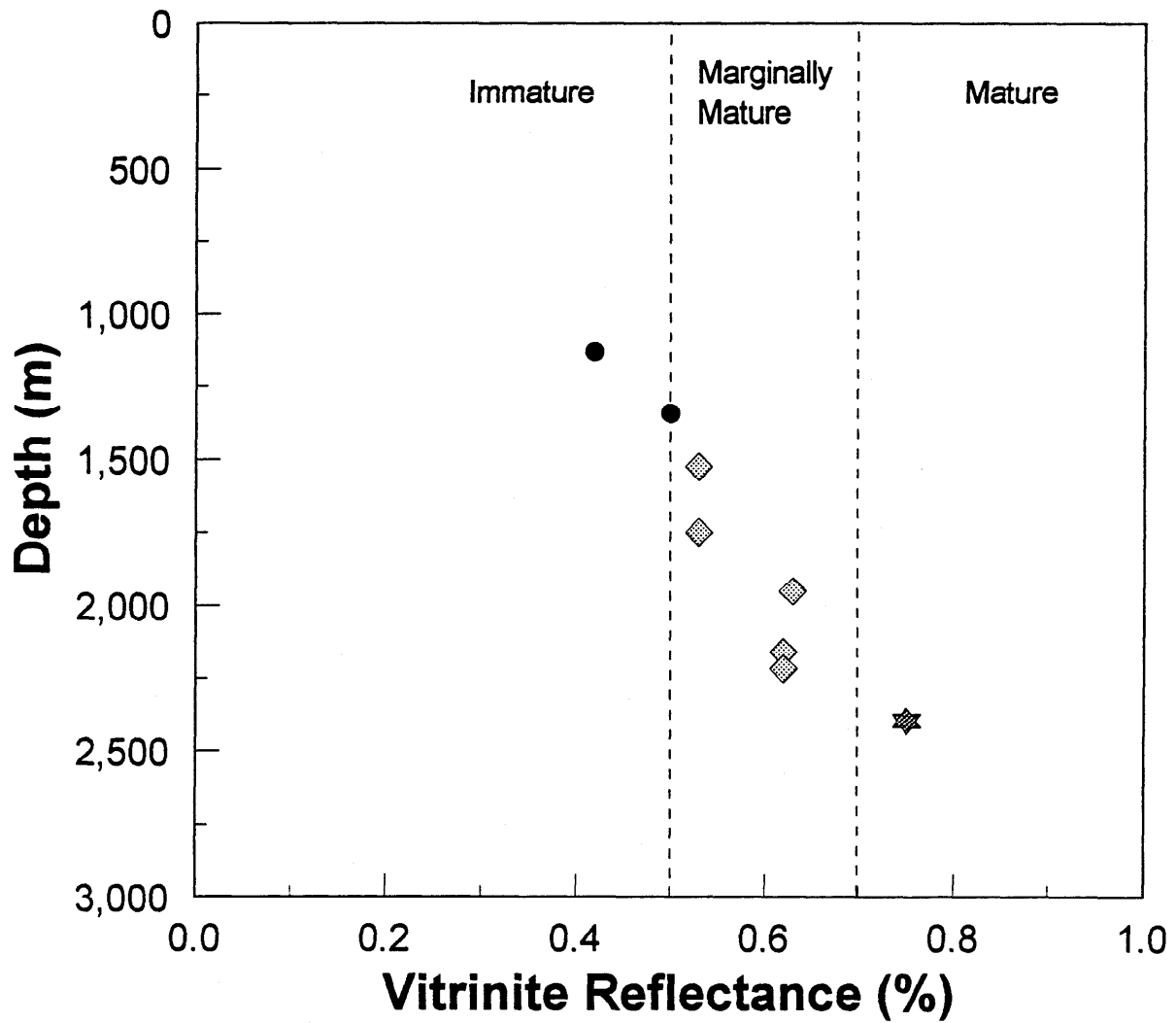
Figure 10

TABLE 4

SUMMARY OF WHOLE OIL ANALYSIS

==============================

WELL = MINERVA-1	DEPTH 1 = 1942.50	DEPTH UNIT = Metres
COUNTRY = Australia	DEPTH 2 = 1942.50	DATE OF JOB = Jan 94
BASIN = Otway		

DESCRIPTION : COLD-TRAPPED COND

COMPOSITION BY CARBON NUMBER

Data Type = ALL CMPDS

Carbon Number	Rel. Wt %
1 - 3	-
4	0.28
5	3.12
6	20.06
7	32.44
8	18.26
9	8.47
10	7.34
11	3.50
12	2.42
13	1.73
14	0.81
15	0.29
16	0.29
17	0.14
18	0.12
19	0.13
20	0.10
21	0.04
22	0.05
23	-
24	0.03
25	0.33
26	0.01
27	-
28	0.01
29	0.01
30	-
31	-
32	-
33	-

COMPOSITION OF C4-C8 FRACTION

Compound	Rel. Wt %
isobutane (A)	0.02
n-butane (B)	0.26
isopentane (C)	0.99
n-pentane (D)	1.65
2,2-dimethylbutane (E)	0.18
cyclopentane (F)	0.47
2,3-dimethylbutane (G)	0.34
2-methylpentane (H)	1.89
3-methylpentane (I)	1.24
n-hexane (J)	3.29
methylcyclopentane (K)	3.63
2,4-dimethylpentane (L)	0.35
benzene (M)	2.26
cyclohexane (N)	7.24
1,1-dimethylcyclopentane (O)	0.58
2-methylhexane (P)	1.56
3-methylhexane (Q)	2.37
1 cis-3-dimethylcyclopentane (R)	0.69
1 trans-3-dimethylcyclopentane (S)	1.33
1 trans-2-dimethylcyclopentane (T)	0.14
n-heptane (U)	4.87
methylcyclohexane (V)	13.77
1 cis-2-dimethylcyclopentane (W)	0.30
n-toluene (X)	6.48
n-octane (Y)	5.03
ethylbenzene (Z)	1.13
M+P-xylene (AA)	3.08
O_xylene (BB)	0.84

CALCULATED DATA - C12+ FRACTION

Pristane/Phytane	-
Pristane/n-C17	-
Phytane/n-C18	-
TMTD/Pristane	-
(C21+C22)/(C28+C29)	4.32

CALCULATED DATA - C4-C8 FRACTION

Paraffin Index I	1.82
Paraffin Index II	14.96
N/K (Maturity)	2.00
C/D (Maturity)	0.60
J/K (Maturity)	0.91
I/M (Water Washing)	0.55
I/J (Biodegradation)	0.38

TMTD = Trimethyltridecane
- = Below detection limit
or not measured

Paraffin Index I = (P+Q) / (R+S+T)
Paraffin Index II = %U in all compounds
N to V and including
2,2-DiMeC6 and 2,3-DiMeC5

FIGURE 11

MINERVA 1, 1942.5m Condensate
Whole Oil
C1-C33 GLC
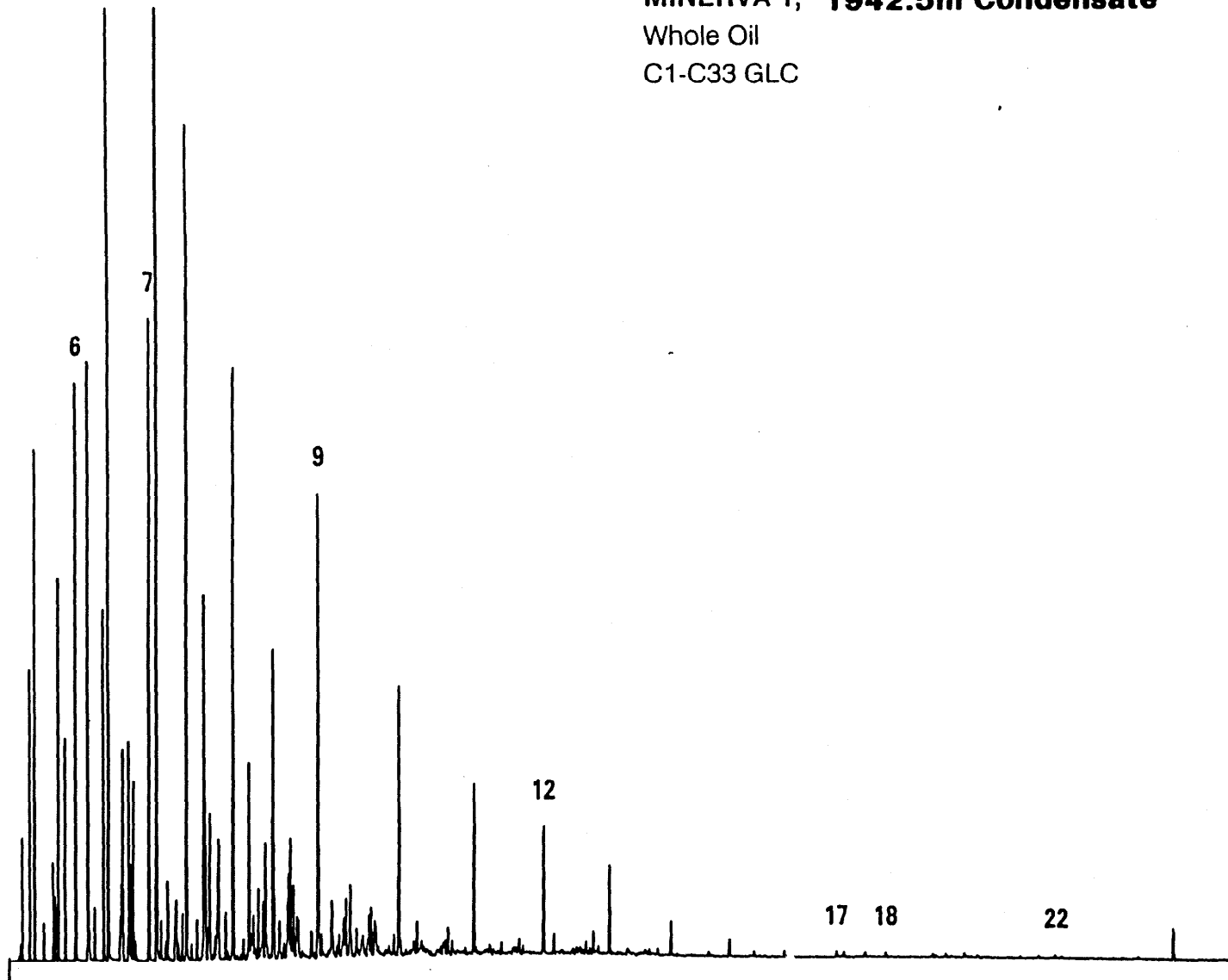
2030W01

FIGURE 12

MINERVA 1, 1942.5m Condensate

Gasoline Range Whole Oil
C1-C8 GLC

C4-C8 Compounds
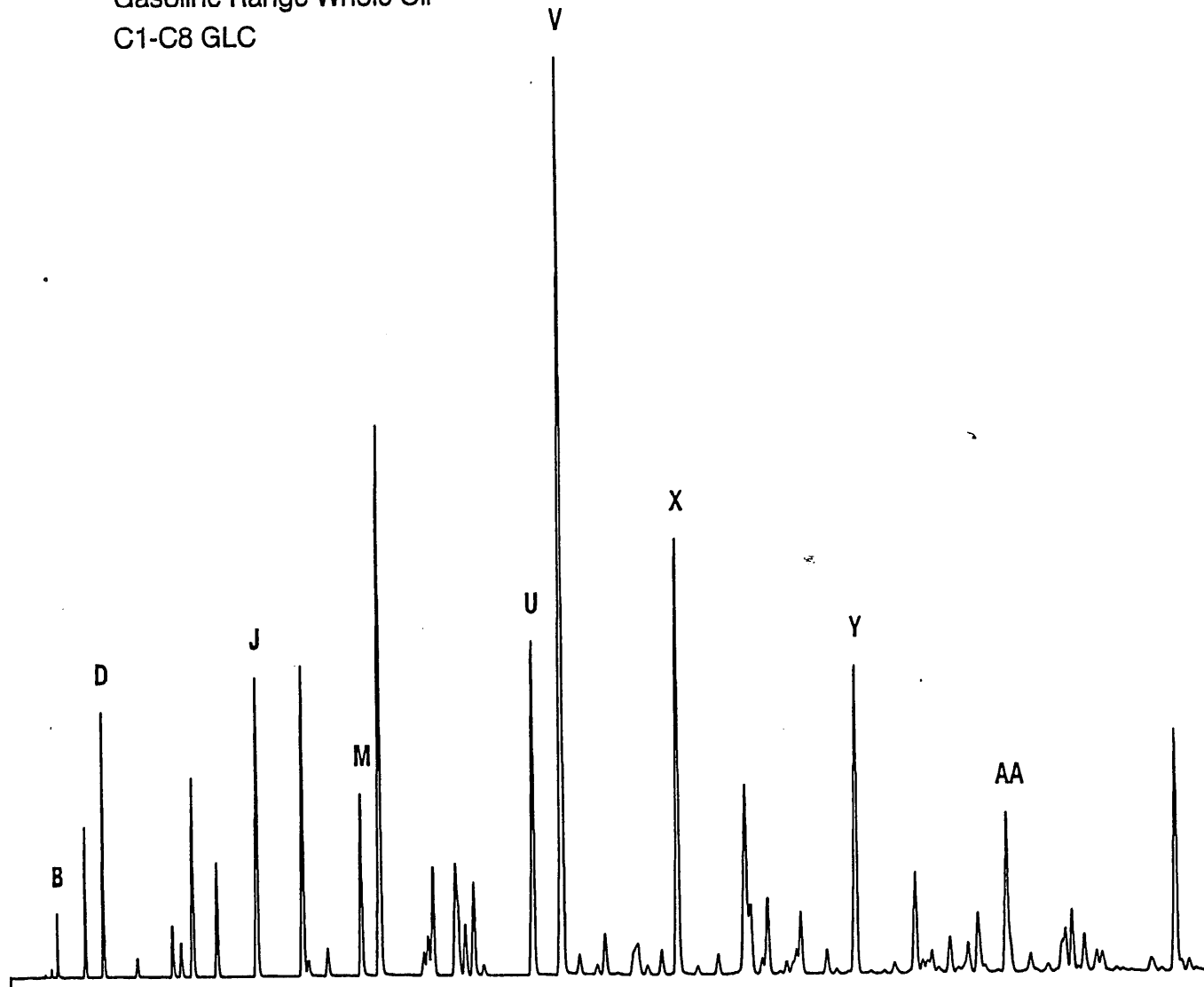
A	isobutane
B	n-butane
C	isopentane
D	n-pentane
E	2,2-dimethylbutane
F	cyclopentane
G	2,3-dimethylbutane
H	2-methylpentane
I	3-methylpentane
J	n-hexane
K	methylcyclopentane
L	2,4-dimethylpentane
M	benzene
N	cyclohexane
O	1,1-dimethylcyclopentane
P	2-methylhexane
Q	3-methylhexane
R	1 cis-3-dimethylcyclopentane
S	1 trans-3-dimethylcyclopentane
T	1 trans-2-dimethylcyclopentane
U	n-heptane
V	methylcyclohexane
W	1 cis-2-dimethylcyclopentane
X	toluene
Y	n-octane
Z	ethylbenzene
AA	M + P-xylene
BB	O-xylene

FIGURE 12

MINV1 / PE900058 / P183

2030W0I

GEOTECHNICAL SERVICES PTY LTD

MINERVA-1
Whole Oil GC Data: 1942.5m Condensate
Normalised Compound Abundances

Figure 13

MINERVA-1
Whole Oil GC Data: 1942.5m Condensate
Paraffin Index I vs Paraffin Index II

Figure 14

MINERVA 1, RFT, **1649.8m Water–Extract**
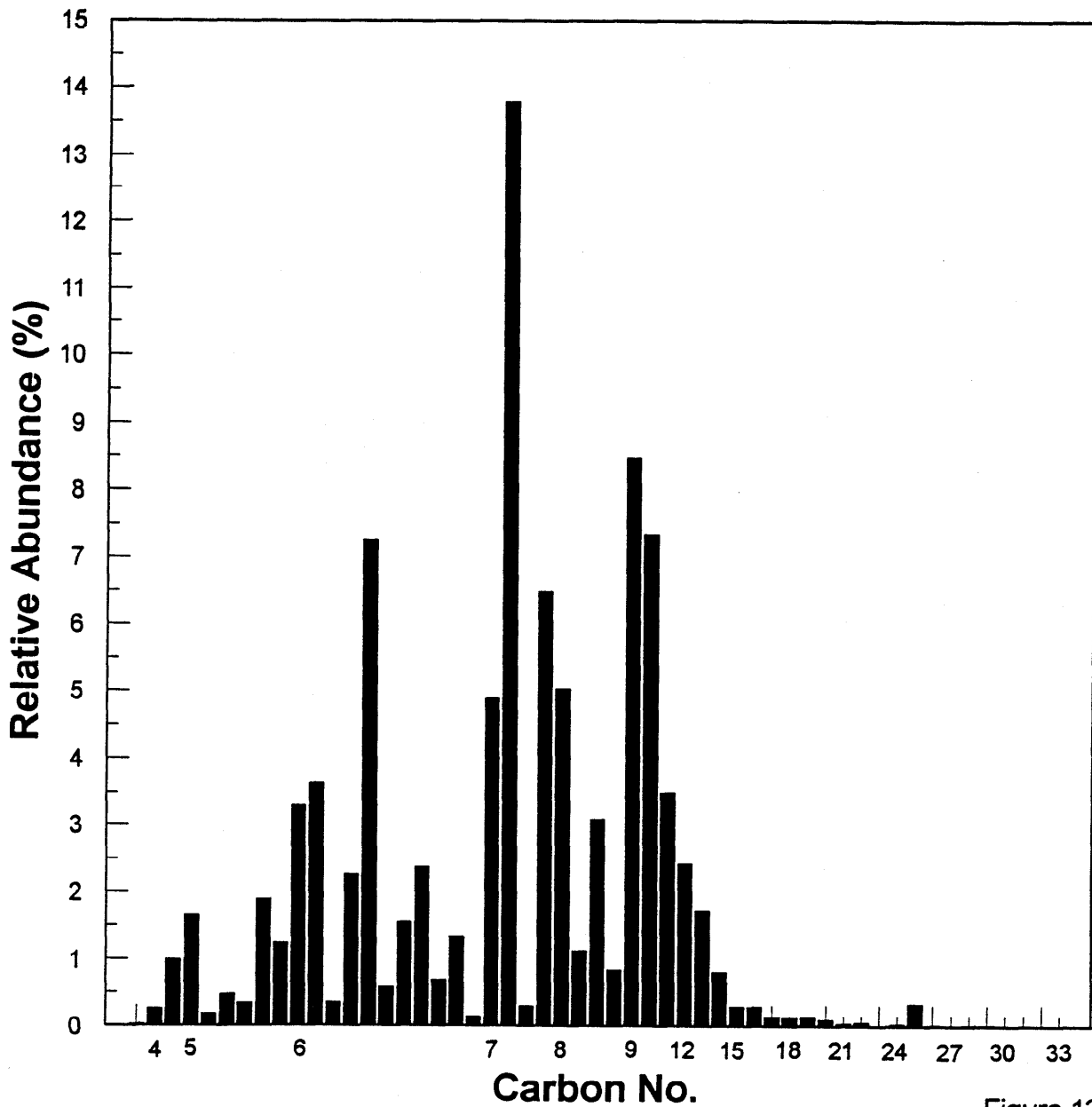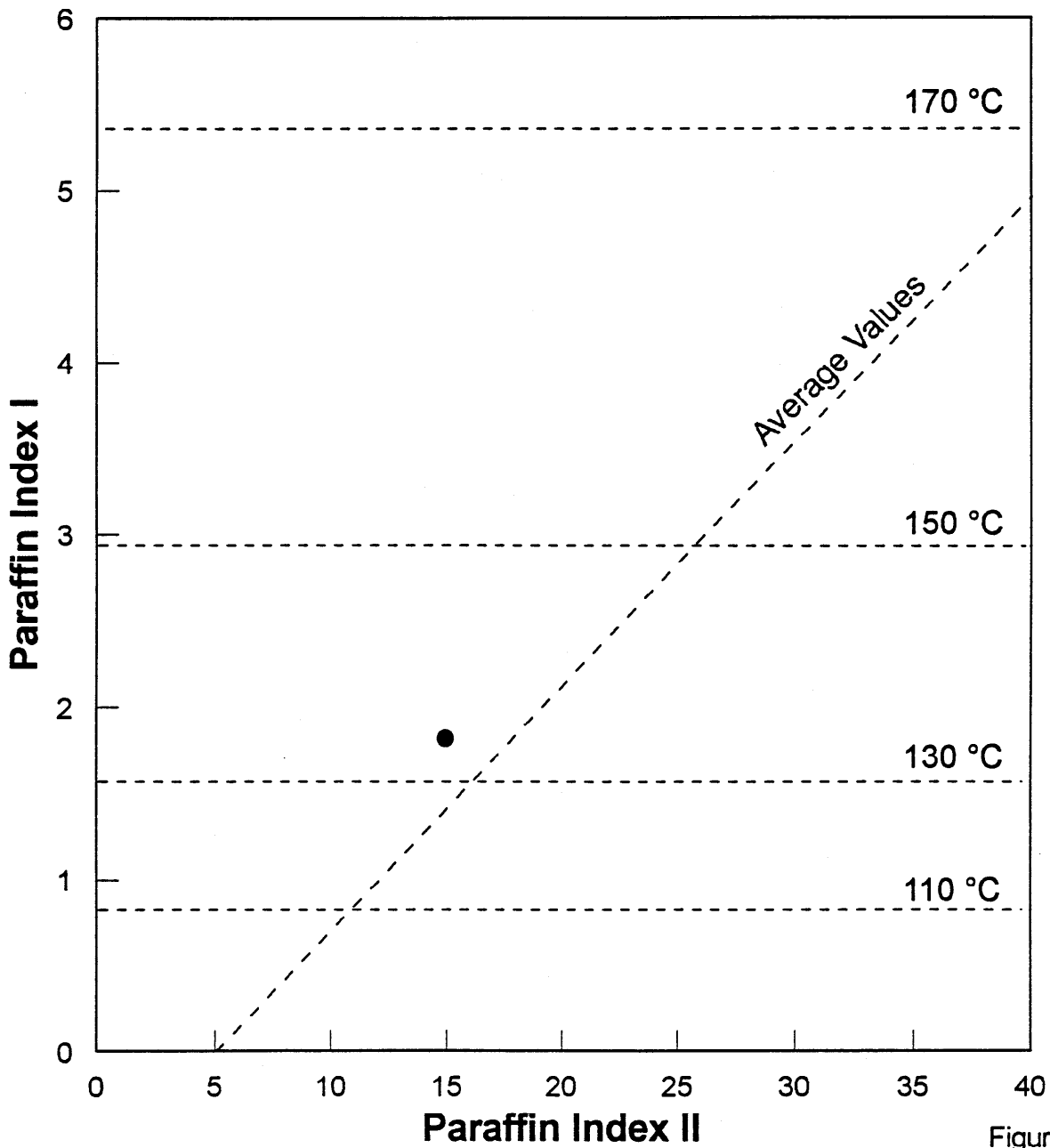Saturate Fraction
C12+ GLC

12

17 Pr

18

Ph
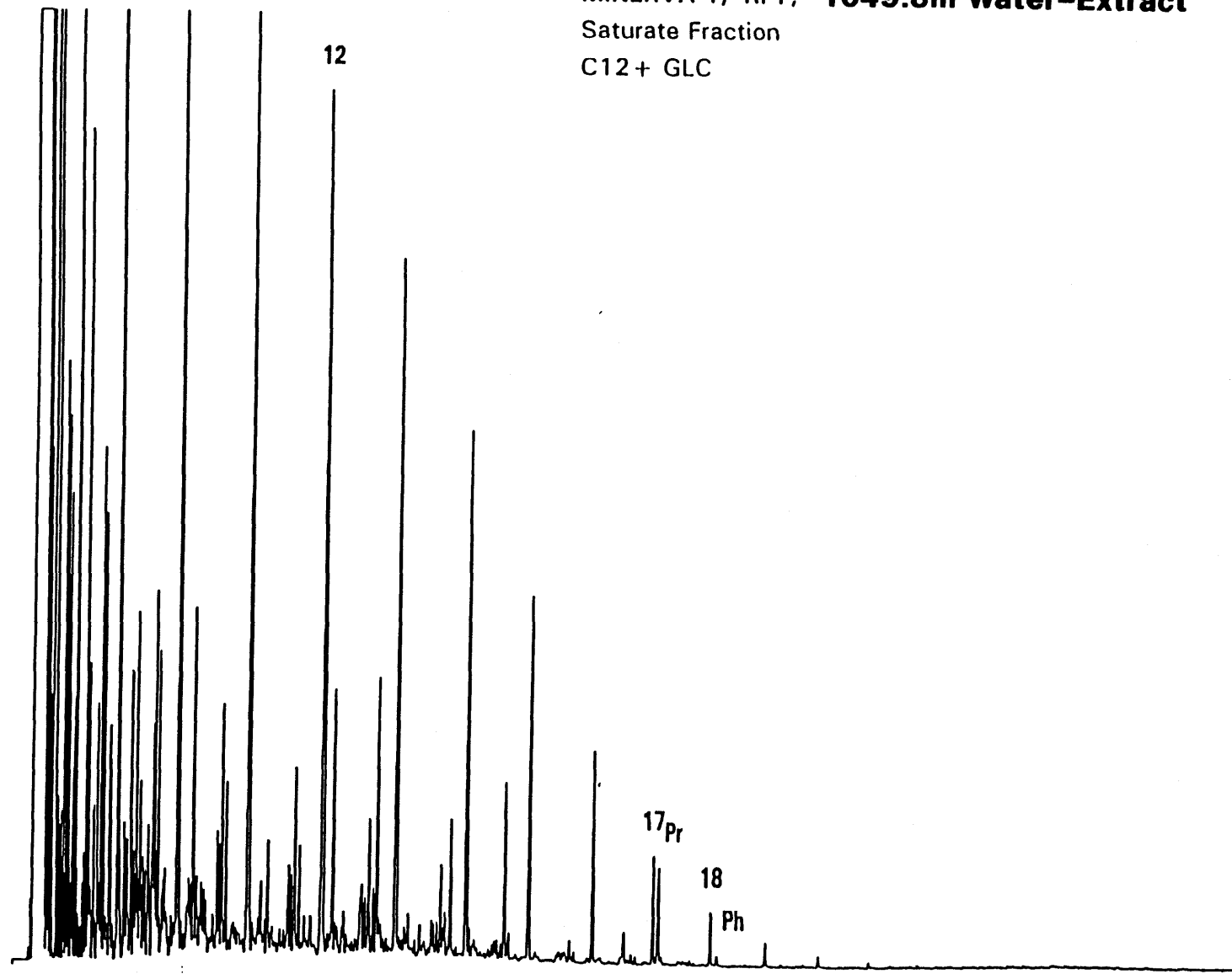
FIG. RE 15

MINERVA 1, 1942.5m Condensate

Saturate Fraction

C12+ GLC

12
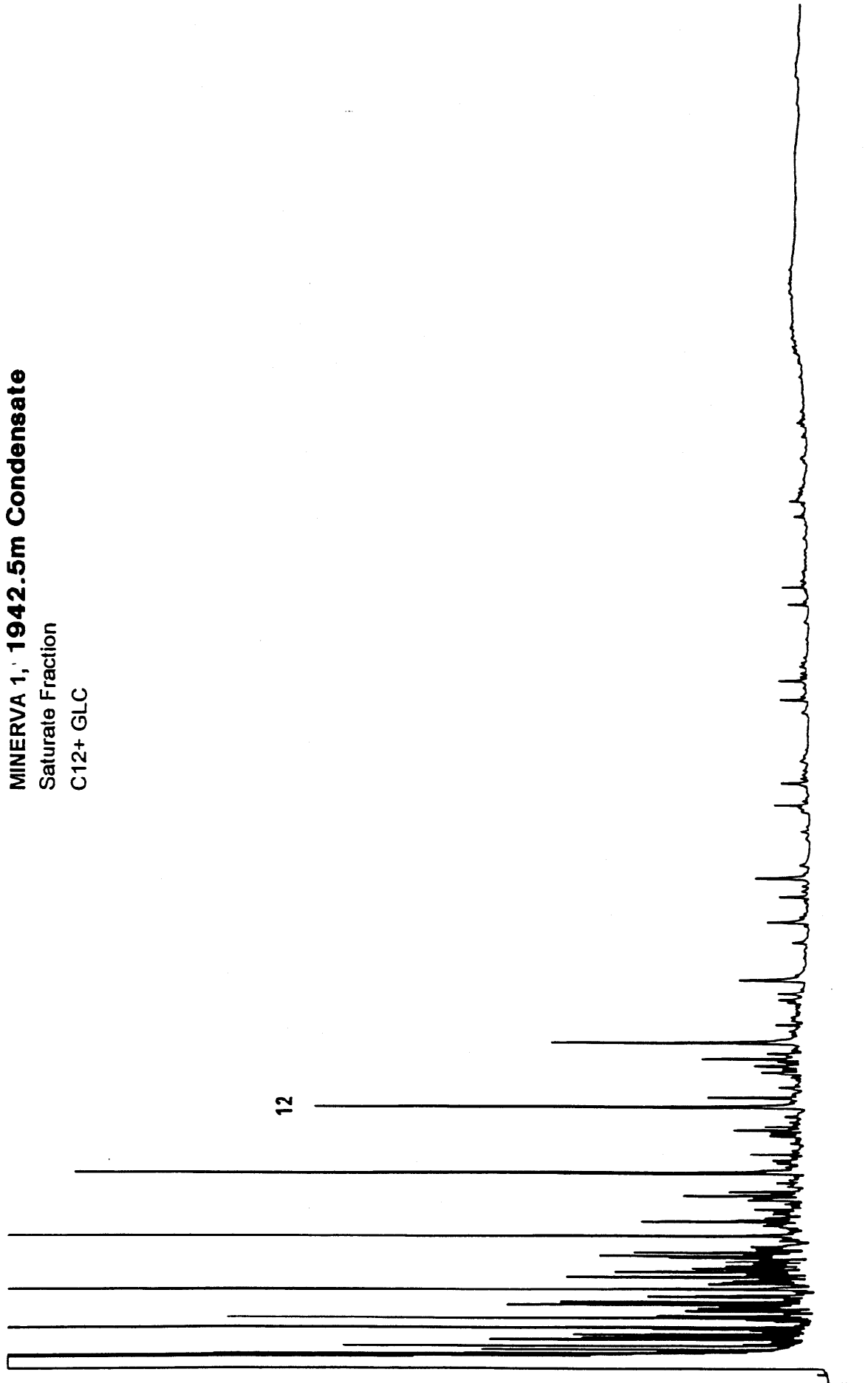
FIGURE 16

TABLE 5

SUMMARY OF GAS CHROMATOGRAPHY DATA - CONDENSATES
ALKANE DISTRIBUTIONS

WELL NAME = MINERVA-1
COUNTRY = Australia
BASIN = Otway

DEPTH UNIT = Metres
DATE OF JOB = Jan-Mar 94

DEPTH 1	DEPTH 2	nC12	nC13	nC14	TMTD	nC15	nC16	iC18	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31	nC32	nC33
1649.80	1649.80	33.5	24.5	16.5	.6	10.2	5.7	.2	2.9	3.1	1.4	.3	.7	.3	.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1942.50	1942.50	48.8	30.4	11.8	-	6.7	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

i = iso   n = normal   N.B. Values are relative %
- = no data   TMTD = Trimethyltridecane

MINERVA-1: Condensates
GC (Sats): Normalised Compound Abundances
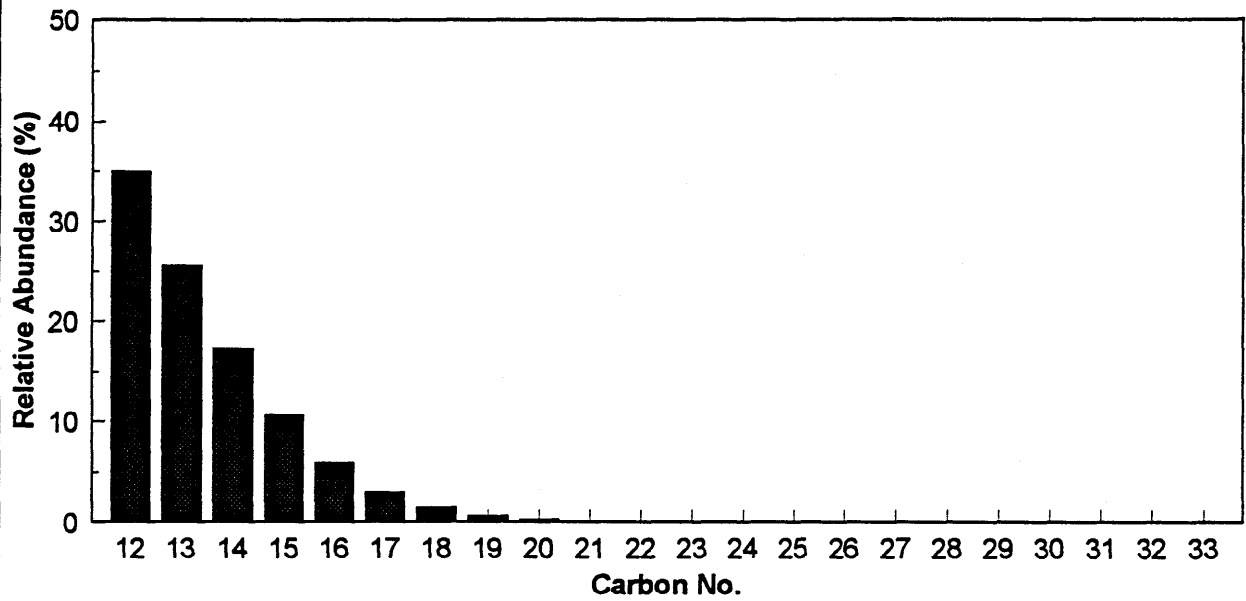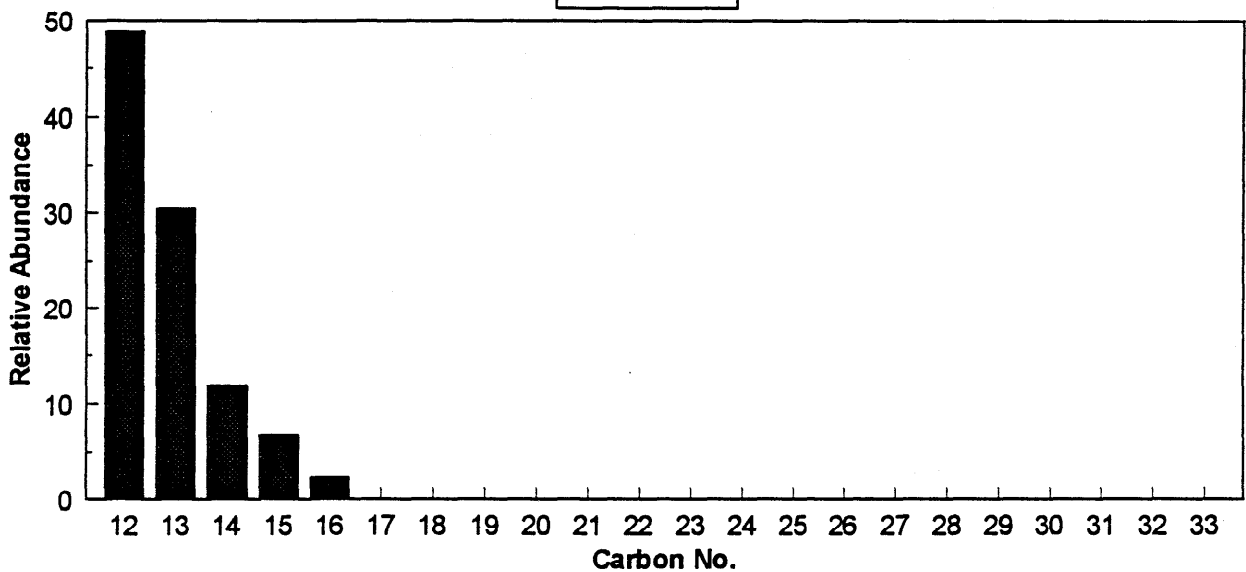
Figure 17

MINERVA-1: Condensates
GC (Sats) Normalised Relative Abundances
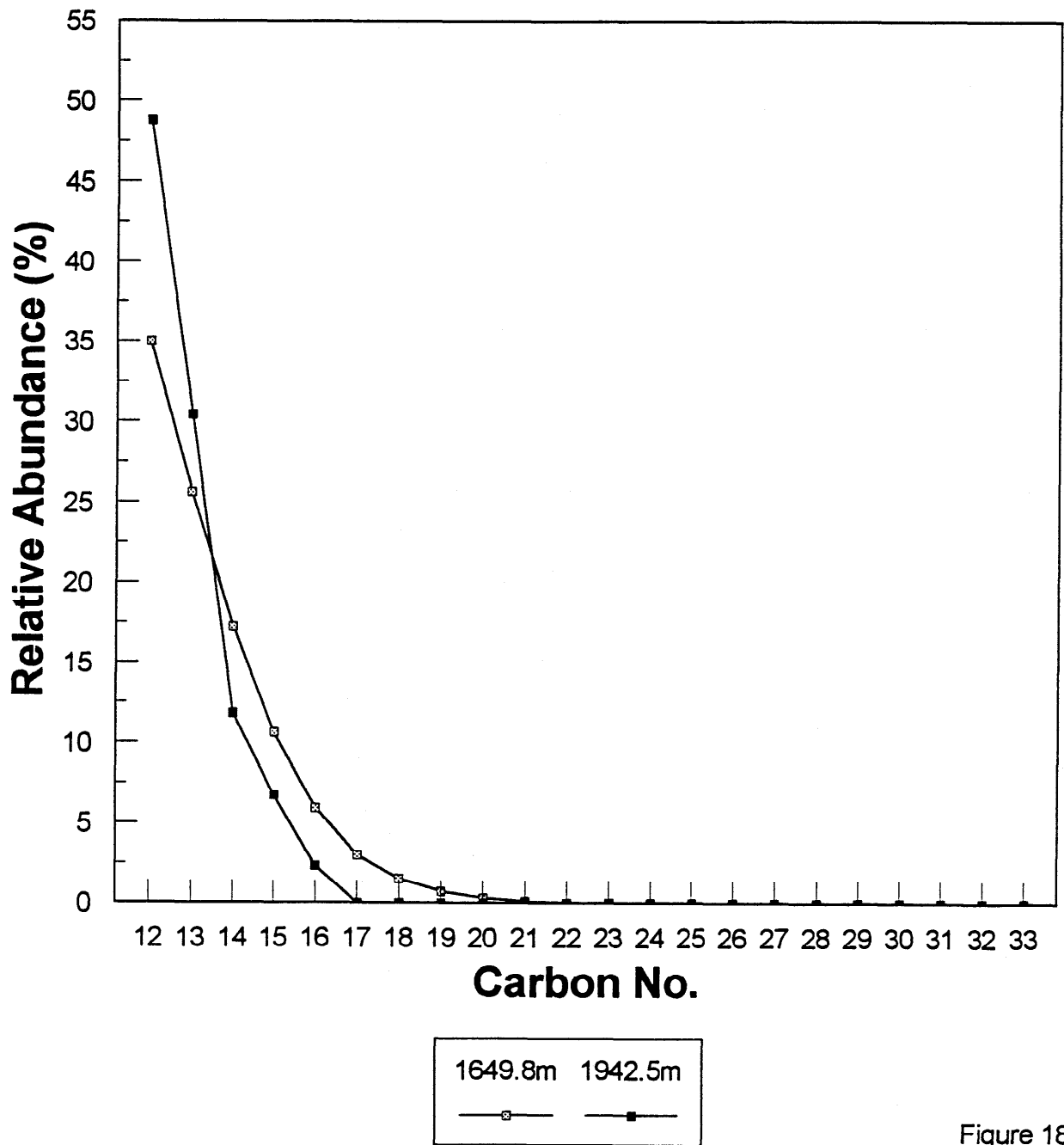
Figure 18

TABLE 6

SUMMARY OF GAS CHROMATOGRAPHY DATA - CONDENSATES
ALKANE COMPOSITIONAL DATA
===

WELL NAME = MINERVA-1
COUNTRY   = Australia
BASIN   = Otway

DEPTH UNIT   = Metres
DATE OF JOB = Jan-Mar 94

DEPTH 1	DEPTH 2	ANALYSIS TYPE	PRISTANE/PHYTANE	PRISTANE/n-C17	PHYTANE/n-C18	TMTD/PRISTANE	CPI(I)	CPI(II)	(C21+C22)/(C28+C29)
1649.80	1649.80	SF	9.03	1.09	0.25	0.19	-	-	-
1942.50	1942.50	SF	-	-	-	-	-	-	-

CPI = Carbon preference index   TMTD = Trimethyltridecane   - = no data
SF = Saturate fraction   WE   = Whole extract

MINERVA-1: 1649.8m Water-Extract Pristane/n-C17 vs Phytane/n-C18
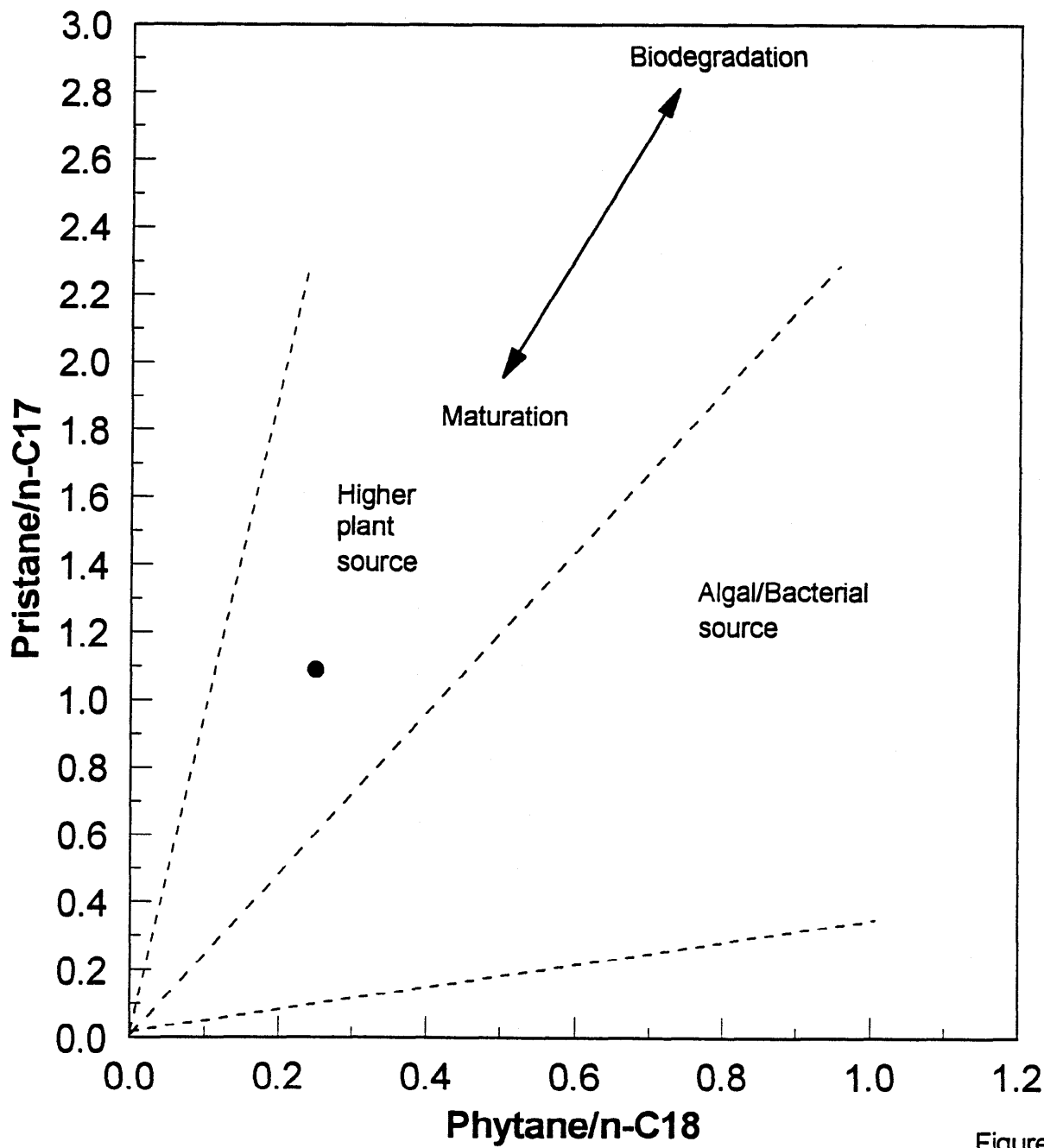
Figure 19

m/z 217 and m/z 191 BIOMARKER TRACES: 1649.8m Water−Extract

FIGURE 20

m/z 217 and m/z 191 BIOMARKER TRACES: 1942.5m Condensate

FIGURE 21

TABLE 7-1

SATURATE FRACTION SIR GC/MS DATA - WATER-EXTRACT

WELL = MINERVA-1	DETAILED COMPOUND ANALYSIS	DEPTH UNIT = Metres
COUNTRY = Australia	DESCRIPTION : COLD-TRAPPED COND	DATE OF JOB = Jan-Mar 94
BASIN = Otway	DEPTH 1 = 1649.80 DEPTH 2 = 1649.80	

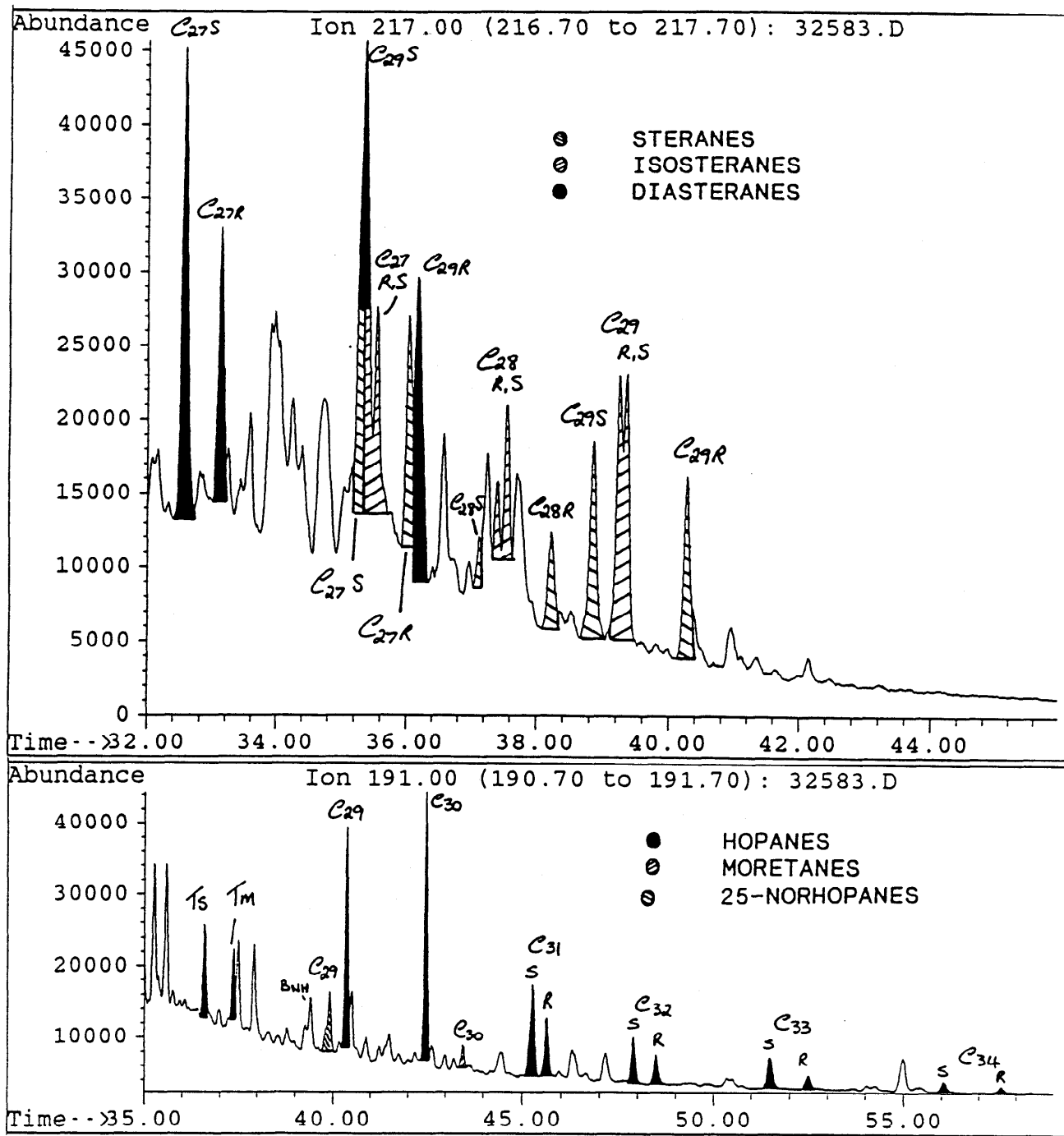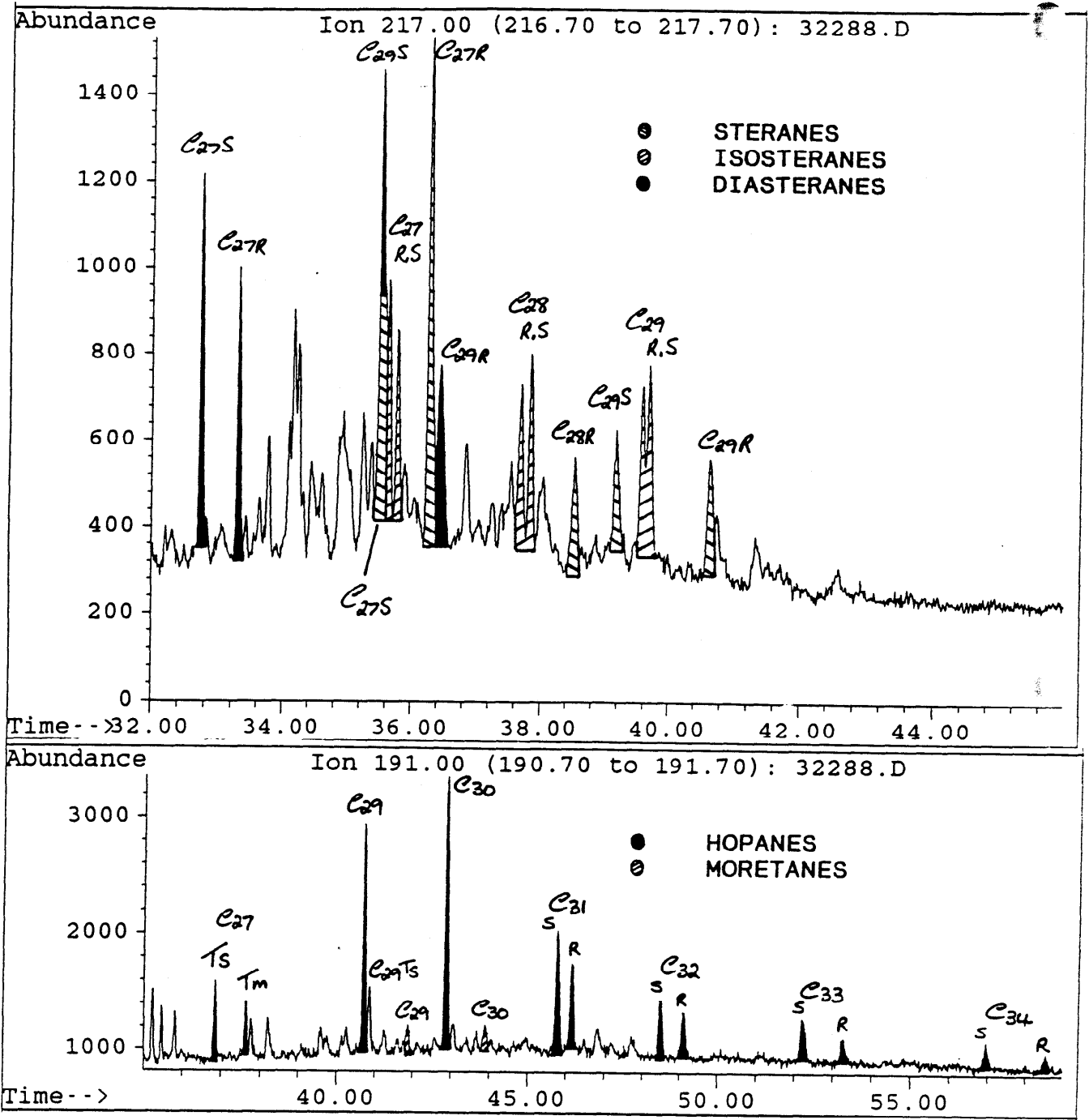| COMPOUND	ION	RELATIVE AMOUNT	COMPOUND	ION	RELATIVE AMOUNT
C23 Tricyclic	191	1800.0	C24 Tricyclic	191	1224.0
C25 Tricyclic	191	753.0	C26 Tricyclic	191	900.0
C28 Tricyclic	191	1001.0	C29 Tricyclic	191	851.0
C24 Tetracyclic	191	883.0			
C27 Hopane (Ts)	191	12796.0	C27 Hopane (Tm)	191	8083.0
C27 Hopane (17B)	191	-			
C28 Hopane (25,30)	191	-	C28 Hopane (28,30)	191	7312.0
C29 Hopane	191	30252.0	C29 Moretane	191	-
C29 Demeth. Hopane	191	8666.0	C29 Hopane (BB)	191	-
C30 Hopane	191	37026.0	C30 Moretane	191	3111.0
C30 Hopane (BB)	191	-			
C31S Hopane	191	13074.0	C31R Hopane	191	8435.0
C31S+R Hopane (BB)	191	-	C31S+R Moretane	191	-
C32S Hopane	191	6639.0	C32R Hopane	191	4388.0
C32S+R Hopane (BB)	191	-	C32S+R Moretane	191	-
C33S Hopane	191	-	C33R Hopane	191	-
Gammacerane	191	-	Oleanane (18a)	191	-
Unknown 1	191	-	Unknown 2	191	-
Unknown 3	191	9266.0	Unknown 4	191	-
C27 Demeth. Hopane	177	-	C28 Demeth. Hopane	177	-
C29 Hopane	177	-	C29 Demeth. Hopane	177	-
C29 Moretane	177	-	C29 Hopane (BB)	177	-
Unknown 3	177	-			
C30 2-Methylhopane	205	-	C31 2-Methylhopane	205	-
C31S Hopane	205	-	C31R Hopane	205	-
C31S+R Moretane	205	-	C31S+R Hopane (BB)	205	-
C21 Sterane	217	-	C22 Sterane	217	-
C27S Normal Sterane	217	-	C27R Normal Sterane	217	15990.0
C27S Isosterane	217	-	C27R Isosterane	217	-
C27S Diasterane	217	-	C27R Diasterane	217	-
C28S Normal Sterane	217	3414.0	C28R Normal Sterane	217	6040.0
C28S Isosterane	217	-	C28R Isosterane	217	-
C28S Diasterane	217	-	C28R Diasterane	217	-
C29S Normal Sterane	217	13448.0	C29R Normal Sterane	217	12871.0
C29S Isosterane	217	18468.0	C29R Isosterane	217	16934.0
C29S Diasterane	217	28947.0	C29R Diasterane	217	20737.0
C27S+R Isosterane	218	51483.0	C28S+R Isosterane	218	23661.0
C29S+R Isosterane	218	57201.0			
C27S Diasterane	259	14133.0	C27R Diasterane	259	9629.0
C28S Diasterane	259	13072.0	C28R Diasterane	259	9524.0
C29S Diasterane	259	13907.0	C29R Diasterane	259	10382.0
16a Phyllocladane	123	-	16B Phyllocladane	123	-
Beyerene	123	-	Labdane	123	-
Fichtelite	123	-	Rimuane	123	-
Nortetracyclane	123	-	Pimerane	123	-
Isopimerane	123	-	Kaurane	123	-
Norisopimerane	123	-	Unknown 1	123	-
Drimane	123	7588.0	Homodrimane	123	4500.0
Rearranged Drimane 1	123	12882.0	Rearranged Drimane 2	123	5880.0
Eudesmane	123	-			
C15 Alkylcyclohexane	83	-	C17 Alkylcyclohexane	83	-
C21 Alkylcyclohexane	83	-	C22 Alkylcyclohexane	83	-
C25 Alkylcyclohexane	83	-	C29 Alkylcyclohexane	83	-

- = no data   IUPAC names corresponding to common names used here are shown at the end of the tables

TABLE 7-2

SATURATE FRACTION SIR GC/MS DATA - WATER EXTRACT

CALCULATED DATA

DESCRIPTION : COLD-TRAPPED COND

WELL   = MINERVA-1   DEPTH 1(m) = 1649.80   DEPTH UNIT = Metres
COUNTRY = Australia   DEPTH 2(m) = 1649.80   DATE OF JOB = Jan-Mar 94
BASIN   = Otway

------ TERPANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% Ts / (Ts + Tm)	191	61.29
% C29 M / (C29 H + C29 M)	191	-
% C30 M / (C30 H + C30 M)	191	7.75
% C31S H / (C31S H + C31R H)	191	60.78
% C31S H / (C31S H + C31R H)	205	-
% C32S H / (C32S H + C32R H)	191	60.21
% U1-U4 / (U1-U4 + C30 H)	191	-
% U1 / (U1 + C30 H)	191	-
% U2 / (U2 + C30 H)	191	-
% U3 / (U3 + C30 H)	191	20.02
% U4 / (U4 + C30 H)	191	-
% C29 H / (C29 H + C30 H)	191	44.97
% C31 2-MeH / (C31 2-MeH + C30 H)	191, 205	-
% C29 BB / (C29 BB + C 29H + C29 M)	191	-
% C29 DeMe / (C29 DeMe + C29H)	177	-
% C28 H's / (C28 H's + C30 H)	191	-
% (Ts + Tm + C28 H's) / C29(H + M) + C30(H + M)	191	-
% Oleanane (18a) / (Oleanane + C30H)	191	-
% Drimane / Homodrimane	123	168.62
% Rea. Drimanes / (Drimane + Homodrimane)	123	155.21
% C22 Alkycyclohex. / C30 H	83, 191	-
% C29 Alkycyclohex. / C30 H	83, 191	-
% C23-C29 Tricyclics / C30 H	191	17.63
% (C30 H + C30 M) / (C29(NS's + IS's + DS's)	191, 217	36.03

------ STERANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% C27 ST's / (C27 + C28 + C29) ST's	217	-
% C28 ST's / (C27 + C28 + C29) ST's	217	-
% C29 ST's / (C27 + C28 + C29) ST's	217	-
% C27S NS / (C27S NS + C27R NS)	217	-
% C28S NS / (C28S NS + C28R NS)	217	36.11
% C29S NS / (C29S NS + C29R NS)	217	51.10
% C27 NS's / C29 NS's	217	-
% C27 IS's / C29 IS's	217	-
% C27 DS's / C29 DS's	217	-
% C27 DS's / C27 ST's	217	-
% C28 DS's / C28 ST's	217	-
% C29 DS's / C29 ST's	217	44.60
% C27 IS's / (C27 IS's + C27 NS's)	217	-
% C28 IS's / (C28 IS's + C28 NS's)	217	-
% C29 IS's / (C29 IS's + C29 NS's)	217	57.36

NOTES : H = Hopane   M = Moretane   Me = Methyl   NS = Normal Sterane
         IS = Iso Sterane DS = Dia Sterane ST = NS + IS + DS U = Unknown
         - = no data available

TABLE 8-1

SATURATE FRACTION SIR GC/MS DATA - CONDENSATE

WELL = MINERVA-1   DETAILED COMPOUND ANALYSIS   DEPTH UNIT = Metres
COUNTRY = Australia   DESCRIPTION : COLD-TRAPPED COND   DATE OF JOB = Jan-Mar 94

BASIN = Otway   DEPTH 1 = 1942.50   DEPTH 2 = 1942.50

COMPOUND	ION	RELATIVE AMOUNT	COMPOUND	ION	RELATIVE AMOUNT
C23 Tricyclic	191	-	C24 Tricyclic	191	-
C25 Tricyclic	191	-	C26 Tricyclic	191	-
C28 Tricyclic	191	-	C29 Tricyclic	191	-
C24 Tetracyclic	191	-			
C27 Hopane (Ts)	191	-	C27 Hopane (Tm)	191	-
C27 Hopane (17B)	191	-			
C28 Hopane (25,30)	191	-	C28 Hopane (28,30)	191	-
C29 Hopane	191	-	C29 Moretane	191	-
C29 Demeth. Hopane	191	-	C29 Hopane (BB)	191	-
C30 Hopane	191	-	C30 Moretane	191	-
C30 Hopane (BB)	191	-			
C31S Hopane	191	-	C31R Hopane	191	-
C31S+R Hopane (BB)	191	-	C31S+R Moretane	191	-
C32S Hopane	191	-	C32R Hopane	191	-
C32S+R Hopane (BB)	191	-	C32S+R Moretane	191	-
C33S Hopane	191	-	C33R Hopane	191	-
Gammacerane	191	-	Oleanane (18a)	191	-
Unknown 1	191	-	Unknown 2	191	-
Unknown 3	191	-	Unknown 4	191	-
C27 Demeth. Hopane	177	-	C28 Demeth. Hopane	177	-
C29 Hopane	177	-	C29 Demeth. Hopane	177	-
C29 Moretane	177	-	C29 Hopane (BB)	177	-
Unknown 3	177	-			
C30 2-Methylhopane	205	-	C31 2-Methylhopane	205	-
C31S Hopane	205	-	C31R Hopane	205	-
C31S+R Moretane	205	-	C31S+R Hopane (BB)	205	-
C21 Sterane	217	-	C22 Sterane	217	-
C27S Normal Sterane	217	-	C27R Normal Sterane	217	-
C27S Isosterane	217	-	C27R Isosterane	217	-
C27S Diasterane	217	-	C27R Diasterane	217	-
C28S Normal Sterane	217	-	C28R Normal Sterane	217	-
C28S Isosterane	217	-	C28R Isosterane	217	-
C28S Diasterane	217	-	C28R Diasterane	217	-
C29S Normal Sterane	217	-	C29R Normal Sterane	217	-
C29S Isosterane	217	-	C29R Isosterane	217	-
C29S Diasterane	217	-	C29R Diasterane	217	-
C27S+R Isosterane	218	-	C28S+R Isosterane	218	-
C29S+R Isosterane	218	-			
C27S Diasterane	259	-	C27R Diasterane	259	-
C28S Diasterane	259	-	C28R Diasterane	259	-
C29S Diasterane	259	-	C29R Diasterane	259	-
16a Phyllocladane	123	-	16B Phyllocladane	123	-
Beyerene	123	-	Labdane	123	-
Fichtelite	123	-	Rimuane	123	-
Nortetracyclane	123	-	Pimerane	123	-
Isopimerane	123	-	Kaurane	123	-
Norisopimerane	123	-	Unknown 1	123	-
Drimane	123	7537.0	Homodrimane	123	3614.6
Rearranged Drimane 1	123	14403.0	Rearranged Drimane 2	123	6942.0
Eudesmane	123	-			
C15 Alkylcyclohexane	83	-	C17 Alkylcyclohexane	83	-
C21 Alkylcyclohexane	83	-	C22 Alkylcyclohexane	83	-
C25 Alkylcyclohexane	83	-	C29 Alkylcyclohexane	83	-

- = no data   IUPAC names corresponding to common names used here are shown at the end of the tables

TABLE 8-2

SATURATE FRACTION SIR GC/MS DATA - CONDENSATE

CALCULATED DATA

DESCRIPTION : COLD-TRAPPED COND

WELL = MINERVA-1	DEPTH 1(m) = 1942.50	DEPTH UNIT = Metres	
COUNTRY = Australia	DEPTH 2(m) = 1942.50	DATE OF JOB = Jan-Mar 94	
BASIN = Otway			

------ TERPANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% Ts / (Ts + Tm)	191	-
% C29 M / (C29 H + C29 M)	191	-
% C30 M / (C30 H + C30 M)	191	-
% C31S H / (C31S H + C31R H)	191	-
% C31S H / (C31S H + C31R H)	205	-
% C32S H / (C32S H + C32R H)	191	-
% U1-U4 / (U1-U4 + C30 H)	191	-
% U1 / (U1 + C30 H)	191	-
% U2 / (U2 + C30 H)	191	-
% U3 / (U3 + C30 H)	191	-
% U4 / (U4 + C30 H)	191	-
% C29 H / (C29 H + C30 H)	191	-
% C31 2-MeH / (C31 2-MeH + C30 H)	191, 205	-
% C29 BB / (C29 BB + C 29H + C29 M)	191	-
% C29 DeMe / (C29 DeMe + C29H)	177	-
% C28 H's / (C28 H's + C30 H)	191	-
% (Ts + Tm + C28 H's) / C29(H + M) + C30(H + M)	191	-
% Oleanane (18a) / (Oleanane + C30H)	191	-
% Drimane / Homodrimane	123	208.51
% Rea. Drimanes / (Drimane + Homodrimane)	123	191.41
% C22 Alkycyclohex. / C30 H	83, 191	-
% C29 Alkycyclohex. / C30 H	83, 191	-
% C23-C29 Tricyclics / C30 H	191	-
% (C30 H + C30 M) / (C29(NS's + IS's + DS's)	191, 217	-

------ STERANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% C27 ST's / (C27 + C28 + C29) ST's	217	-
% C28 ST's / (C27 + C28 + C29) ST's	217	-
% C29 ST's / (C27 + C28 + C29) ST's	217	-
% C27S NS / (C27S NS + C27R NS)	217	-
% C28S NS / (C28S NS + C28R NS)	217	-
% C29S NS / (C29S NS + C29R NS)	217	-
% C27 NS's / C29 NS's	217	-
% C27 IS's / C29 IS's	217	-
% C27 DS's / C29 DS's	217	-
% C27 DS's / C27 ST's	217	-
% C28 DS's / C28 ST's	217	-
% C29 DS's / C29 ST's	217	-
% C27 IS's / (C27 IS's + C27 NS's)	217	-
% C28 IS's / (C28 IS's + C28 NS's)	217	-
% C29 IS's / (C29 IS's + C29 NS's)	217	-

NOTES : H = Hopane   M = Moretane   Me = Methyl   NS = Normal Sterane

IS = Iso Sterane DS = Dia Sterane   ST = NS + IS + DS   U = Unknown

- = no data available

TABLE 9-1

SATURATE FRACTION SIR GC/MS DATA - CONDENSATE

WELL = MINERVA-1			DETAILED COMPOUND ANALYSIS		DEPTH UNIT = Metres	
COUNTRY = Australia			DESCRIPTION : TOPPED		DATE OF JOB = Jan-Mar 94	
BASIN = Otway			DEPTH 1 = 1942.50	DEPTH 2 = 1942.50		

COMPOUND	ION	RELATIVE AMOUNT	COMPOUND	ION	RELATIVE AMOUNT
C23 Tricyclic	191	-	C24 Tricyclic	191	-
C25 Tricyclic	191	-	C26 Tricyclic	191	-
C28 Tricyclic	191	-	C29 Tricyclic	191	-
C24 Tetracyclic	191	-			
C27 Hopane (Ts)	191	709.0	C27 Hopane (Tm)	191	511.0
C27 Hopane (17B)	191	-			
C28 Hopane (25,30)	191	-	C28 Hopane (28,30)	191	-
C29 Hopane	191	1979.0	C29 Moretane	191	267.3
C29 Demeth. Hopane	191	-	C29 Hopane (BB)	191	-
C30 Hopane	191	2299.0	C30 Moretane	191	229.1
C30 Hopane (BB)	191	-			
C31S Hopane	191	1078.0	C31R Hopane	191	711.0
C31S+R Hopane (BB)	191	-	C31S+R Moretane	191	-
C32S Hopane	191	537.0	C32R Hopane	191	350.0
C32S+R Hopane (BB)	191	-	C32S+R Moretane	191	-
C33S Hopane	191	-	C33R Hopane	191	-
Gammacerane	191	-	Oleanane (18a)	191	-
Unknown 1	191	-	Unknown 2	191	-
Unknown 3	191	559.0	Unknown 4	191	-
C27 Demeth. Hopane	177	-	C28 Demeth. Hopane	177	-
C29 Hopane	177	-	C29 Demeth. Hopane	177	-
C29 Moretane	177	-	C29 Hopane (BB)	177	-
Unknown 3	177	-			
C30 2-Methylhopane	205	-	C31 2-Methylhopane	205	-
C31S Hopane	205	-	C31R Hopane	205	-
C31S+R Moretane	205	-	C31S+R Hopane (BB)	205	-
C21 Sterane	217	-	C22 Sterane	217	-
C27S Normal Sterane	217	-	C27R Normal Sterane	217	1173.0
C27S Isosterane	217	-	C27R Isosterane	217	-
C27S Diasterane	217	-	C27R Diasterane	217	-
C28S Normal Sterane	217	-	C28R Normal Sterane	217	279.0
C28S Isosterane	217	-	C28R Isosterane	217	-
C28S Diasterane	217	-	C28R Diasterane	217	-
C29S Normal Sterane	217	283.0	C29R Normal Sterane	217	270.0
C29S Isosterane	217	447.0	C29R Isosterane	217	396.0
C29S Diasterane	217	1039.0	C29R Diasterane	217	422.0
C27S+R Isosterane	218	1754.0	C28S+R Isosterane	218	1182.0
C29S+R Isosterane	218	1424.0			
C27S Diasterane	259	514.0	C27R Diasterane	259	339.0
C28S Diasterane	259	584.0	C28R Diasterane	259	315.7
C29S Diasterane	259	257.0	C29R Diasterane	259	219.2
16a Phyllocladane	123	-	16B Phyllocladane	123	-
Beyerene	123	-	Labdane	123	-
Fichtelite	123	-	Rimuane	123	-
Nortetracyclane	123	-	Pimerane	123	-
Isopimerane	123	-	Kaurane	123	-
Norisopimerane	123	-	Unknown 1	123	-
Drimane	123	-	Homodrimane	123	-
Rearranged Drimane 1	123	-	Rearranged Drimane 2	123	-
Eudesmane	123	-			
C15 Alkylcyclohexane	83	-	C17 Alkylcyclohexane	83	-
C21 Alkylcyclohexane	83	-	C22 Alkylcyclohexane	83	-
C25 Alkylcyclohexane	83	-	C29 Alkylcyclohexane	83	-

- = no data   IUPAC names corresponding to common names used here are shown at the end of the tables

TABLE 9-2

SATURATE FRACTION SIR GC/MS DATA - CONDENSATE

CALCULATED DATA

DESCRIPTION : TOPPED

WELL = MINERVA-1	DEPTH 1(m) = 1942.50	DEPTH UNIT = Metres
COUNTRY = Australia	DEPTH 2(m) = 1942.50	DATE OF JOB = Jan-Mar 94
BASIN = Otway		

------ TERPANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% Ts / (Ts + Tm)	191	58.11
% C29 M / (C29 H + C29 M)	191	11.90
% C30 M / (C30 H + C30 M)	191	9.06
% C31S H / (C31S H + C31R H)	191	60.26
% C31S H / (C31S H + C31R H)	205	-
% C32S H / (C32S H + C32R H)	191	60.54
% U1-U4 / (U1-U4 + C30 H)	191	-
% U1 / (U1 + C30 H)	191	-
% U2 / (U2 + C30 H)	191	-
% U3 / (U3 + C30 H)	191	19.56
% U4 / (U4 + C30 H)	191	-
% C29 H / (C29 H + C30 H)	191	46.26
% C31 2-MeH / (C31 2-MeH + C30 H)	191, 205	-
% C29 BB / (C29 BB + C 29H + C29 M)	191	-
% C29 DeMe / (C29 DeMe + C29H)	177	-
% C28 H's / (C28 H's + C30 H)	191	-
% (Ts + Tm + C28 H's) / C29(H + M) + C30(H + M)	191	-
% Oleanane (18a) / (Oleanane + C30H)	191	-
% Drimane / Homodrimane	123	-
% Rea. Drimanes / (Drimane + Homodrimane)	123	-
% C22 Alkycyclohex. / C30 H	83, 191	-
% C29 Alkycyclohex. / C30 H	83, 191	-
% C23-C29 Tricyclics / C30 H	191	-
% (C30 H + C30 M) / (C29(NS's + IS's + DS's)	191, 217	88.49

------ STERANE PARAMETERS ------

PARAMETER	ION(s)	VALUE
% C27 ST's / (C27 + C28 + C29) ST's	217	-
% C28 ST's / (C27 + C28 + C29) ST's	217	-
% C29 ST's / (C27 + C28 + C29) ST's	217	-
% C27S NS / (C27S NS + C27R NS)	217	-
% C28S NS / (C28S NS + C28R NS)	217	-
% C29S NS / (C29S NS + C29R NS)	217	51.18
% C27 NS's / C29 NS's	217	-
% C27 IS's / C29 IS's	217	-
% C27 DS's / C29 DS's	217	-
% C27 DS's / C27 ST's	217	-
% C28 DS's / C28 ST's	217	-
% C29 DS's / C29 ST's	217	51.14
% C27 IS's / (C27 IS's + C27 NS's)	217	-
% C28 IS's / (C28 IS's + C28 NS's)	217	-
% C29 IS's / (C29 IS's + C29 NS's)	217	60.39

NOTES : H = Hopane   M = Moretane   Me = Methyl   NS = Normal Sterane
         IS = Iso Sterane DS = Dia Sterane ST = NS + IS + DS   U = Unknown
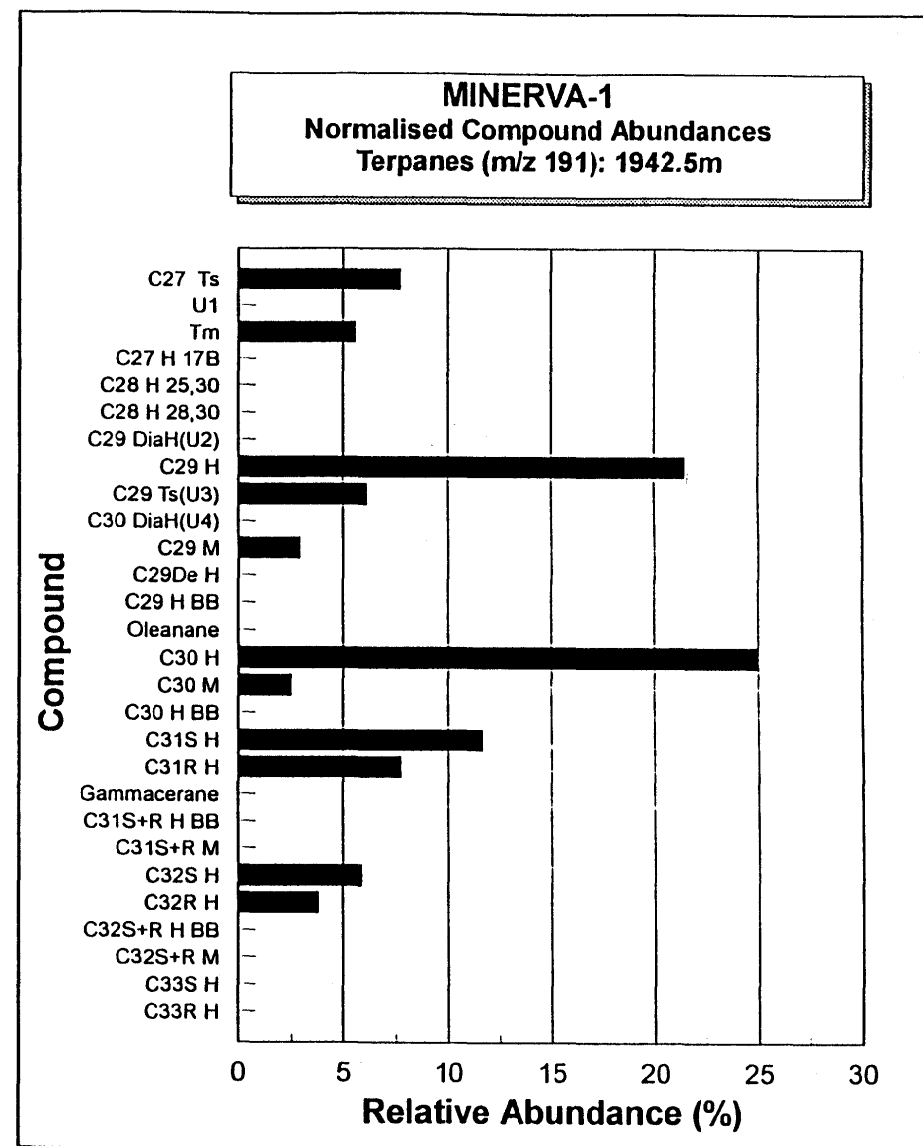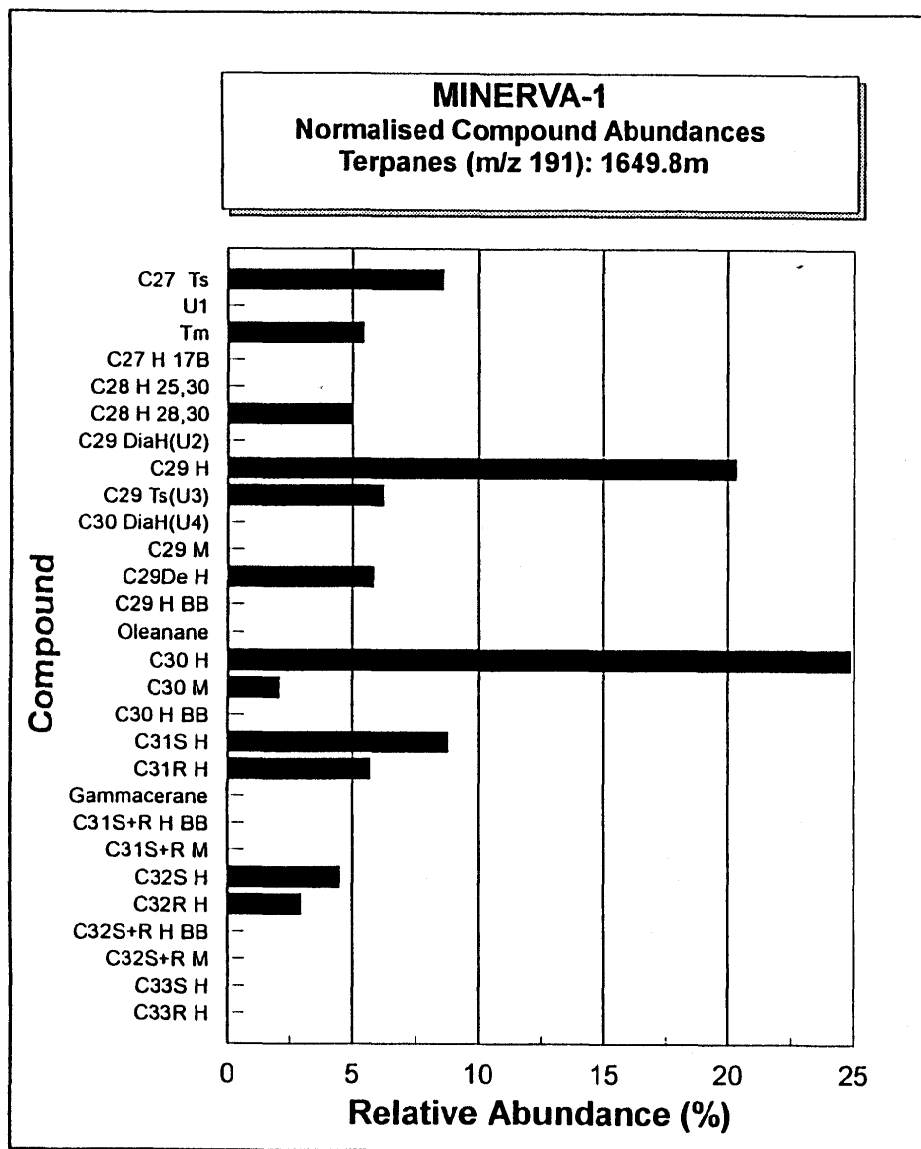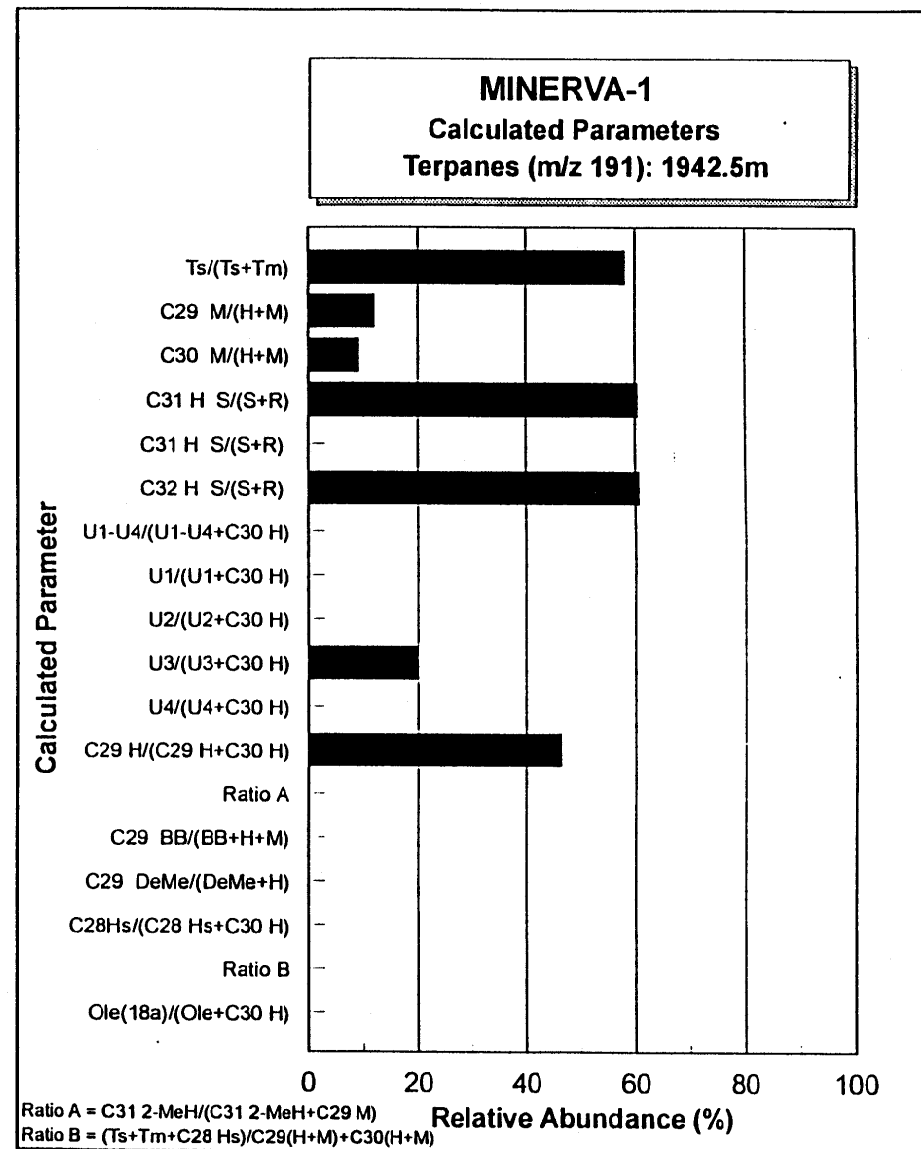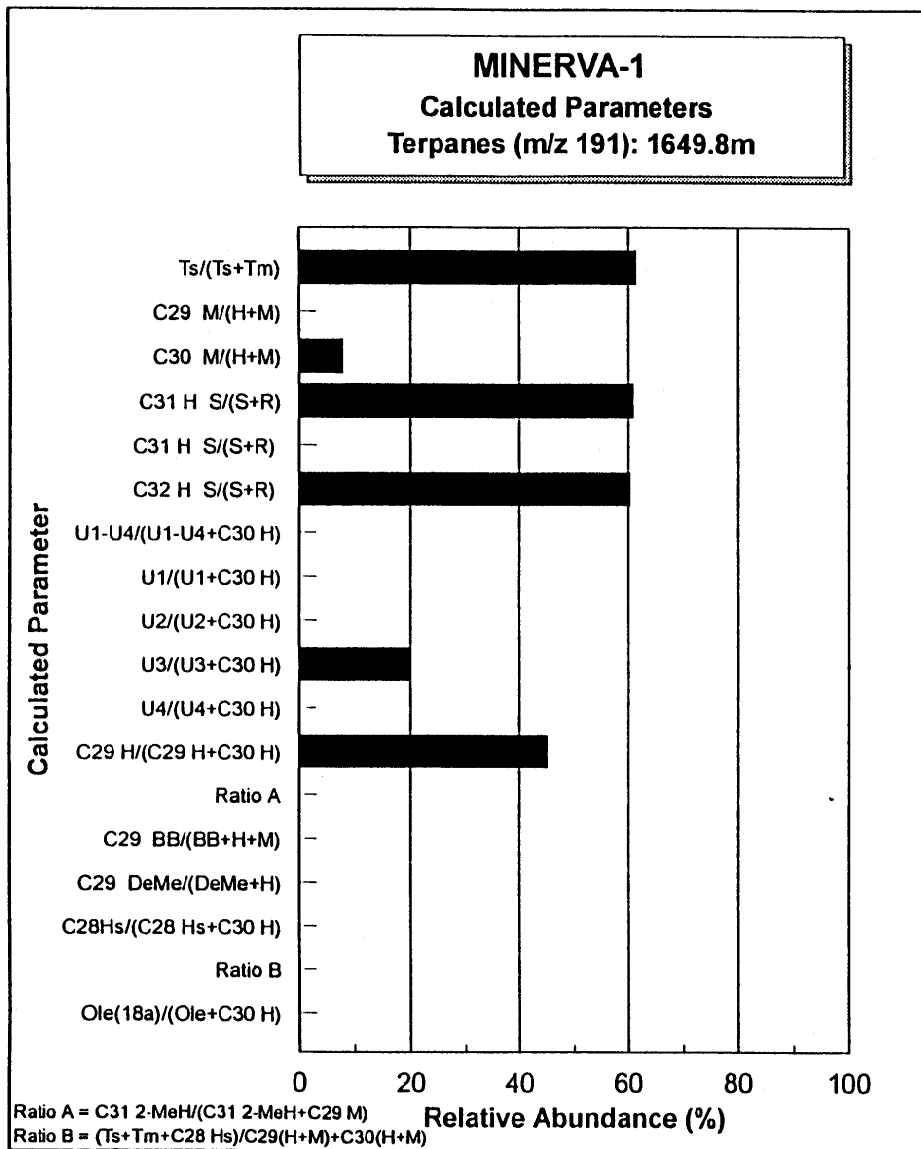   - = no data available

Figure 22a

MINERVA-1
Calculated Parameters
Terpanes (m/z 191): 1649.8m

MINERVA-1
Calculated Parameters
Terpanes (m/z 191): 1942.5m

Ratio A = C31 2-MeH/(C31 2-MeH+C29 M)
Ratio B = (Ts+Tm+C28 Hs)/C29(H+M)+C30(H+M)

Figure 22b

MINERVA-1
Normalised Compound Abundances
Steranes (m/z 217): 1649.8m

MINERVA-1
Normalised Compound Abundances
Steranes (m/z 217): 1942.5m

Figure 23a

MINERVA-1
Calculated Parameters
Steranes (m/z 217): 1649.8m

MINERVA-1
Calculated Parameters
Steranes (m/z 217): 1942.5m

Ratio C = (C30 H+C30 M)/(C29(NSs+ISs+DSs)

Figure 23b

MINERVA-1
Normalised Compound Abundances
Terpanes (m/z 191)

MINERVA-1
Calculated Parameters
Terpanes (m/z 191)

Ratio A = C31 2-MeH/(C31 2-MeH+C29 M)
Ratio B = (Ts+Tm+C28 Hs)/C29(H+M)+C30(H+M)

Figure 24a

MINERVA-1
Normalised Compound Abundances
Steranes (m/z 217)

MINERVA-1
Calculated Parameters
Steranes (m/z 217)

Ratio C = (C30 H+C30 M)/(C29(NSs+ISs+DSs)

Figure 24b

MINERVA-1: 1649.8m Water Extract Pristane/Phytane vs Hopane/Sterane Ratio
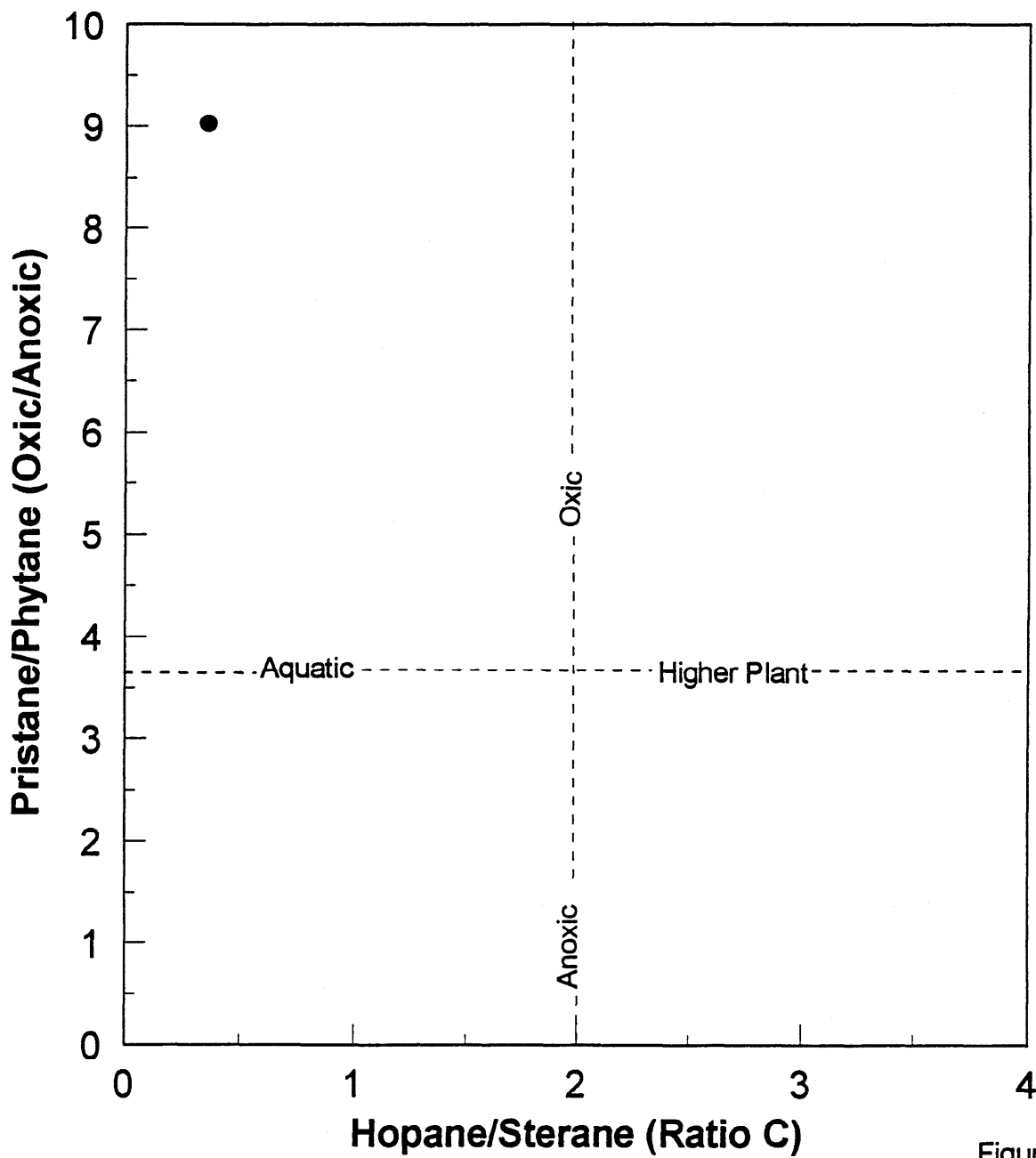
Figure 25

MINERVA-1: Condensates Facies Interpretation based on Sterane Abundances (R Isomers Only)
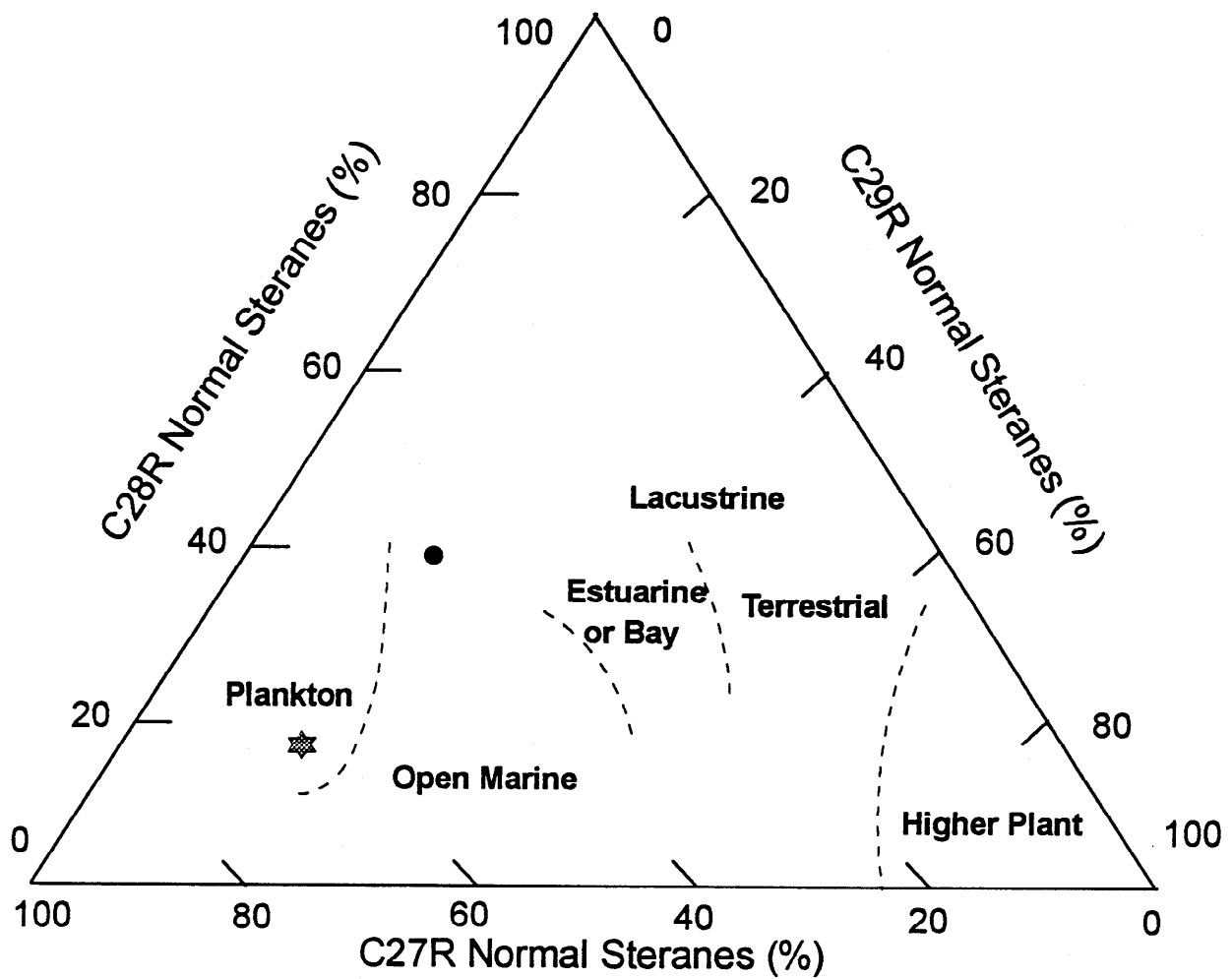
Figure 26

MINERVA-1: 1649.8m Water Extract
Pristane/Phytane vs C29R/C27R
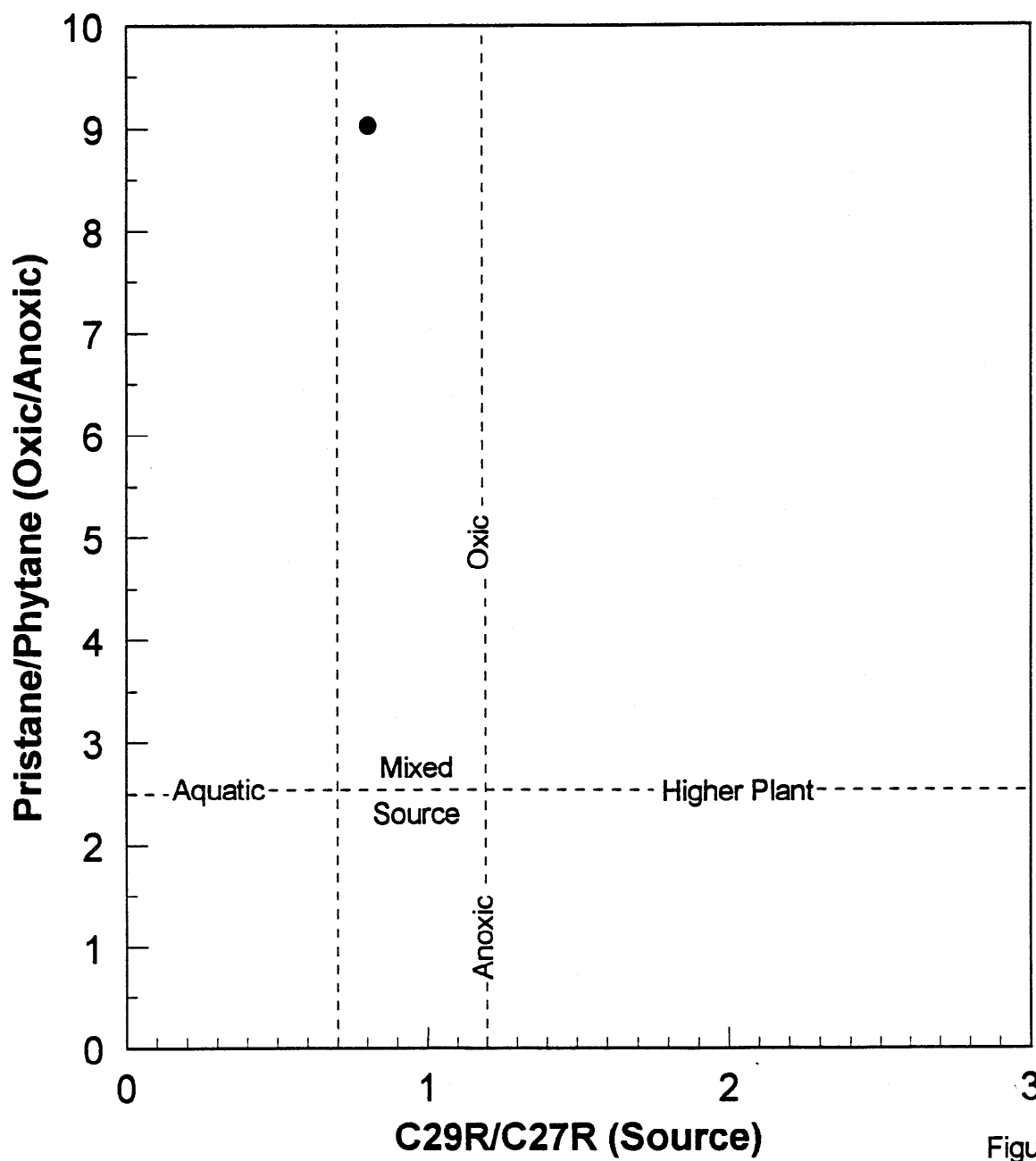
Figure 27

MINERVA-1

C29 20S/(20S + 20R) vs C29 ββ/(ββ + αα)
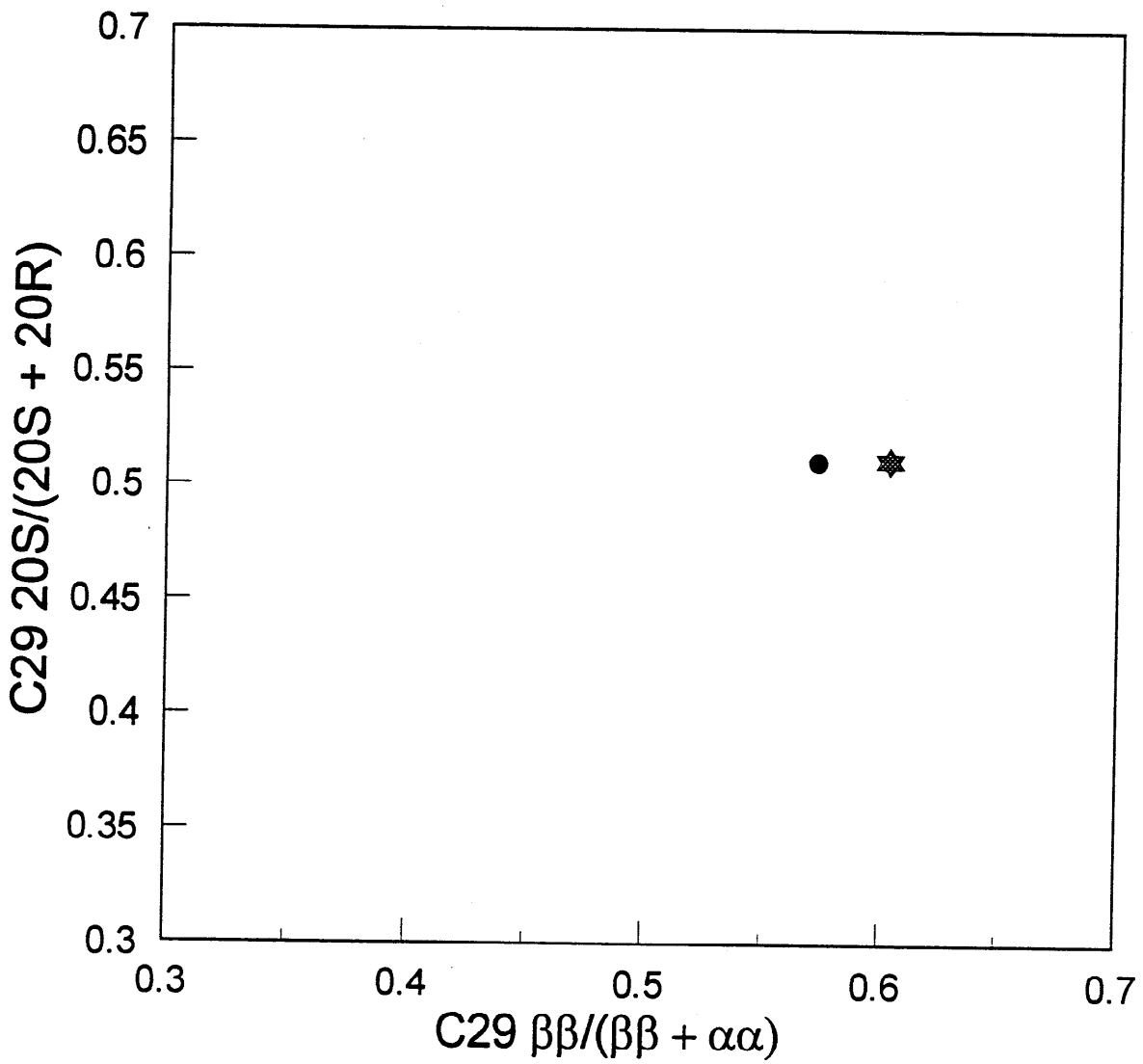
1649.8m   1942.5m

Figure 28

TABLE 10

DI & TRI NUCLEAR AROMATIC GC/MS DATA - WATER EXTRACT

DESCRIPTION : COLD-TRAPPED COND

WELL   = MINERVA-1   DEPTH UNIT = Metres
COUNTRY = Australia   DATE OF JOB = Jan-Mar 94
BASIN   = Otway

        DEPTH 1 = 1649.80   DEPTH 2 = 1649.80

A. DETAILED COMPOUND ANALYSIS

COMPOUND	ION	RELATIVE AMOUNT
1,5-Dimethylnaphthalene	156	48038.0
1,6-Dimethylnaphthalene	156	205160.0
1,8-Dimethylnaphthalene	156	-
2,6-Dimethylnaphthalene	156	256121.0
2,7-Dimethylnaphthalene	156	-
1,4+2,3-Dimethylnaphthalene	156	101189.0
1,2,5-Trimethylnaphthalene	170	109144.0
1,2,7-Trimethylnaphthalene	170	-
1,3,6-Trimethylnaphthalene	170	67221.0
1,3,7-Trimethylnaphthalene	170	46790.0
2,3,6-Trimethylnaphthalene	170	32154.0
1,3,5+1,4,6-Trimethylnaphthalene	170	53799.0
Phenanthrene	178	38619.0
1-Methylphenanthrene	192	12728.0
2-Methylphenanthrene	192	13937.0
3-Methylphenanthrene	192	11978.0
9-Methylphenanthrene	192	14777.0
1,7-Dimethylphenanthrene	206	8802.0
Compound X (1,3 + 3,9 + 2,10 + 3,10-DMP)	206	13492.0
Retene	219	7024.0
Cadalene	198	-
Eudalene	184	-

B. CALCULATED DATA

PARAMETER	ION	VALUE
DNR-1 = (2,6-DMN + 2,7-DMN) / 1,5-DMN	156	-
DNR-2 = 2,7-DMN / 1,8-DMN	156	-
DNR-5 = 1,6-DMN / 1,8-DMN	156	-
DNR-6 = ((2,6-DMN + 2,7-DMN) / 1,4+2,3-DMN)*0.91	156	-
TNR-1 = (2,3,6-TMN / 1,3,5+1,4,6-TMN)*0.82	170	0.49
TNR-5 = (1,2,5-TMN / 1,3,6-TMN)*0.75	170	1.22
TNR-6 = 1,2,7-TMN / 1,3,7-TMN	170	-
MPR-1 = (2-MP + 3-MP) / 1-MP	192	2.04
MPI-1 = (1.5 x (2-MP + 3-MP)) / (0.667*Ph + 1-MP + 9-MP)	178,192	0.73
MPI-2 = (3 x 2-MP) / (0.667*Ph + 1-MP + 9-MP)	178,192	0.78
Rc(a) = (0.6 x MPI-1) + 0.4	na	0.84
Rc(b) = (-0.6 x MPI-1) + 2.3	na	1.86
1,7-Dimethylphenantrene / Compound X	206	0.65
Retene / 9-Methylphenantrene	192,219	0.48
1-Methylphenanthrene / 9-Methylphenanthrene	192	0.86

Notes : DMN = Dimethylnaphthalene TMN = Trimethylnaphthalene   - = no data
         MP = Methylphenanthrene   Ph = Phenanthrene   na = not applicable

TABLE 11

DI & TRI NUCLEAR AROMATIC GC/MS DATA - CONDENSATE

DESCRIPTION : COLD-TRAPPED COND

WELL   = MINERVA-1   DEPTH UNIT = Metres
COUNTRY = Australia   DATE OF JOB = Jan-Mar 94
BASIN   = Otway

DEPTH 1 = 1942.50   DEPTH 2 = 1942.50

A. DETAILED COMPOUND ANALYSIS

COMPOUND	ION	RELATIVE AMOUNT
1,5-Dimethylnaphthalene	156	184080.0
1,6-Dimethylnaphthalene	156	889276.0
1,8-Dimethylnaphthalene	156	0.0
2,6-Dimethylnaphthalene	156	902411.0
2,7-Dimethylnaphthalene	156	0.0
1,4+2,3-Dimethylnaphthalene	156	350861.0
1,2,5-Trimethylnaphthalene	170	290906.0
1,2,7-Trimethylnaphthalene	170	0.0
1,3,6-Trimethylnaphthalene	170	200361.0
1,3,7-Trimethylnaphthalene	170	159937.0
2,3,6-Trimethylnaphthalene	170	148514.0
1,3,5+1,4,6-Trimethylnaphthalene	170	141342.0
Phenanthrene	178	183774.0
1-Methylphenanthrene	192	54218.0
2-Methylphenanthrene	192	94126.0
3-Methylphenanthrene	192	90043.0
9-Methylphenanthrene	192	69641.0
1,7-Dimethylphenanthrene	206	24706.0
Compound X (1,3 + 3,9 + 2,10 + 3,10-DMP)	206	73721.0
Retene	219	3810.0
Cadalene	198	-
Eudalene	184	-

B. CALCULATED DATA

PARAMETER	ION	VALUE
DNR-1 = (2,6-DMN + 2,7-DMN) / 1,5-DMN	156	4.90
DNR-2 = 2,7-DMN / 1,8-DMN	156	0.00
DNR-5 = 1,6-DMN / 1,8-DMN	156	0.00
DNR-6 = ((2,6-DMN + 2,7-DMN) / 1,4+2,3-DMN)*0.91	156	2.34
TNR-1 = (2,3,6-TMN / 1,3,5+1,4,6-TMN)*0.82	170	0.86
TNR-5 = (1,2,5-TMN / 1,3,6-TMN)*0.75	170	1.09
TNR-6 = 1,2,7-TMN / 1,3,7-TMN	170	0.00
MPR-1 = (2-MP + 3-MP) / 1-MP	192	3.40
MPI-1 = (1.5 x (2-MP + 3-MP)) / (0.667*Ph + 1-MP + 9-MP)	178,192	1.12
MPI-2 = (3 x 2-MP) / (0.667*Ph + 1-MP + 9-MP)	178,192	1.15
Rc(a) = (0.6 x MPI-1) + 0.4	na	1.07
Rc(b) = (-0.6 x MPI-1) + 2.3	na	1.63
1,7-Dimethylphenantrene / Compound X	206	0.34
Retene / 9-Methylphenantrene	192,219	0.05
1-Methylphenanthrene / 9-Methylphenanthrene	192	0.78

Notes : DMN = Dimethylnaphthalene   TMN = Trimethylnaphthalene   - = no data
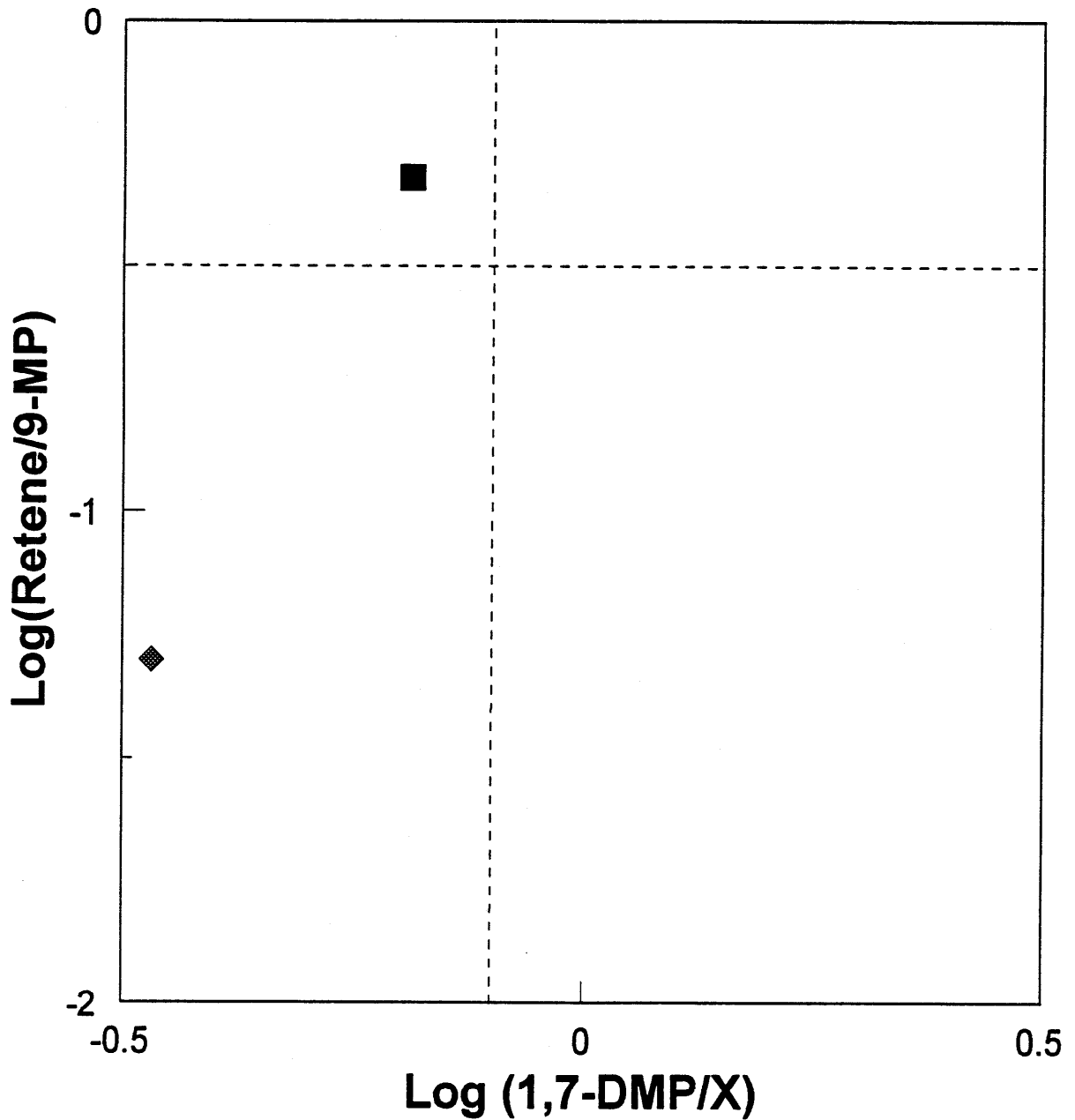   MP = Methylphenanthrene   Ph = Phenanthrene   na = not applicable

MINERVA-1
MPI-1-derived Rc(a) and Rc(b) vs Depth
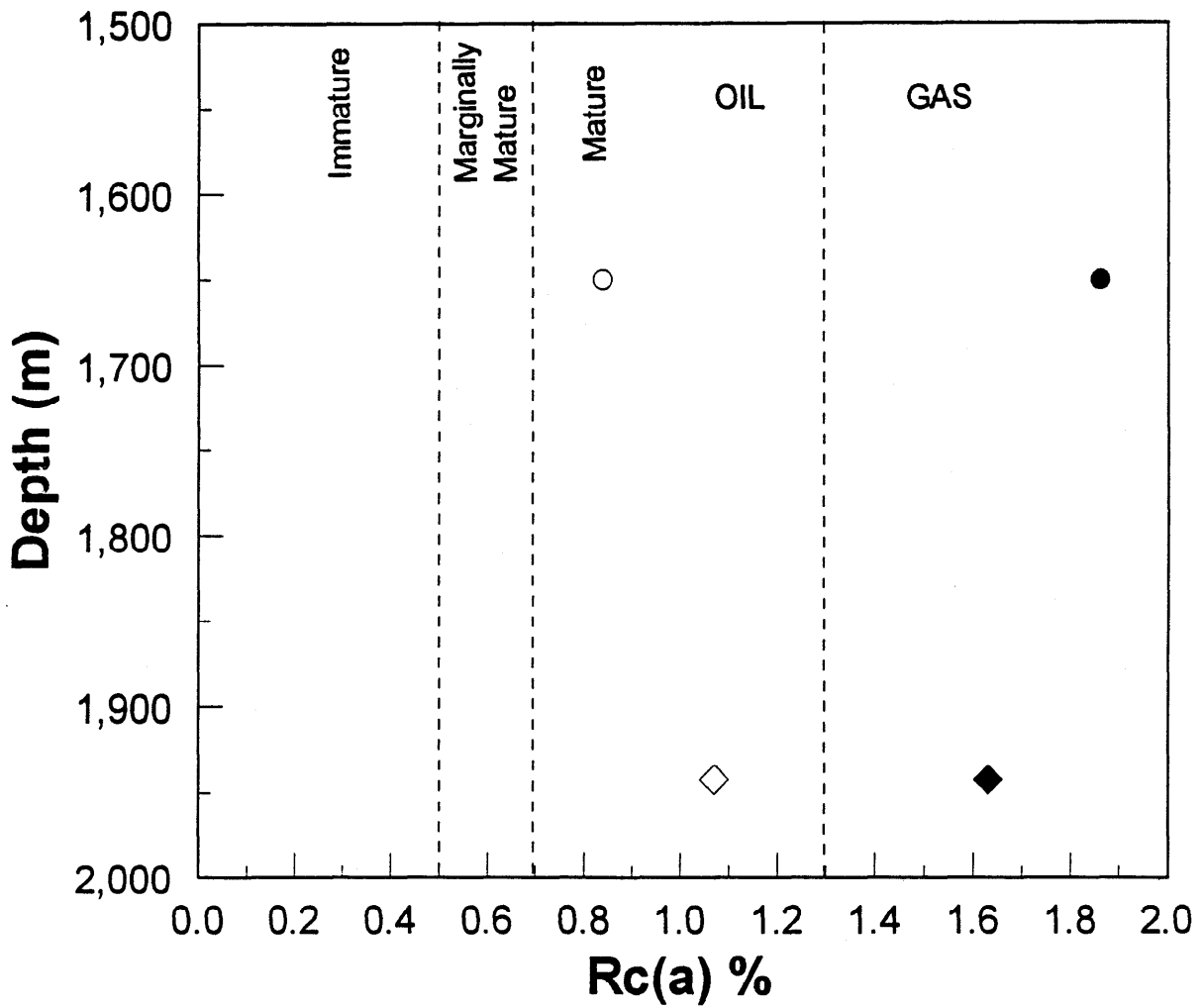
1649.8m Rc(a)	1942.5m Rc(a)	1649.8m Rc(b)	1942.5m Rc(b)
○	◇	●	◆

Figure 29

Figure 30

MINERVA-1
Log(1-MP/9-MP) vs Log(1,2,5-TMN/1,3,6-TMN)
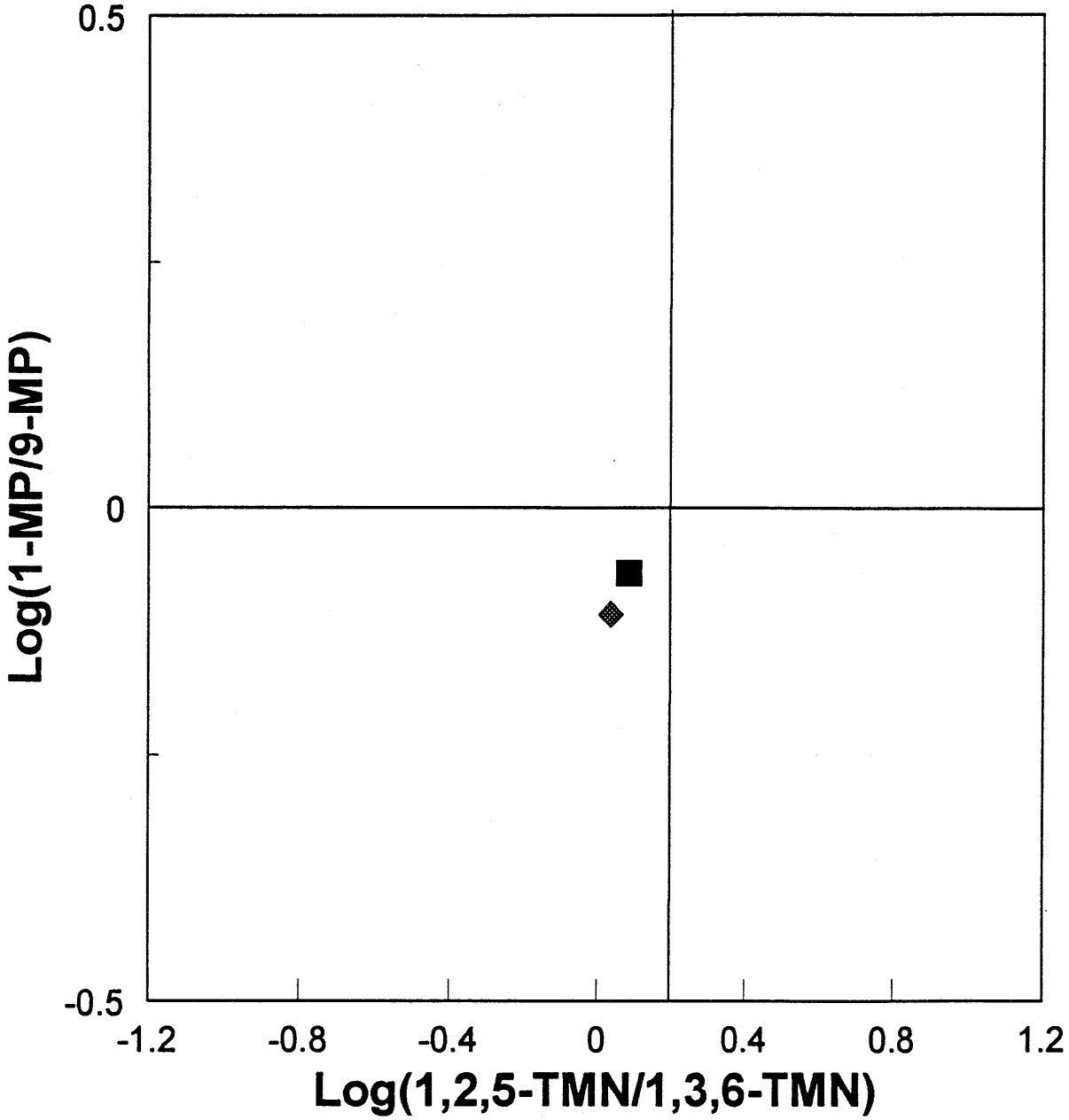
Legend: 1649.8m (■), 1942.5m (◆)

Figure 31

TABLE 12

GAS ANALYSIS DATA
==================

WELL   = MINERVA-1   DEPTH UNIT = Metres
COUNTRY = Australia   DATE OF JOB = Aug 93
BASIN   = Otway
DESCRIPTION : RFT

DEPTH 1(m) = 1649.80   DEPTH 2(m) = 1649.80

COMPOUND	% by VOLUME
Methane	94.35
Ethane	2.48
Propane	.98
IsoButane	.16
n-Butane	.19
IsoPentane	.06
n-Pentane	.05
C6+	.01
Carbon Dioxide	.23
Nitrogen	1.44
Hydrogen Sulphide	-
Oxygen	.05
Hydrogen	-
Helium	-
Argon	-

NOTES :   - = not reported

TABLE 13

GAS ANALYSIS DATA
=================

WELL   = MINERVA-1   DEPTH UNIT = Metres
COUNTRY = Australia   DATE OF JOB = Aug 93
BASIN   = Otway
                    DESCRIPTION : RFT

DEPTH 1(m) = 1931.00   DEPTH 2(m) = 1931.00

COMPOUND	% by VOLUME
Methane	93.71
Ethane	2.16
Propane	.81
IsoButane	.10
n-Butane	.17
IsoPentane	.03
n-Pentane	.06
C6+	.12
Carbon Dioxide	1.71
Nitrogen	1.08
Hydrogen Sulphide	-
Oxygen	.05
Hydrogen	-
Helium	-
Argon	-

NOTES :   - = not reported

MINERVA-1
Gas Analysis Data
Normalised Relative Abundances
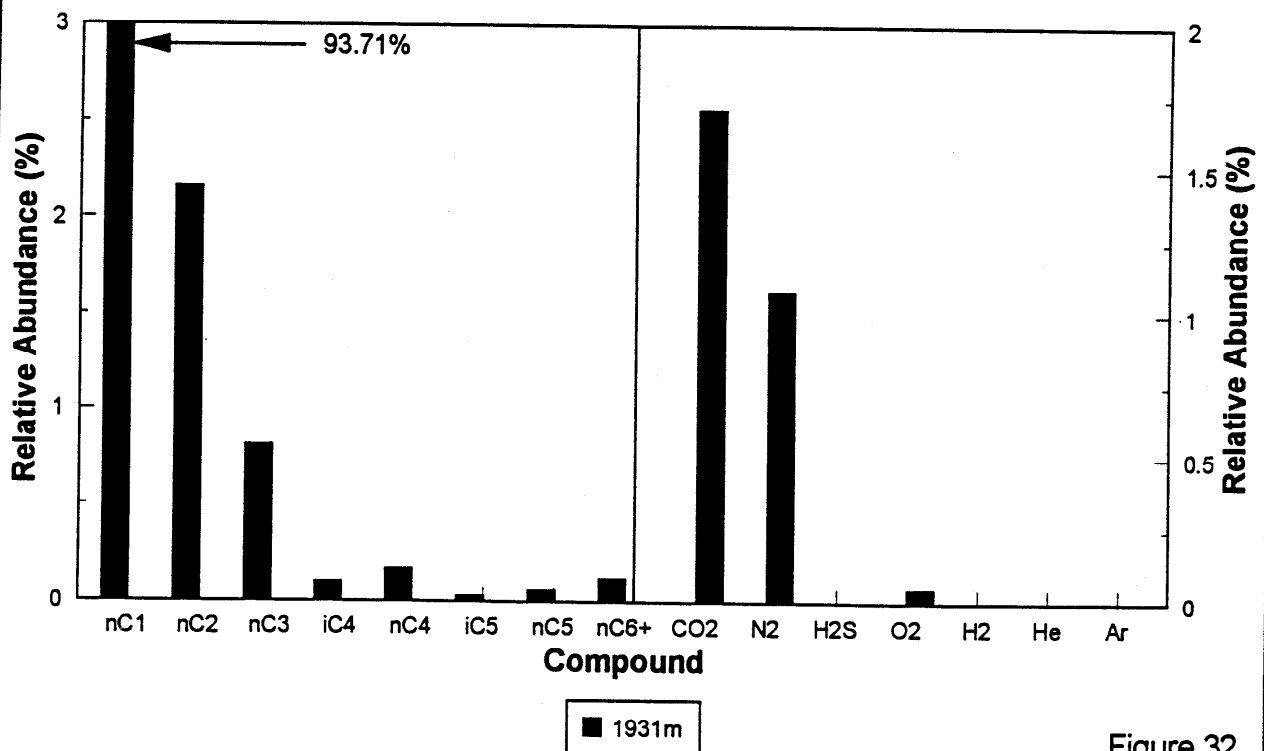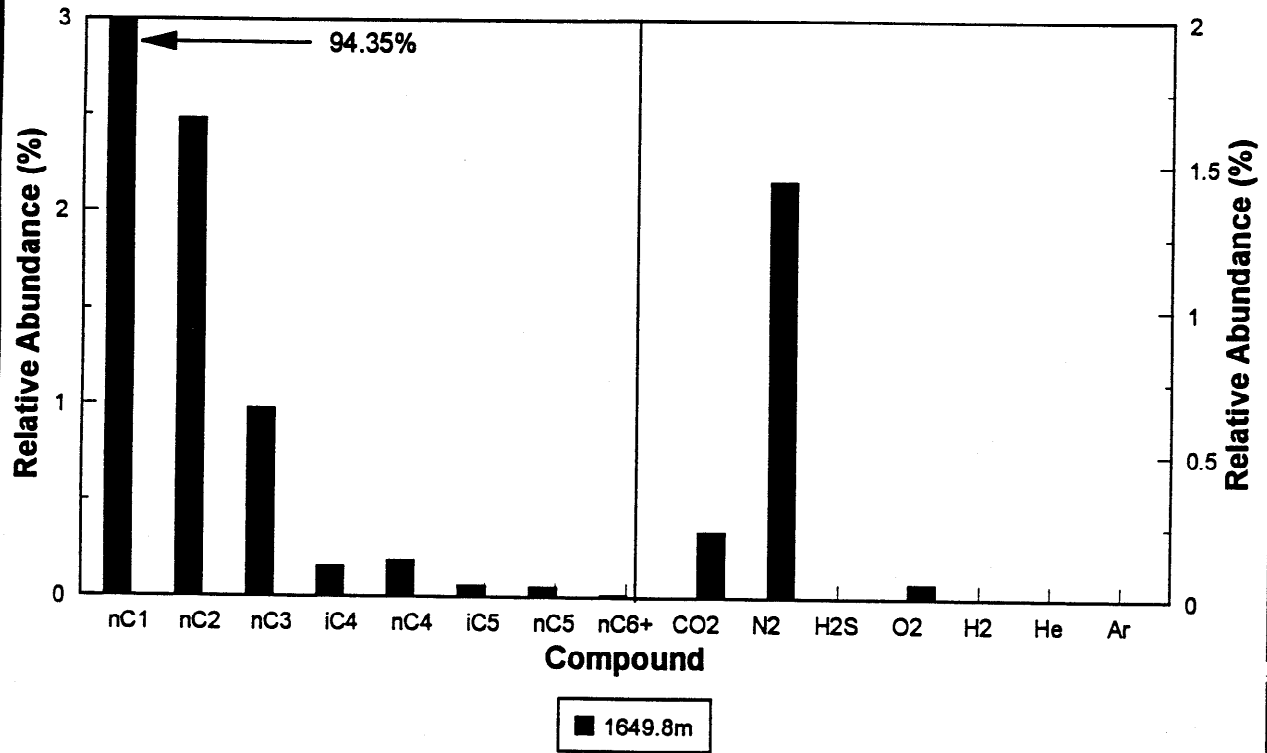
Figure 32

TABLE 14

CARBON ISOTOPE ANALYSIS DATA - GAS
===================================

WELL NAME = MINERVA-1
COUNTRY   = Australia
BASIN   = Otway

DEPTH UNIT = Metres
DATE OF JOB = Aug 93

--- delta C VALUES ---

DEPTH 1	DEPTH 2	METHANE	ETHANE	PROPANE	ISO-BUTANE	n-BUTANE	ISO-PENTANE	n-PENTANE	CARBON DIOXIDE
1649.80	1649.80	-34.30	-24.80	-25.50	-	-25.50	-	-25.90	-26.10
1931.00	1931.00	-34.10	-24.10	-25.40	-	-25.60	-	-26.20	-13.10

All values permil relative to PDB
- = no data

GAS ISOTOPE MATURATION PLOT 1
MINERVA-1
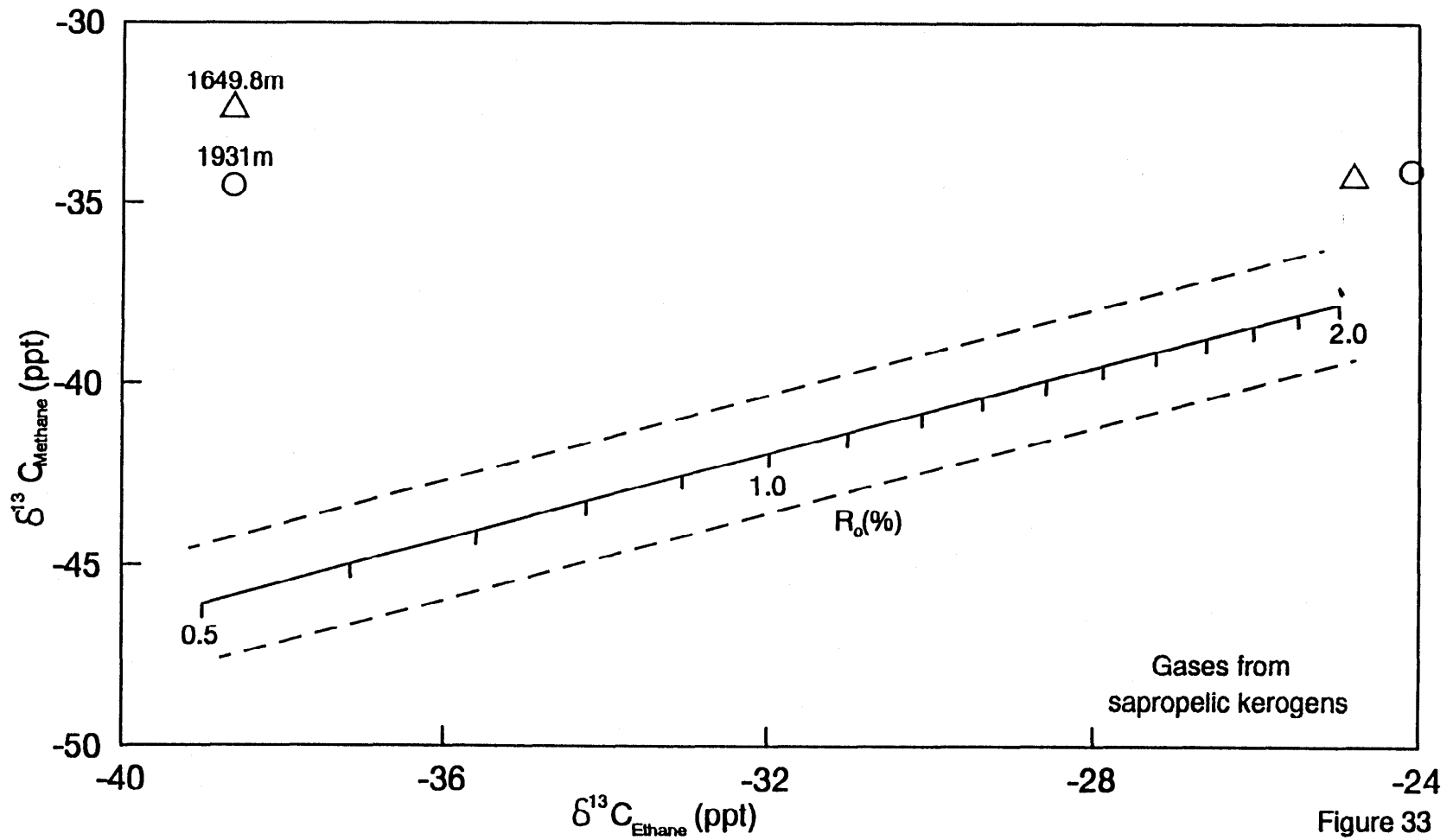
Figure 33

GAS ISOTOPE MATURATION PLOT 2
MINERVA-1
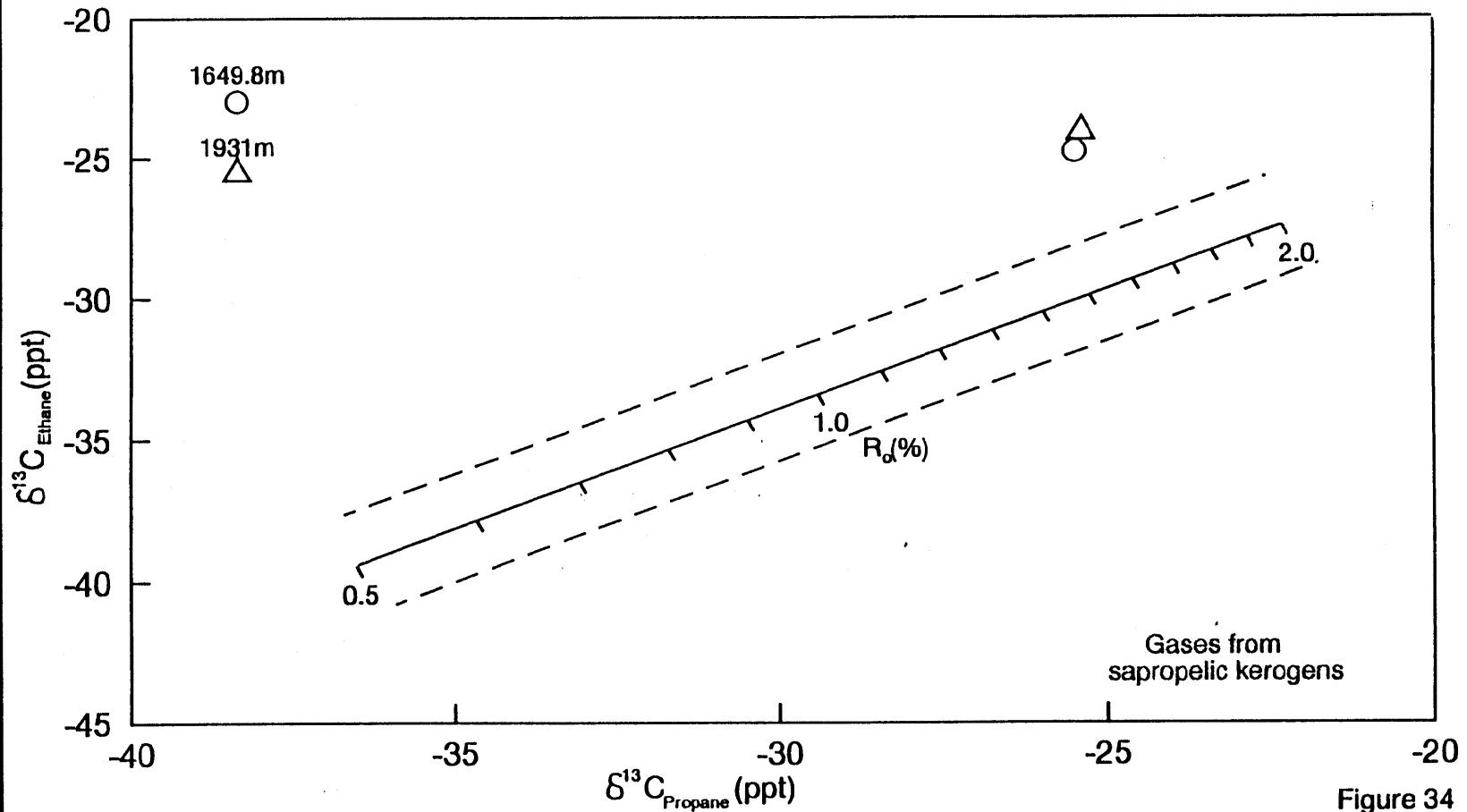
Figure 34

GAS CHARACTERISATION PLOT
MINERVA-1

1649.8m
○

1931m
△

"B"

-70

-60

Diagenetic?

"M"

-50 δ¹³C$_{CH_4}$(ppt)

Ms

TT(m) shallow

-40

deepdry   Md

Mixed source

-30

TT(h)   ~1.2%

~2.0%

~3.0%   R$_0$

Figure 35

-20

0   10   C$_2$+ (%)   20   30
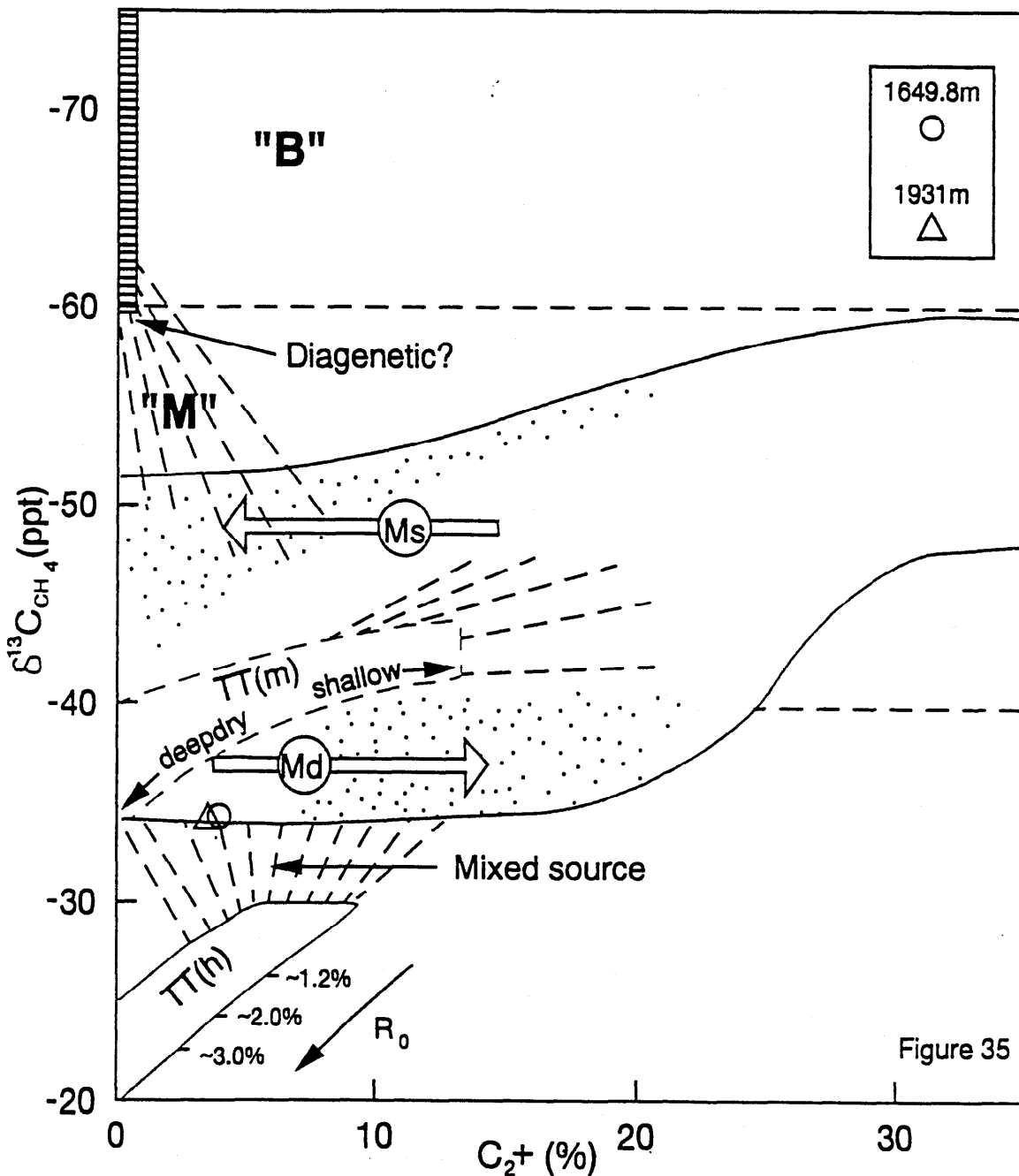
▭ Mixed	TT(m) = Non-associated gas from a marine source
▦ Migrated	TT(h) = Non-associated gas from a humic source
"B" = Biogenic gas	Ms = Shallow migrated gas
"M" = Mixed gas	Md = Deep migrated gas

7

SPECIAL CORE ANALYSIS
STUDY FOR
MINERVA 1

ACS
LABORATORIES
AUSTRALIA

BHP Petroleum Pty Ltd
BHP Petroleum Plaza
120 Collins Street
MELBOURNE VIC 3000

Attention: Mr Lee Yong

REPORT: 008/225

CLIENT REFERENCE: ke:ly:1342:ec

MATERIAL: Core Plugs

LOCALITY: Minerva 1

WORK REQUIRED: Special Core Analysis

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

ROBERT D EAST
Technical Services Manager

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Minerva No. 1 SCAL

1. INTRODUCTION

A facsimile dated 15th June 1993 was received from Keith Edwards of BHP Petroleum Pty Ltd outlining a proposed special core analysis program for Minerva 1. Further discussions between ACS Laboratories personnel and Lee Yong of BHPP refined a final SCAL program as outlined below

The SCAL program consisted of a preparatory stage and Phases 1 and 2.

STAGE	ANALYSIS	TABLES	SAMPLES SELECTED
Preliminary	Sample preparation	I, II	All
Phase 1a	Air-brine capillary pressure drainage, single point, centrifuge method	III	24, 50, 59, 61
Phase 1b	Air-brine capillary pressure drainage, full curve, centrifuge method	IV - VII	21, 31, 56, 65
Phase 1c	Air-brine capillary pressure drainage, full curve, porous plate method, with formation factor/resistivity index	VIII - X	53, 52, 12, 37
Phase 1d	as above	as above	17, 5, 34, 49
Phase 2a	Effective permeability to gas at irreducible water saturation	XI	21, 31, 56, 65, 61, 59, 24, 50
Phase 2b (i)	Air-brine capillary pressure imbibition, end point, centrifuge method, effective permeability to brine at residual gas saturation	XII - XIII	61, 24, 59, 50
Phase 2b (ii)	Air-brine spontaneous imbibition, effective permeability to gas at residual gas saturation	XIV - XV	21, 65, 56, 31
Phase 2b (iii)	Air-brine forced imbibition, centrifuge method, effective permeability to brine at residual gas saturation for each point on a full curve	XVI - XVII	21, 65, 56, 31
Phase 2c	Basic water flood, includes effective permeability to gas at irreducible water saturation and effective permeability to brine at residual gas saturation	XVIII	12, 37, 52, 53

Procedures for the analyses requested are outlined in the following text.

2. SAMPLE PREPARATION

Preparation of samples for the special core analysis program consisted of: plug selection and plug photography; facing all selected plug samples square; re-analysing samples for ambient and overburden pore volume (porosity) and permeability.

2.1 Sample Selection and Plug Photography

One-and-a-half inch diameter plug samples were initially selected by BHPP from routine core analysis data (ACS Report HG/205). These samples were photographed and copies delivered to BHPP Melbourne. Due to the initial unsuitability of some of the selected plugs, replacements were chosen. These were then photographed and delivered to BHPP to comprise a complete set of final SCAL plugs.

Samples were then faced square using a diamond impregnated wheel.

Since facing of samples slightly alters their dimensions permeability to air and porosity were redetermined.

2.2 Permeability to Air - Ambient

Air permeability was determined on the plug samples. The samples were firstly placed in a Hassler cell with a confining pressure of 250 psi. The confining pressure was used to prevent bypassing of air around the samples when the measurement was made. To determine permeability a known air pressure was applied to the upstream face of the sample, creating a flow of air through the core plug. Permeability for the samples was calculated using Darcy's Law through knowledge of the upstream pressure, flow rate, viscosity of air and the samples' dimensions.

2.3 Helium Injection Porosity - Ambient

The porosity of the clean dry core plugs was determined as follows. The plugs were first placed in a sealed matrix cup. Helium held at 100 psi reference pressure was then introduced to the cup. From the resultant pressure change the unknown grain volume was calculated using Boyle's Law.

The bulk volume was determined by mercury immersion. The difference between the grain volume and the bulk volume is the pore volume and from this the 'effective' porosity was calculated as the volume percentage of pores with respect to the bulk volume.

2.4 Porosity and Permeability - Overburden

To determine the porosity and air permeability of the core plugs at overburden pressure the samples were first placed in a thick walled rubber sleeve. This assembly was loaded into a hydrostatic cell and the pore volume determined at 'ambient' pressure. An overburden pressure of 2100 psi was then applied to the samples and the pore volume reduction caused by this increase in pressure determined. By this means the actual overburden pore volume and bulk volume was determined. These data are used to derive porosity at the applied overburden

pressure. Air permeability at overburden pressure was then measured in the hydrostatic cell as described previously.

3. FORMATION FACTOR (FF)

On completion of porosity and air permeability determinations, samples were evacuated and pressure saturated with a 36,000 ppm NaCl brine. Resistivity of the brine was measured as 0.18 ohm.m at 25°C. Samples were removed from the pressure saturator and weighed to ensure that 100% brine saturation had been achieved. A quality control check was made on measurements of ambient porosity by determining the porosity of the fully saturated plug by Archimedes' principle.

Samples were then placed on the cell electrodes with a thin silver leaf between the plug endface and electrode to ensure contact. A strongly hydrophilic filter was placed at one end of the sample. This assembly was then loaded into a rubber sleeve and placed into the hydrostatic cell. The cell was pressured to the desired overburden pressure of 2100 psi using a mineral oil.

Brine was slowly flowed through the sample and electrical resistivity readings recorded until stable. The samples were left to stand for a further 24 hours and readings repeated to ensure that ionic equilibrium had been attained.

4. RESISTIVITY INDEX (RI)

After formation factor measurements were completed, humidified air was introduced to the samples as a means of establishing the required water saturation[1]. Air pressure was continually applied to the samples.

Volumes of displaced brine were monitored as a function of time. Resistivity values and temperatures were recorded.

All electrical properties readings were recorded at room temperature and converted to a standard temperature of 25°C using the following equation derived by Hilchie[2].

---

de Waal et al, J.A., _Measurement and Evaluation of Resistivity Index Curves_, Koninklijke/Shell Exploratie en Produktie Laboratorium, SPWLA 13th Annual Logging Symposium, June 11-14 1989.

[2] Hilchie, D.W., _A New Water Resistivity versus Temperature Equation_, The Log Analyst, Jul-Aug 1984, pp. 20-22.

$$R_T = R_1[(T_1+X)/(T+X)]$$

and $\quad X = 10^{(-0.340396\log R_1 + 0.641427)}$

where: $\quad R_T$ = resistivity at temperature T (ohm.m)

T = temperature (°C) i.e. 25°C

R_1 = resistivity at temperature T_1 (ohm.m)

T_1 = temperature at room conditions (°C)

5. CAPILLARY PRESSURE - Porous Plate

All samples selected to undergo these analyses were firstly pressure saturated with the 36,000 ppm NaCl brine. 100% brine saturation was determined gravimetrically and as an additional quality control check, porosity was determined by Archimedes' principle. Samples were then placed into individual cells with a strongly hydrophilic porous plate at one end.

A humidified air was then introduced to the samples at the first pressure of 0.5 psi. Effluent water displaced by the gas was collected in a pipette. Displacement was monitored as a function of time. When the volume of brine displaced had stabilised, the pressure on the gas phase was increased to obtain the next point on the capillary pressure versus fluid saturation profile.

6. CAPILLARY PRESSURE - Centrifuge

The samples selected for these analyses (after saturation with the brine using the procedures described above) were placed into individual cups and loaded into the centrifuge. At each rotor speed, the water displaced by centrifugal forces was monitored as a function of time. As standard practices require[3], samples were left at each rotational speed for a minimum of 24 hours, or until there was no change in consecutive readings of produced water. The induced capillary pressures were then calculated from the following equation[4]:-

---

[3] Omoregie, Zuwa, Factors Affecting the Equivalency of Different Capillary Pressure Measurement Techniques, S. Chevron, Oilfield Research Co., SPE Formation Evaluation, March 1988, pp. 157-155.

[4] Hassler, Brunner, Measurement of Capillary Pressures in Small Core Samples, AIME, Vol. 160, 1945, pp. 114-123.

$$P_C = \frac{1}{2}\Delta\rho\omega^2(r^2_2-r^2_1) \; x \; (1.013 x 14.696 x 10^{-6})$$

where: P_C = capillary pressure at the inlet face of the core (psi).

$\Delta\rho$ = density difference of the two fluids, ie. air and water (gms/cm^3).

ω = angular velocity (rad/sec)
   = 2π(RPM)/60

r_2 = radius from the centre of the centrifuge to the bottom of the core plug (cm).

r_1 = radius from the centre of the centrifuge to the top of the core plug (cm).

The centrifuge method of determining the relation between saturation and capillary pressure provides values of average saturation. These average saturation values must then be converted to obtain the endface saturation which is equivalent to the induced capillary pressure, thereby obtaining the true profile of capillary pressure versus saturation. The true endface saturation has been calculated by applying a series of data regressions to the average saturation values.

7.   BASIC WATERFLOOD

Connate (irreducible) water saturation was obtained through one of the above capillary pressure procedures. Each sample in turn was placed into a hydrostatic core holder under a confining pressure of 2100 psi. At this stage effective permeability to gas was measured.

The gas was displaced using a 36,000 ppm brine, and effluent volumes of gas and water recorded. Finally, effective permeability to brine was determined at residual gas saturation.

The flow rate used for Basic Waterflood measurement was approximately 4 ccs/min. Brine permeability readings were taken once gas flow from the sample had ceased. Consecutive constant brine permeability readings were taken to indicate stable residual gas saturation values. The differential pressure across the sample is a function of flow rate and permeability. Pore volume throughput to achieve stable residual gas saturations was approximately 2 pore volumes for samples 37 and 52 and 5 pore volumes for 12 and 53.

POROSITY AND AIR PERMEABILITY

Company   BHP Petroleum Pty Ltd
Well   Minerva 1

Ambient

Table I

Sample Number	Depth, metres	Permeability to Air, millidarcies	Porosity, fraction	Grain Density (gms/cm^3)
9	1823.47	1660	0.158	
12	1828.15	2076	0.195	
17	1829.57	1874	0.125	
21	1830.77	2502	0.118	
24	1831.70	701	0.120	
31	1833.80	23.3	0.147	
34	1834.70	188	0.135	
37	1835.60	318	0.186	
49	1840.60	17.2	0.164	
50	1840.90	318	0.187	
52	1842.80	709	0.129	
53	1843.10	5854	0.157	
56	1844.05	402	0.152	
59	1844.90	1601	0.177	
61	1845.52	5641	0.157	
65	1846.72	1371	0.144	

Porosity vs Permeability
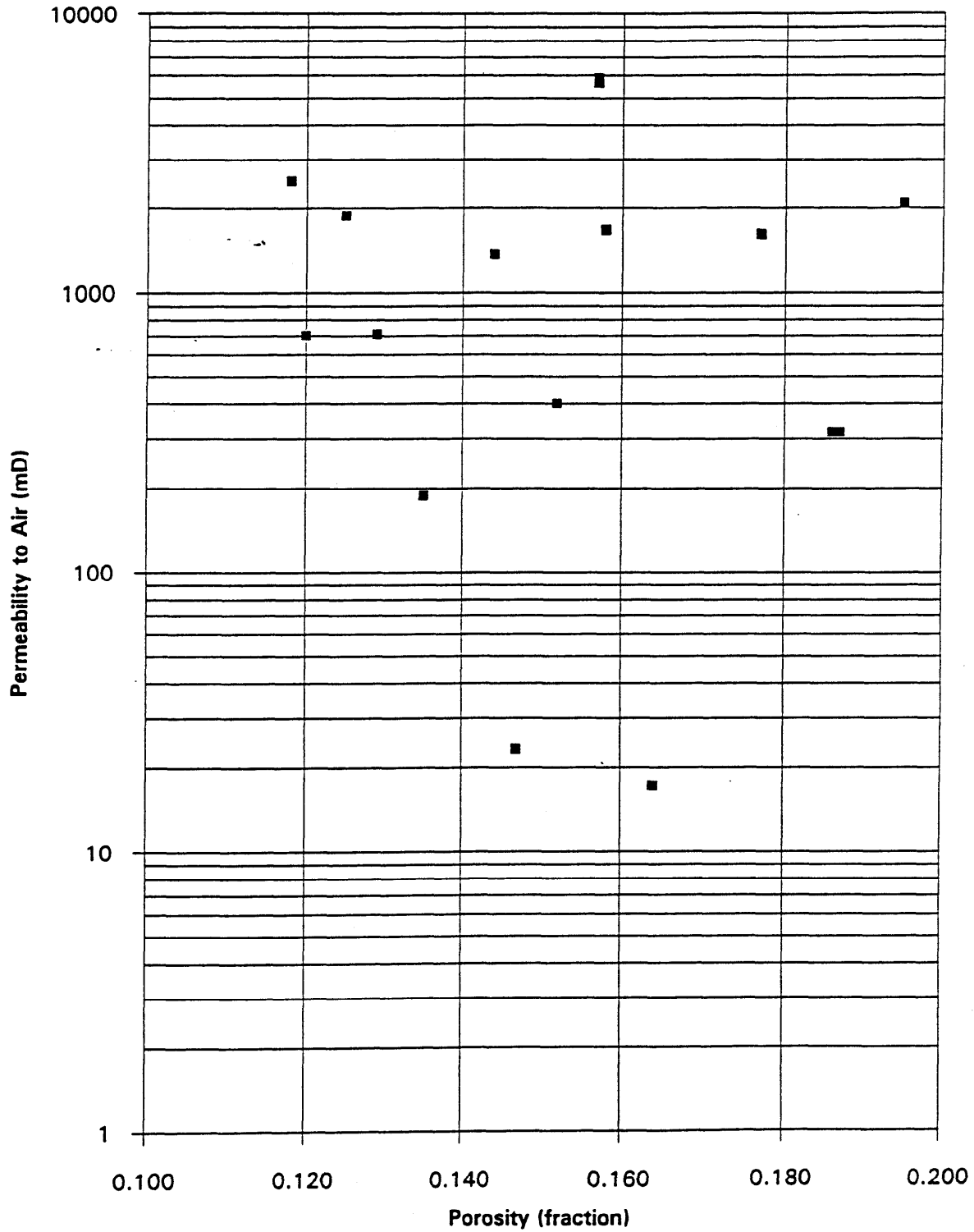
Company: BHP Petroleum Pty Ltd
Well: Minerva 1

- Ambient

7

POROSITY AND AIR PERMEABILITY

Company   BHP Petroleum Pty Ltd
Well   Minerva 1

Overburden Pressure   2100 psi

Table II

Sample Number	Depth, metres	Overburden Permeability to Air, millidarcies	Overburden Porosity, fraction	Grain Density (gms/cm^3)
9	1823.47	1389	0.152	
12	1828.15	1571	0.186	
17	1829.57	1494	0.116	
21	1830.77	1793	0.108	
24	1831.70	551	0.110	
31	1833.80	17.3	0.139	
34	1834.70	158	0.126	
37	1835.60	268	0.178	
49	1840.60	12.3	0.156	
50	1840.90	261	0.180	
52	1842.80	558	0.123	
53	1843.10	3366	0.148	
56	1844.05	283	0.146	
59	1844.90	1348	0.172	
61	1845.52	3145	0.150	
65	1846.72	1133	0.138	

Porosity vs Permeability

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**

Overburden Pressure 2100 psi
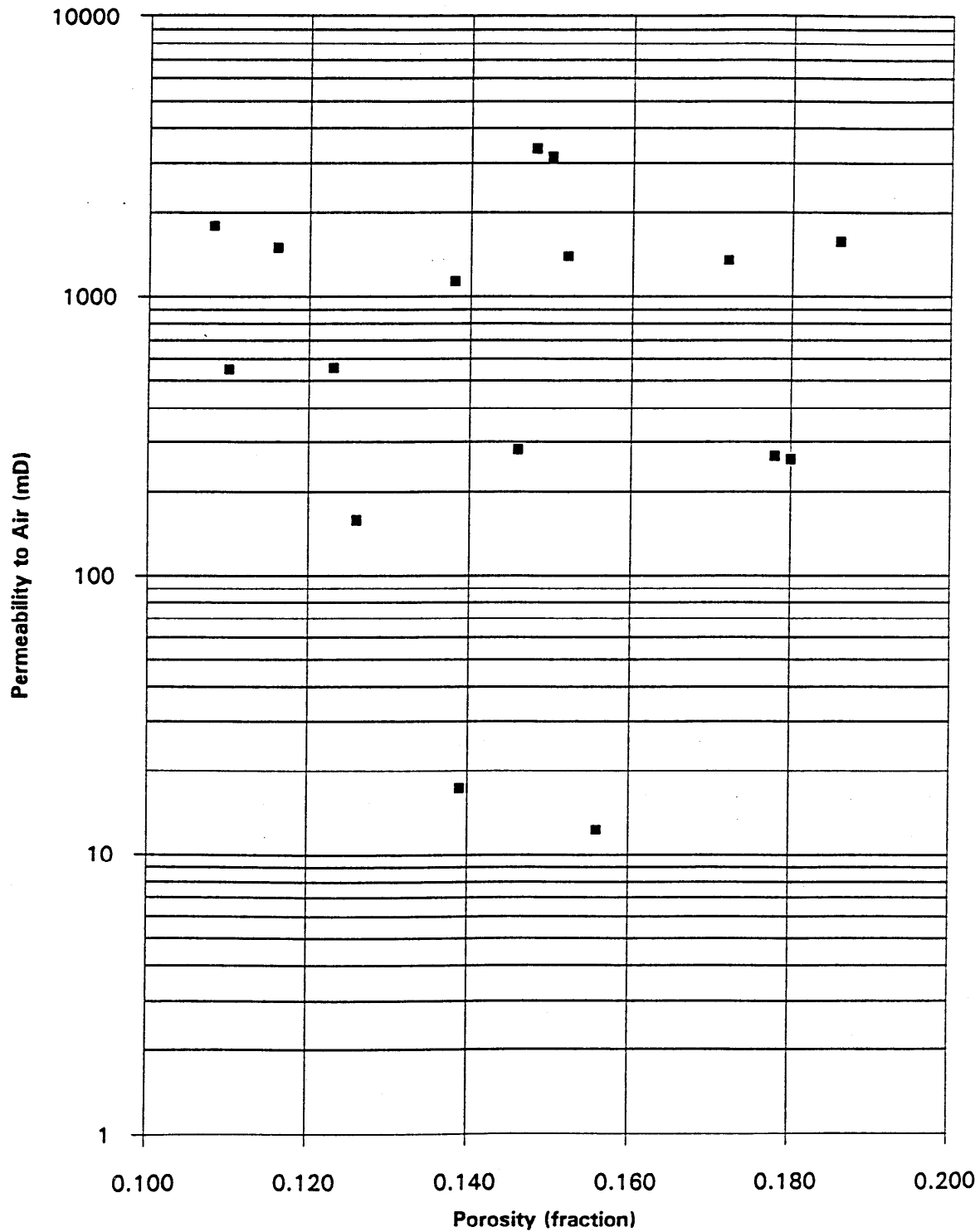
CONNATE WATER SATURATION

Company	BHP Petroleum
Well	Minerva 1
Test Method	Centrifuge Air/Brine Drainage
Ambient	
Phase 1a	

Table III

Sample Number	Capillary Pressure, psi	Permeability to Air, millidarcies	Porosity, fraction	Average Saturation, fraction	End-Face* Saturation
24	77.8	701	0.1200	.075	0.065
50	93.5	318	0.1870	.178	0.158
59	93.6	1601	0.1770	.100	0.088
61	93.7	5641	0.1570	.081	0.071

*   End-Face saturation (extrapolated)

Connate Water Saturation

Company: BHP Petroleum Pty Ltd
Well: Minerva 1

Ambient

Phase 1a
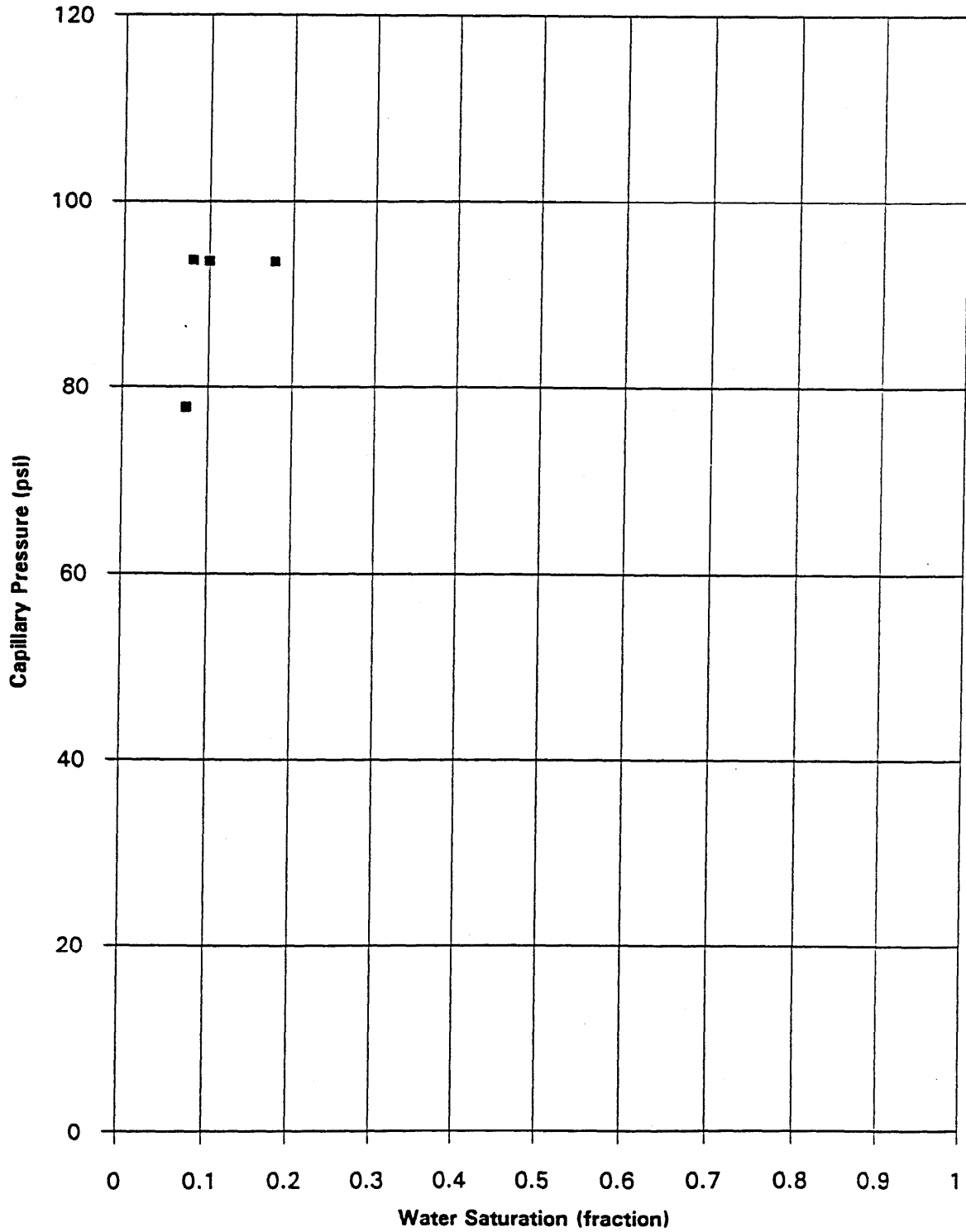
Capillary Pressure (psi) vs Water Saturation (fraction)

CAPILLARY PRESSURE

Company	BHP Petroleum
Well	Minerva 1

Test Method	Centrifuge: Air/Brine Drainage
Sample Number	21
Depth	1830.77 metres
Permeability to Air	2502 millidarcies
Porosity	0.118 fraction
Ambient	

Phase 1b

Table IV

Capillary Pressure (psi)	Average Saturation, fraction	End-Face Saturation, fraction
0.4	0.722	0.216
1.9	0.243	0.113
3.8	0.165	0.088
6.9	0.134	0.075
10.8	0.119	0.068
16.2	0.104	0.063
22.0	0.088	0.060
28.3	0.077	0.058
36.6	0.070	0.056
43.8	0.068	0.055
63.6	0.068	0.053
69.1	0.067	0.053
74.7	0.067	0.053
86.6	0.067	0.052

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **21**

Test Method: **Centrifuge Air/Brine Drainage**
Ambient
Phase 1b
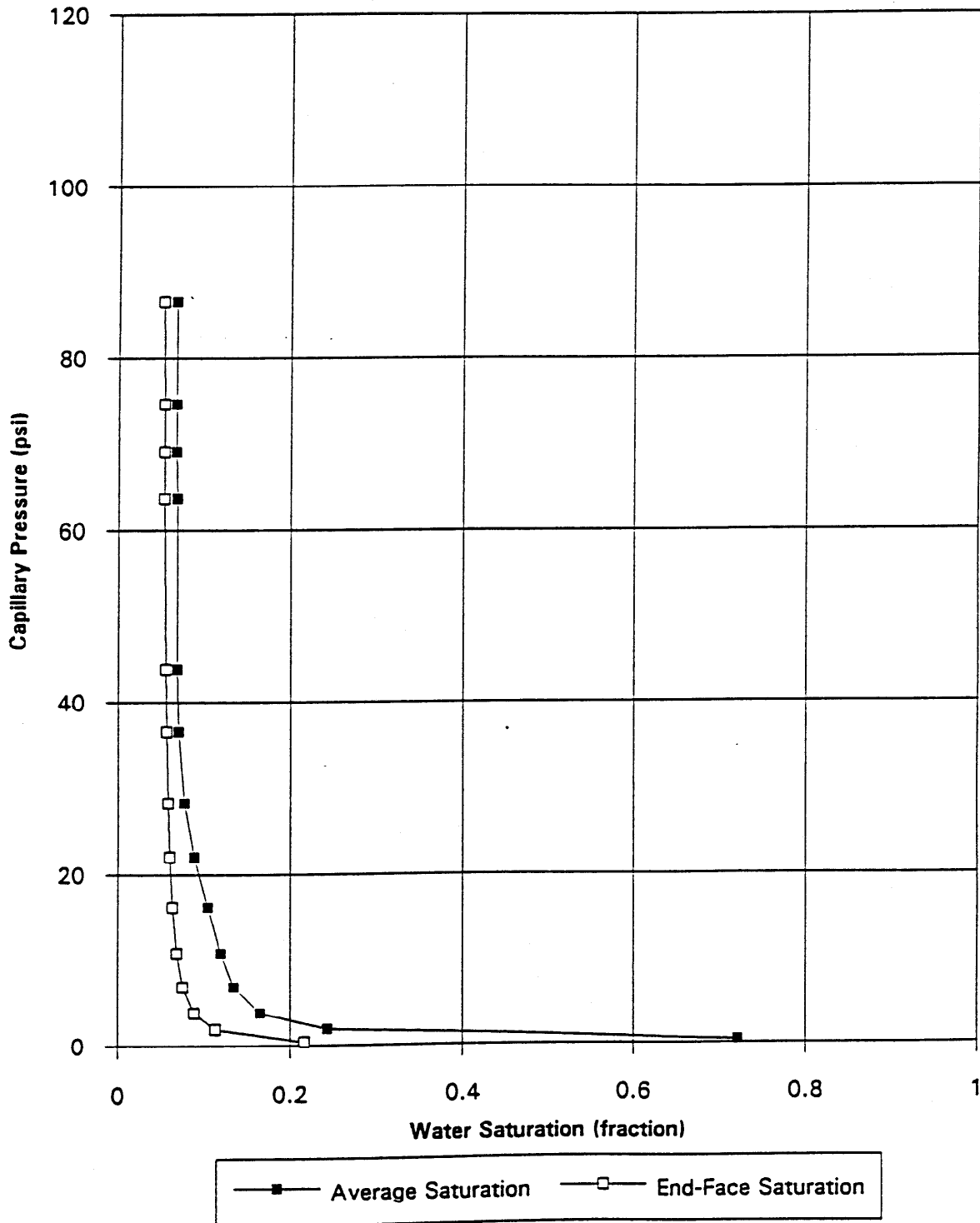
CAPILLARY PRESSURE

Company	BHP Petroleum
Well	Minerva 1
Test Method	Centrifuge: Air/Brine Drainage
Sample Number	31
Depth	1833.80 metres
Permeability to Air	23.3 millidarcies
Porosity	0.147 fraction
Ambient	

Phase 1b

Table V

Capillary Pressure (psi)	Average Saturation, fraction	End-Face Saturation, fraction
0.5	0.853	0.794
2.2	0.818	0.553
4.7	0.689	0.445
8.3	0.583	0.385
13.1	0.501	0.350
19.6	0.436	0.325
26.6	0.407	0.309
34.2	0.377	0.299
44.3	0.346	0.289
53.0	0.330	0.283
77.0	0.324	0.272
83.6	0.321	0.270
90.4	0.320	0.268
104.8	0.318	0.265

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **31**

Test Method: **Centrifuge Air/Brine Drainage**
Ambient
Phase 1b
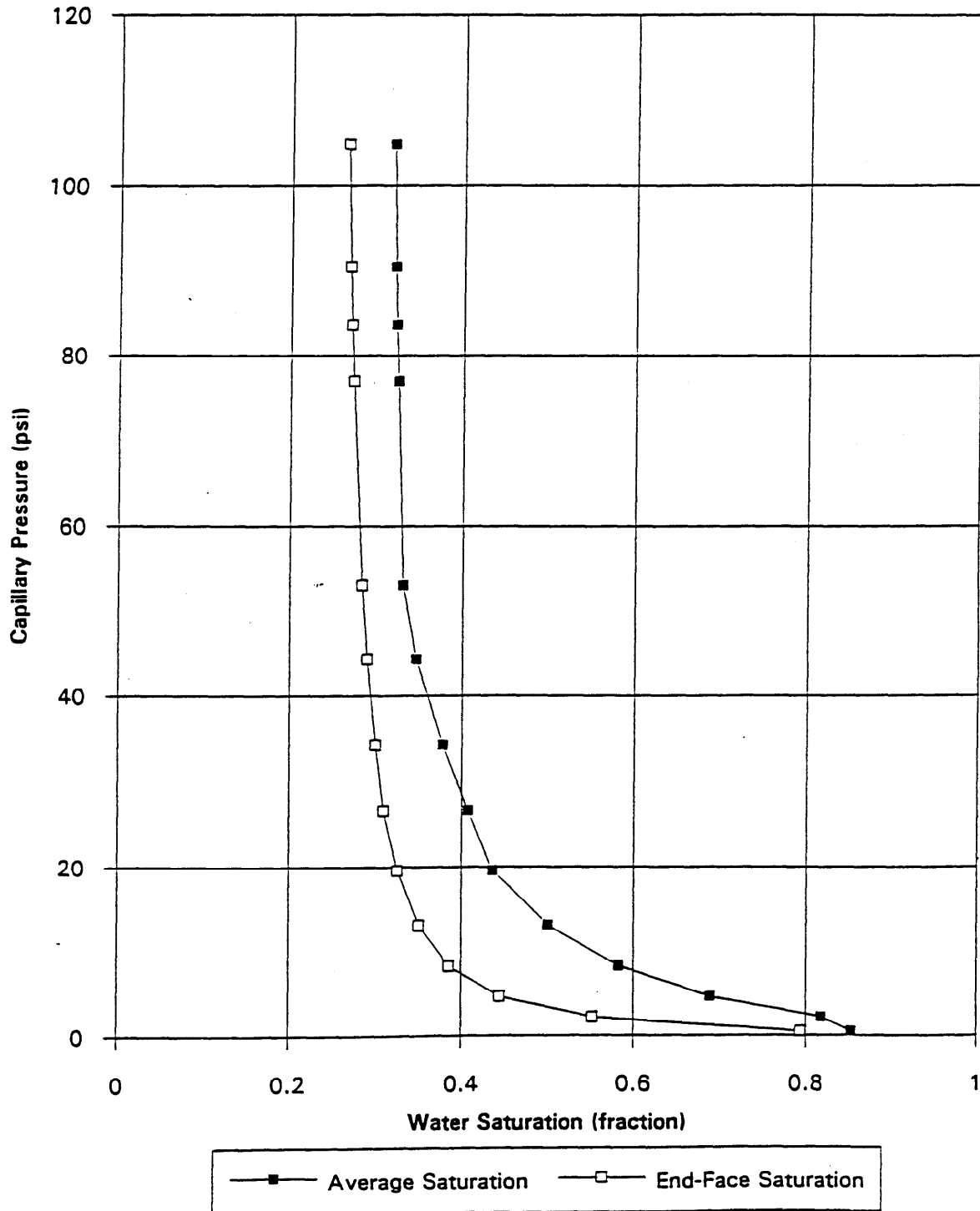
CAPILLARY PRESSURE

Company	BHP Petroleum
Well	Minerva 1
Test Method	Centrifuge: Air/Brine Drainage
Sample Number	56
Depth	1844.05 metres
Permeability to Air	402 millidarcies
Porosity	0.152 fraction
Ambient	

Phase 1b

Table VI

Capillary Pressure (psi)	Average Saturation, fraction	End-Face Saturation, fraction
0.5	0.707	0.506
2.2	0.448	0.282
4.6	0.307	0.216
8.3	0.254	0.179
13.1	0.200	0.157
19.6	0.166	0.140
26.6	0.149	0.130
34.2	0.132	0.123
44.2	0.121	0.115
52.9	0.119	0.112
76.9	0.114	0.104
83.5	0.113	0.103
90.3	0.113	0.100
104.7	0.113	0.099

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **56**

Test Method: **Centrifuge Air/Brine Drainage**
Ambient
Phase 1b
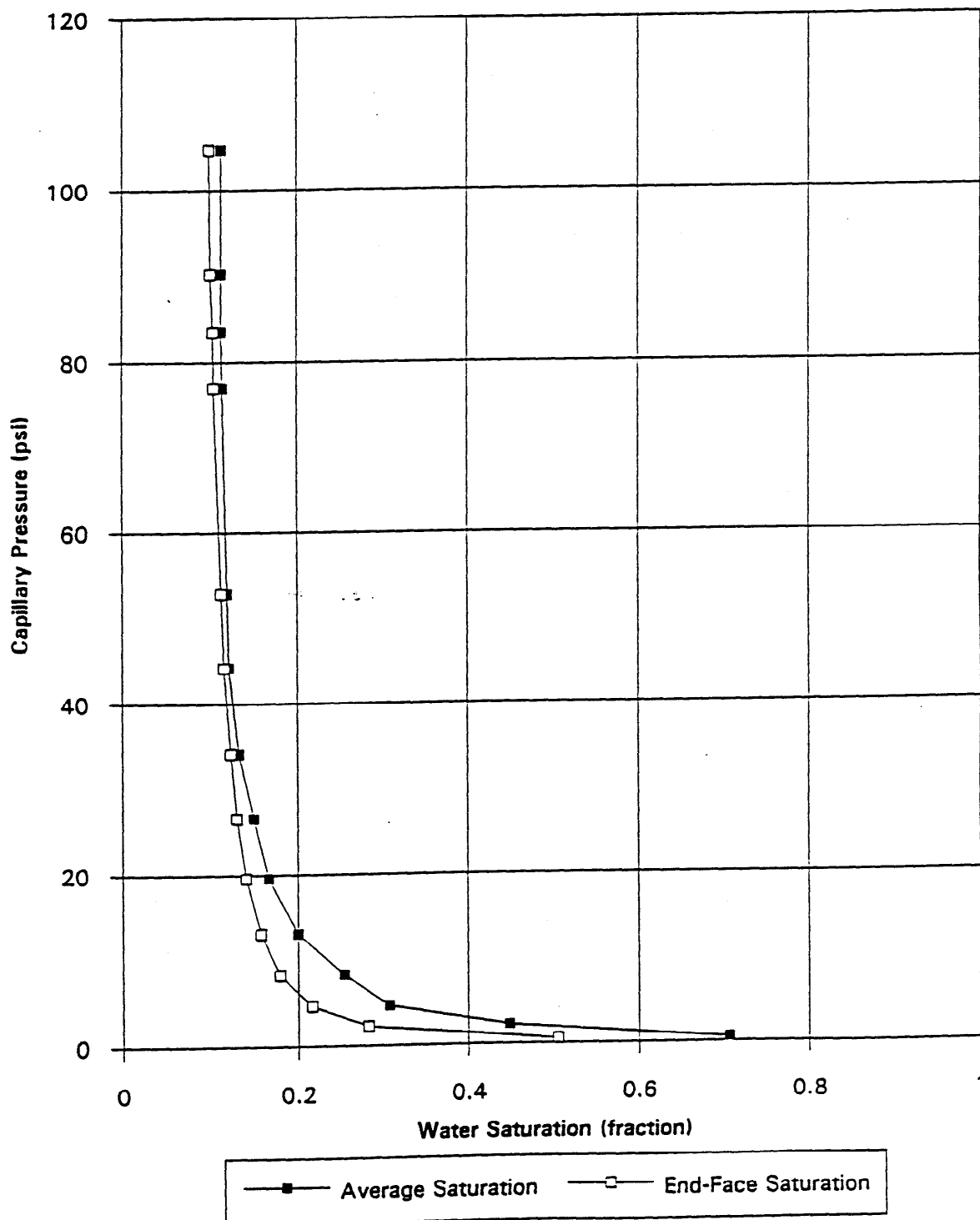
CAPILLARY PRESSURE

Company	BHP Petroleum
Well	Minerva 1
Test Method	Centrifuge: Air/Brine Drainage
Sample Number	65
Depth	1846.77 metres
Permeability to Air	1371 millidarcies
Porosity	0.144 fraction
Ambient	

Phase 1b

Table VII

Capillary Pressure (psi)	Average Saturation, fraction	End-Face Saturation, fraction
0.5	0.869	0.324
2.2	0.403	0.155
4.6	0.263	0.119
8.3	0.200	0.101
13.1	0.165	0.091
19.5	0.129	0.085
26.5	0.111	0.079
34.2	0.099	0.077
44.2	0.087	0.076
52.9	0.085	0.074
76.9	0.083	0.073
83.5	0.083	0.072
90.3	0.082	0.072
104.7	0.082	0.072

Capillary Pressure

Company: BHP Petroleum Pty Ltd
Well: Minerva 1
Sample: 65

Test Method: Centrifuge Air/Brine Drainage
Ambient
Phase 1b
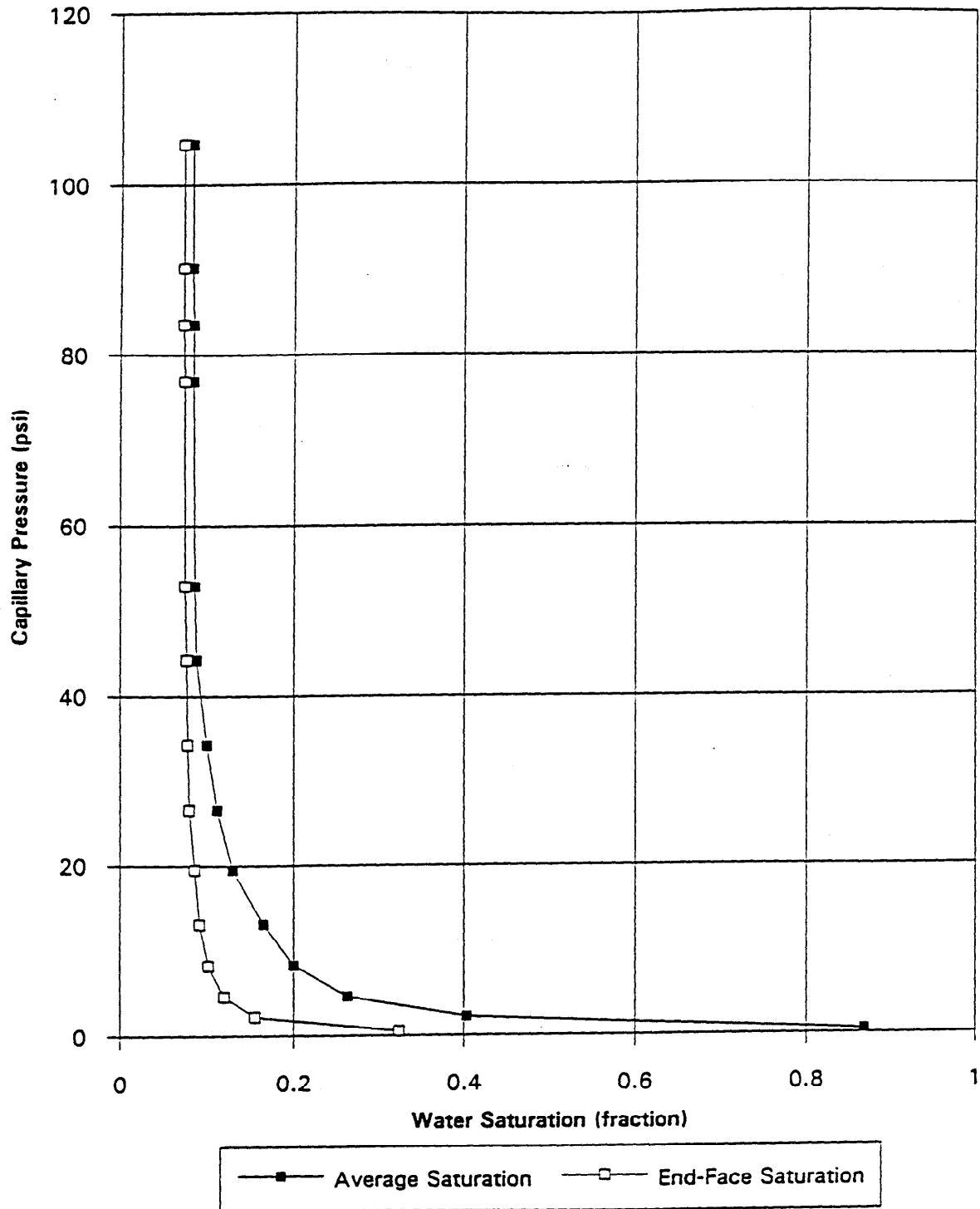
8/225 Minerva 1

FORMATION FACTOR

Company	BHP Petroleum Pty Ltd
Well	Minerva 1

Saturant	35,000 ppm brine
Rw of Saturant	0.18 ohm-m @ 25°C
Overburden Pressure	2100 psi

Phase 1c/d

Table VIII

Sample Number	Depth, metres	Overburden Permeability to Air, millidarcies	Overburden Porosity, fraction	Formation Factor (FF)	Cementation Exponent, 'm'
9	1823.47	1389	0.152	24.1	1.69
12	1828.15	1571	0.186	20.4	1.79
17	1829.57	1494	0.116	39.8	1.71
34	1834.70	158	0.126	41.6	1.80
37	1835.60	268	0.178	20.9	1.76
49	1840.60	12.3	0.156	36.0	1.93
52	1842.80	558	0.123	43.8	1.80
53	1843.10	3366	0.148	13.3	1.36

Formation Factor

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**

Overburden Pressure 2100 psi
Phase 1c/d

Porosity (fraction)

RESISTIVITY INDEX

Company	BHP Petroleum Pty Ltd
Well	Minerva 1

Saturant	35,000 ppm brine
Rw of Saturant	0.18 ohm-m @ 25°C
Overburden Pressure	2,100 psi

Phase 1c/d   Table IX
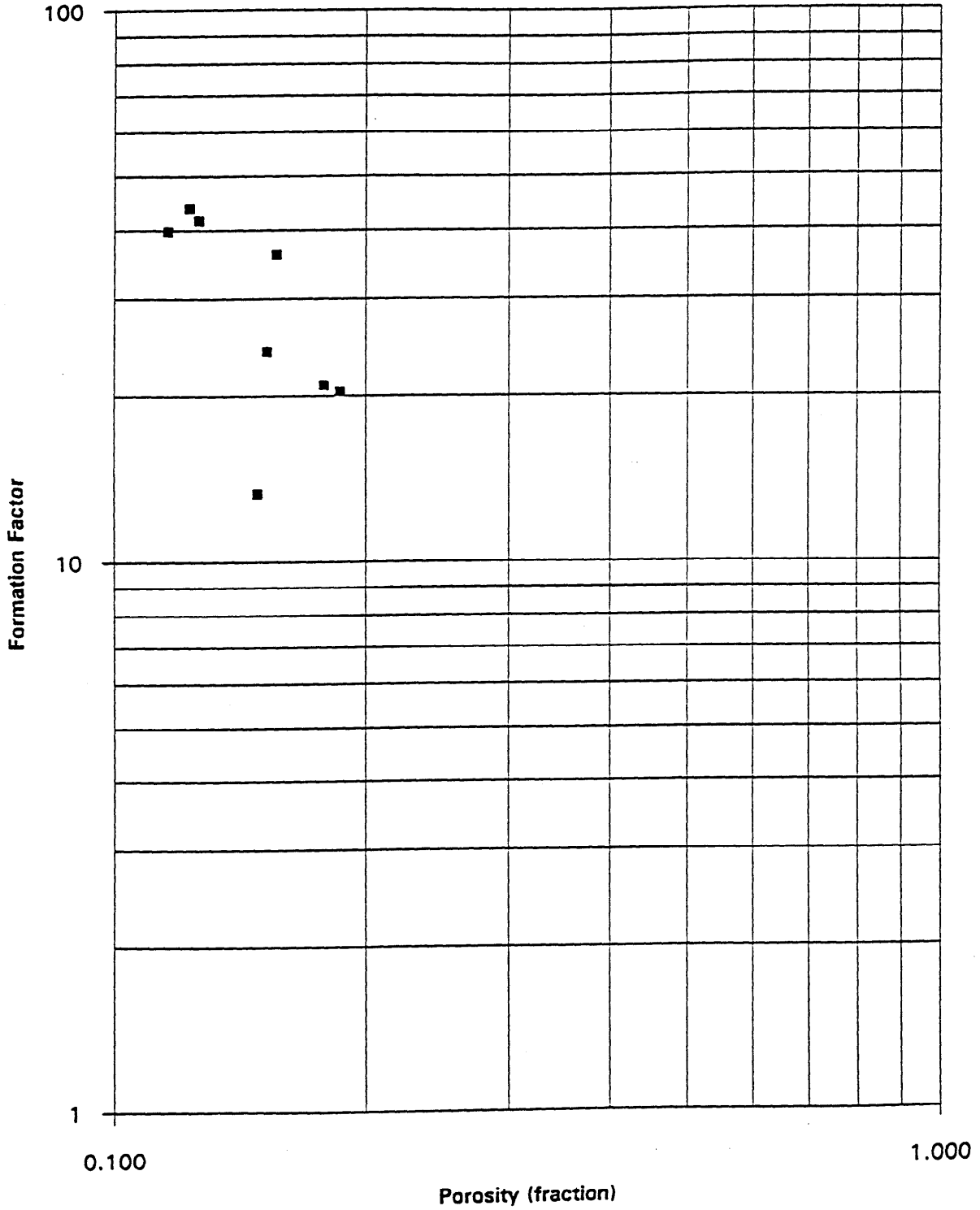
Sample Number	Depth, metres	Overburden Permeability to Air, millidarcies	Overburden Porosity, fraction	Formation Factor (FF)	Brine Saturation, fraction	Resistivity Index (RI)	Saturation Exponent, 'n'
9	1823.47	1389	0.152	24.0	1.000	1.00	-
					0.751	1.65	1.73
					0.475	3.54	1.78
					0.374	5.86	1.80
					0.314	8.85	1.88
					0.279	11.1	1.89
					0.258	13.7	1.93
					0.223	19.5	1.98
					0.199	26.6	2.01
					0.118	72.3	2.00
					0.074	195	2.01
						mean 'n'	1.90
12		1571	0.186	20.3	1.000	1.00	-
					0.743	1.69	1.77
					0.422	4.49	1.74
					0.372	5.60	1.74
					0.327	6.53	1.68
					0.283	7.96	1.64
					0.240	10.3	1.63
					0.224	10.9	1.60
					0.220	11.8	1.63
						mean 'n'	1.68
17		1494	0.116	39.8	1.000	1.00	-
					0.476	3.66	1.75
					0.383	5.52	1.78
					0.338	7.12	1.81
					0.294	8.92	1.77
					0.194	18.7	1.79
					0.168	23.3	1.77
					0.148	33.0	1.83
						mean 'n'	1.87

Table IX (cont.)

Sample Number	Depth, metres	Overburden Permeability to Air, millidarcies	Overburden Porosity, fraction	Formation Factor (FF)	Brine Saturation, fraction	Resistivity Index (RI)	Saturation Exponent, 'n'
34	1834.70	158	0.126	41.6	1.000	-	
					0.753	1.73	1.93
					0.725	1.85	1.91
					0.674	2.12	1.90
					0.546	3.18	1.91
					0.490	3.98	1.93
					0.455	4.73	1.97
					0.393	6.18	1.95
					0.374	6.68	1.93
						mean 'n'	1.93
37	1835.60	268	0.178	20.9	1.000	1.00	-
					0.681	2.13	1.97
					0.567	3.23	2.06
					0.473	4.61	2.04
					0.330	9.71	2.05
					0.294	12.5	2.06
					0.264	17.1	2.13
					0.248	18.6	2.10
						mean 'n'	2.06
49	1840.60	12.3	0.156	37.2	1.000	1.00	-
					0.791	1.49	1.69
					0.653	2.35	1.88
					0.593	2.68	1.89
					0.543	3.24	1.92
					0.458	4.44	1.91
					0.401	5.79	1.92
						mean 'n'	1.87
52	1842.80	558	0.123	43.8	1.000	1.00	-
					0.822	1.47	1.97
					0.464	4.55	1.97
					0.368	7.46	2.01
					0.344	8.71	2.03
					0.250	15.1	1.96
					0.224	17.6	1.91
					0.197	26.4	2.01
					0.184	27.9	1.96
					0.177	30.0	1.96
						mean 'n'	1.98

Sample Number	Depth, metres	Overburden Permeability to Air, millidarcies	Overburden Porosity, fraction	Formation Factor (FF)	Brine Saturation, fraction	Resistivity Index (RI)	Saturation Exponent, 'n'
53	1843.10	3366	0.148	13.3	1.000	1.00	-
					0.323	10.0	2.04
					0.255	14.6	1.96
					0.193	21.8	1.88
					0.179	27.4	1.93
					0.158	34.9	1.93
					0.137	45.1	1.92
					0.111	68.8	1.92
						mean 'n'	1.94

Resistivity Index

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **9**

Overburden Pressure 2100 psi
Phase 1c/d

Water Saturation (fraction)

8/225 Minerva 1

ACS Laboratories Pty Ltd
ACN: 008 273 005

Resistivity Index

Water Saturation (fraction)

Resistivity Index

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: 17

Overburden Pressure 2100 psi
Phase 1c/d

Water Saturation (fraction)
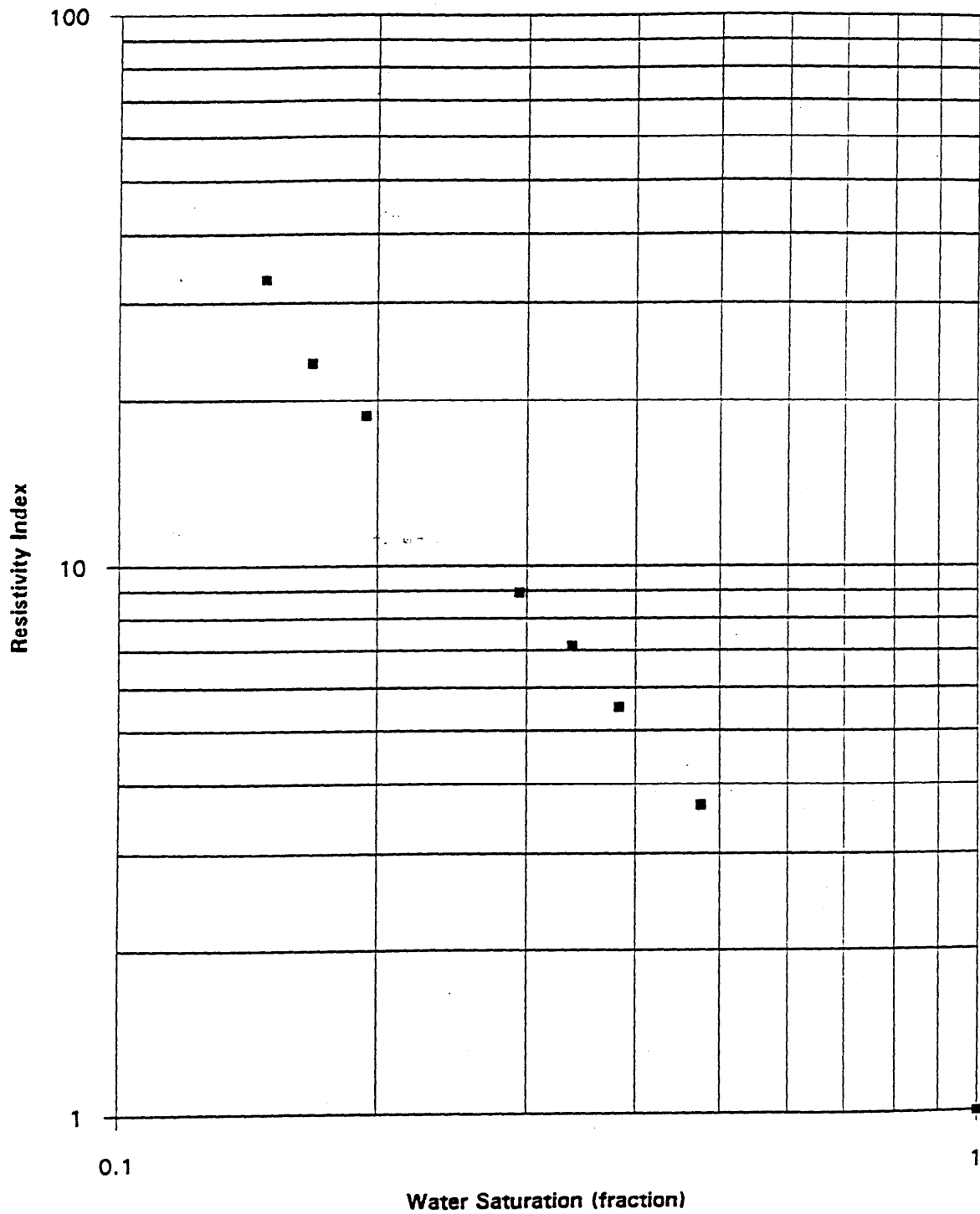
Resistivity Index

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **34**

Overburden Pressure 2100 psi
Phase 1c/d

Water Saturation (fraction)
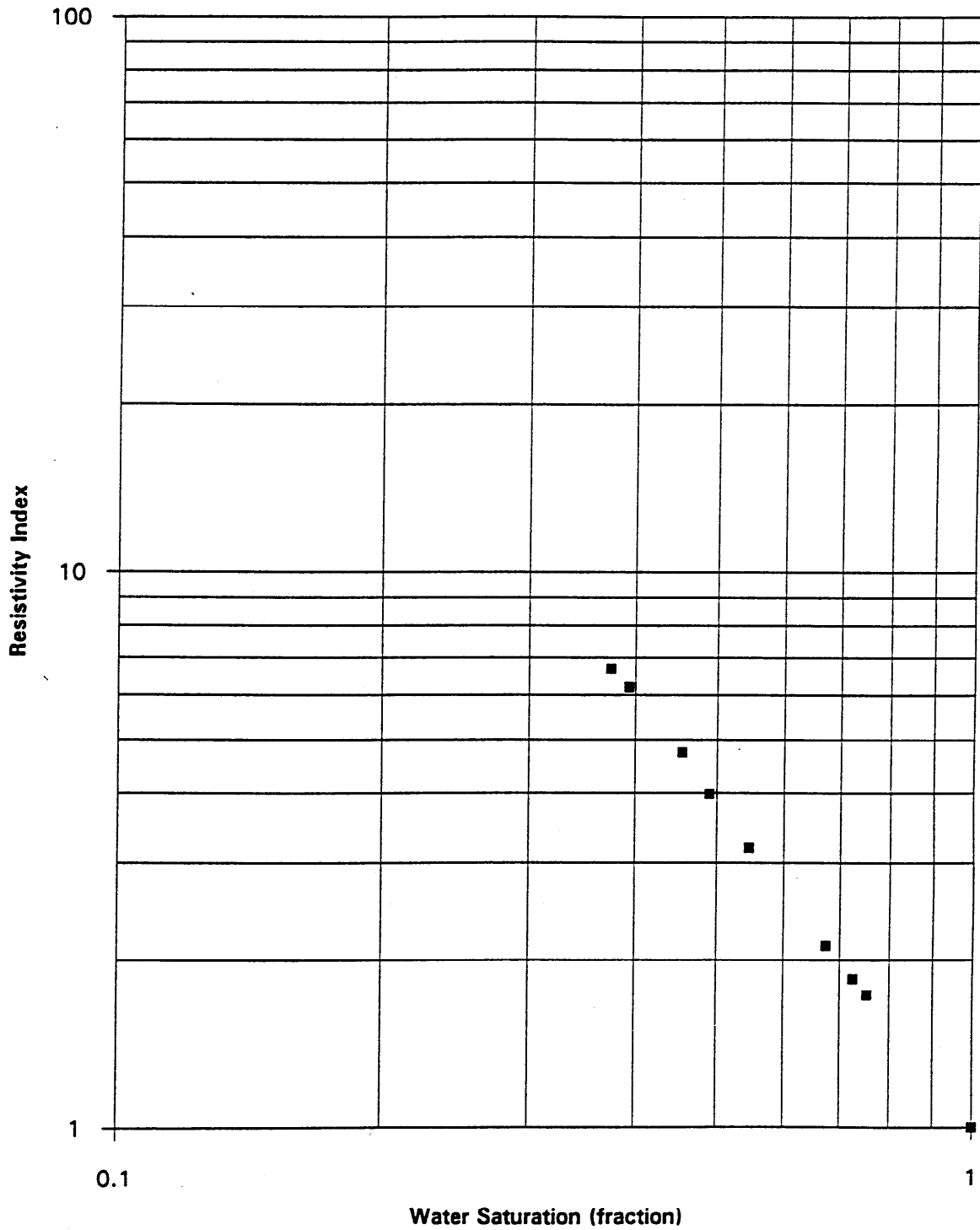
Resistivity Index

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **52**

Overburden Pressure 2100 psi
Phase 1c/d

Water Saturation (fraction)

Resistivity Index

Company: BHP Petroleum Pty Ltd
Well: Minerva 1
Sample: 53

Overburden Pressure 2100 psi
Phase 1c/d

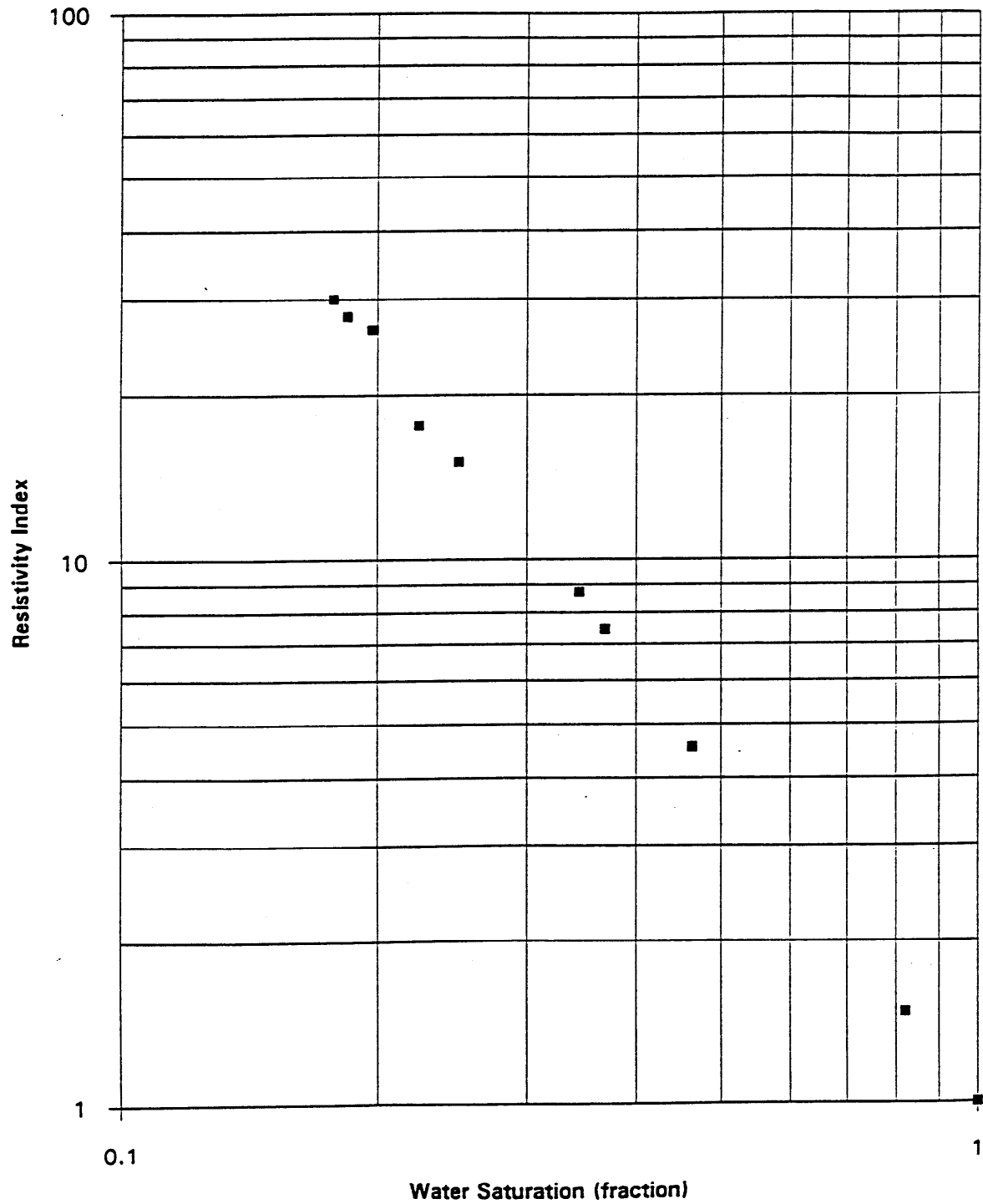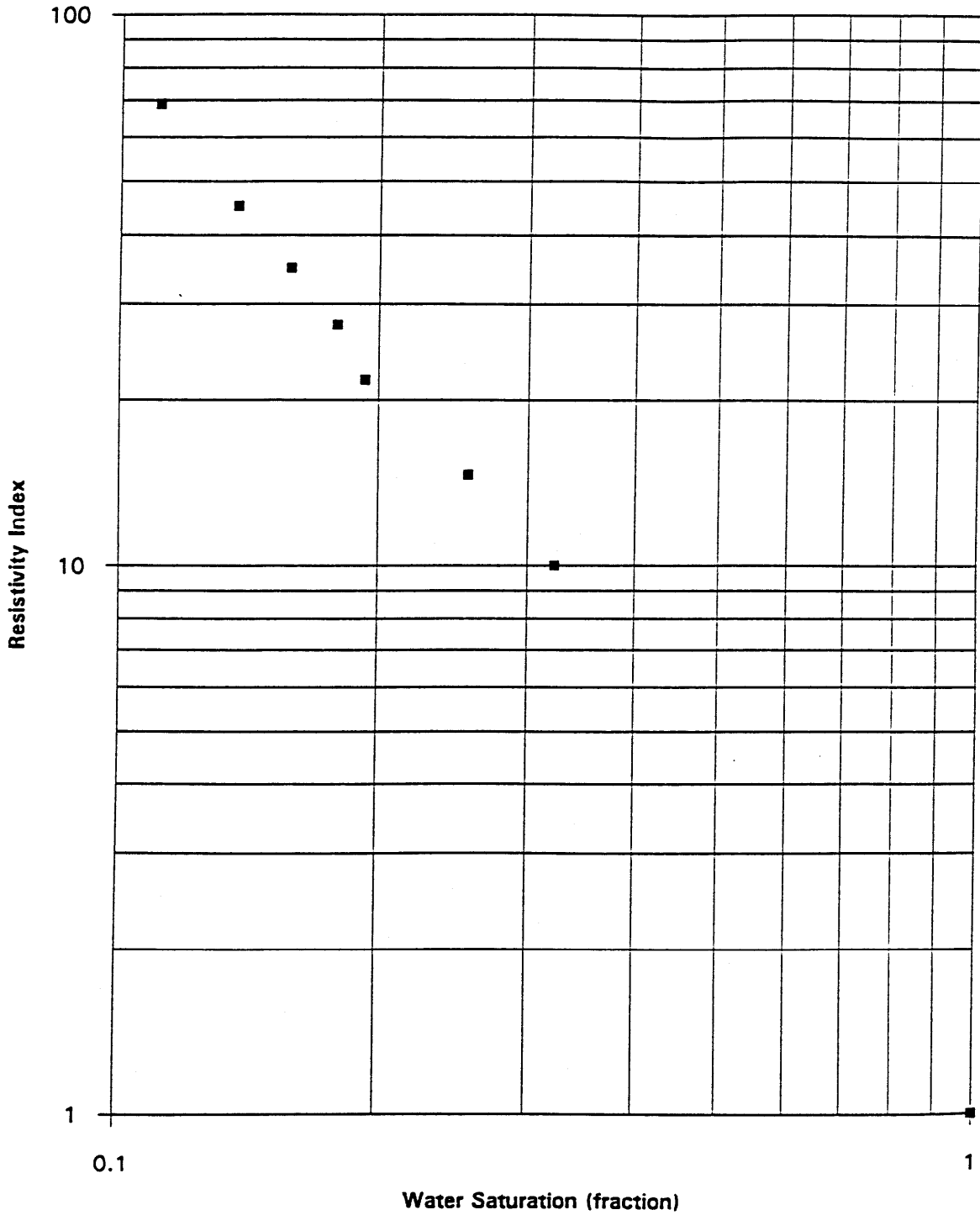**Resistivity Index** (y-axis, logarithmic scale from 1 to 100)

Water Saturation (fraction) (x-axis, logarithmic scale from 0.1 to 1)

CAPILLARY PRESSURE - ATTACHEMNT 1

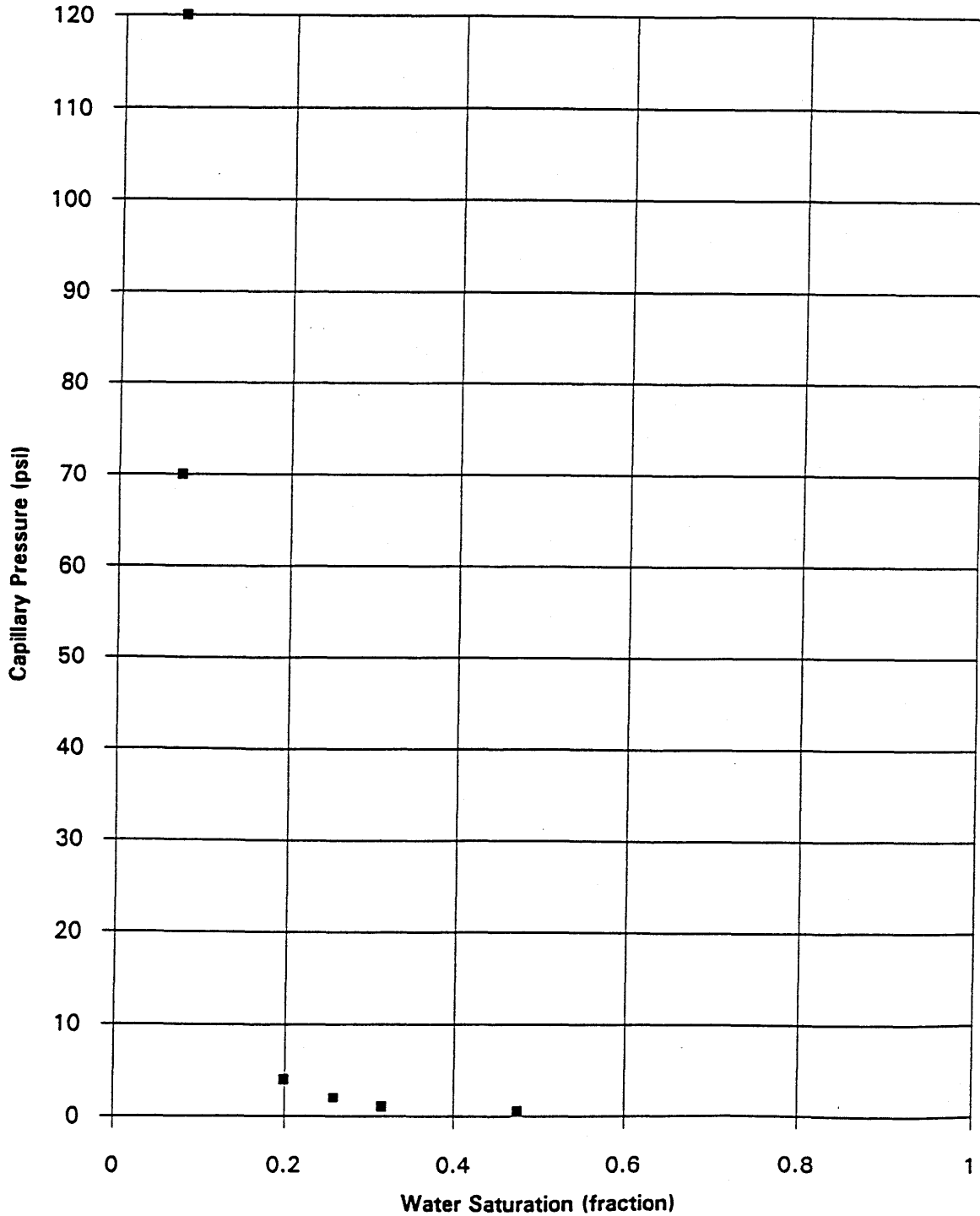Company   BHP Petroleum Pty Ltd
Well   Minerva 1

Test Method   Air/Brine Porous Plate Drainage
Overburden Pressure   2100 psi

Phase 1c/d   Table X

Sample Number	Depth, metres	Permeability to air, millidarcies	Porosity, fraction	0.5	1.0	2.0	4.0	10	15	30	70	120	200
								Saturation, fraction				(interpolated)	
9	1823.47	1389	0.152	0.475	0.314	0.258	0.199	-	-	-	0.074	0.071	0.065
12	1828.15	1571	0.186	0.743	0.422	0.372	0.327	-	-	-	0.224	0.222	0.220
17	1829.57	1494	0.116	0.476	0.383	0.338	0.294	-	-	-	0.150	0.149	0.148
34	1834.70	158	0.126	0.858	0.753	0.725	0.674	-	-	-	0.393	0.386	0.374
37	1835.60	268	0.178	-	0.681	0.567	0.473	-	0.294	-	0.248	0.240	0.227
49	1840.60	12.3	0.156	-	-	-	0.791	0.635	0.593	0.543	0.458	0.436	0.401
52	1842.80	558	0.123	0.822	0.464	0.368	-	-	0.224	0.197	-	0.187	0.177
53	1843.10	3366	0.148	0.255	0.193	-	0.158	-	0.111	-	0.099	0.098	0.098

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **9**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure 2100 psi
Phase 1c/d

8/225 Minerva 1

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **12**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure 2100 psi
Phase 1c/d

8/225 Minerva 1

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **17**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure 2100 psi
Phase 1c/d
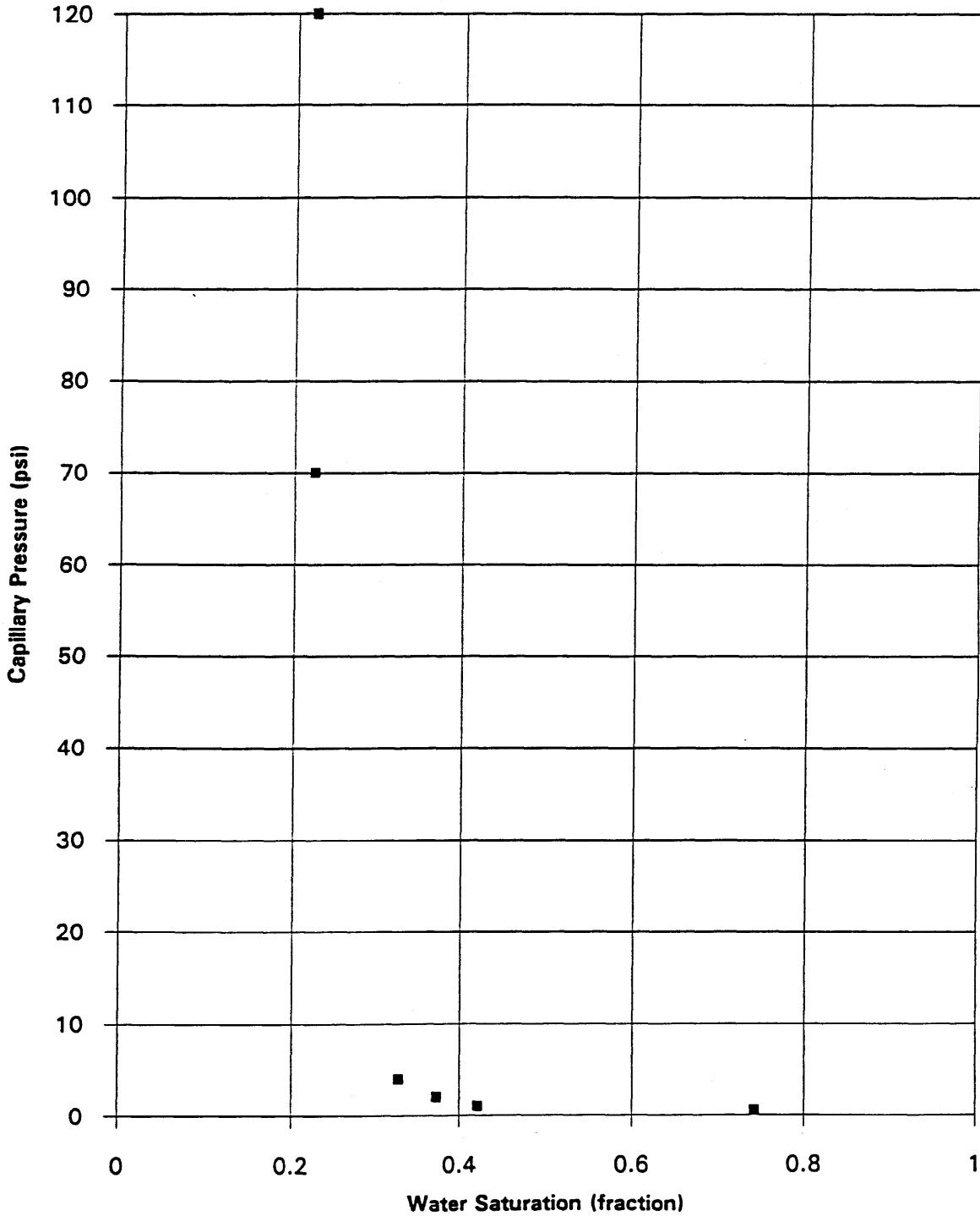
Capillary Pressure
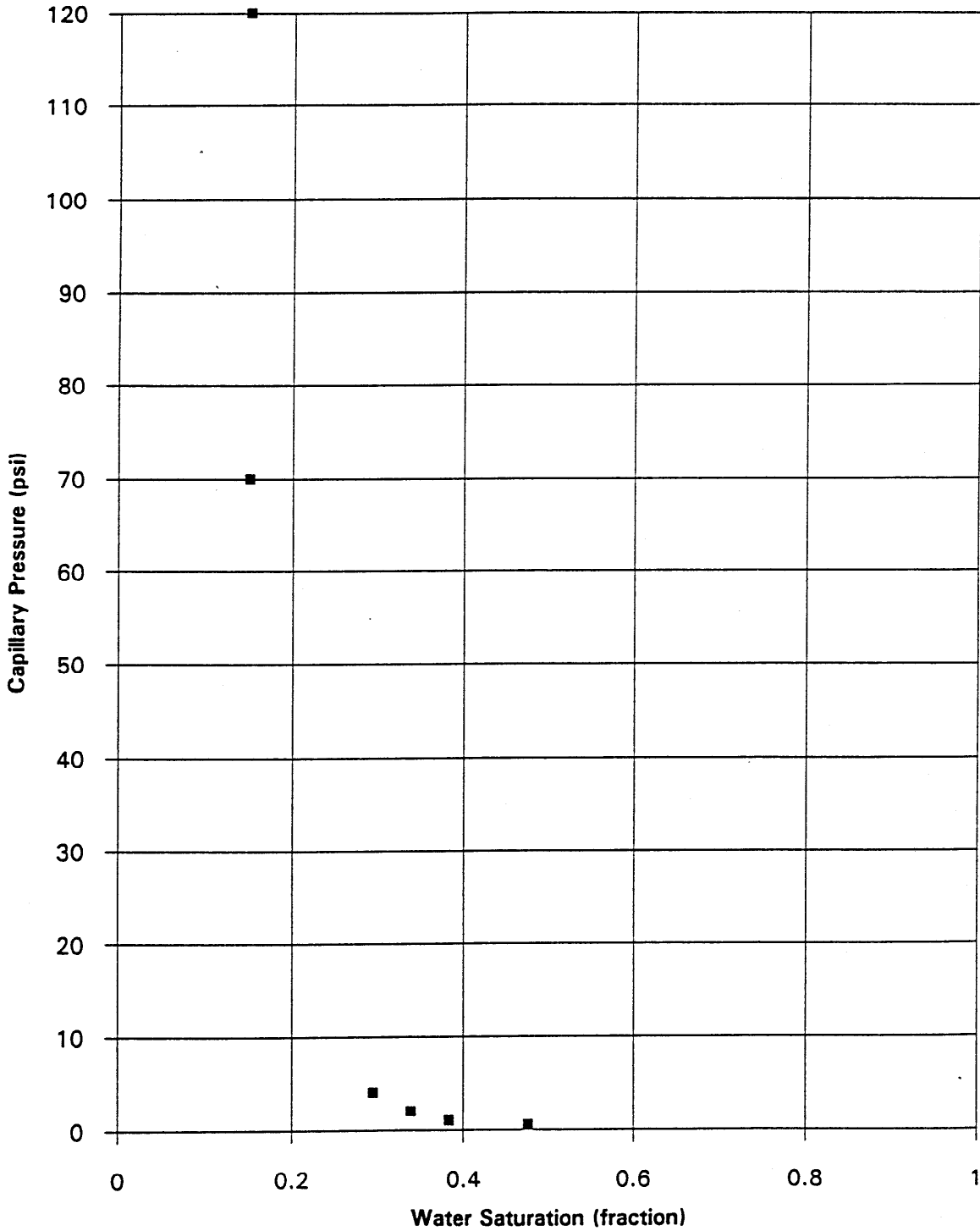
Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **34**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure 2100 psi
Phase 1c/d

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
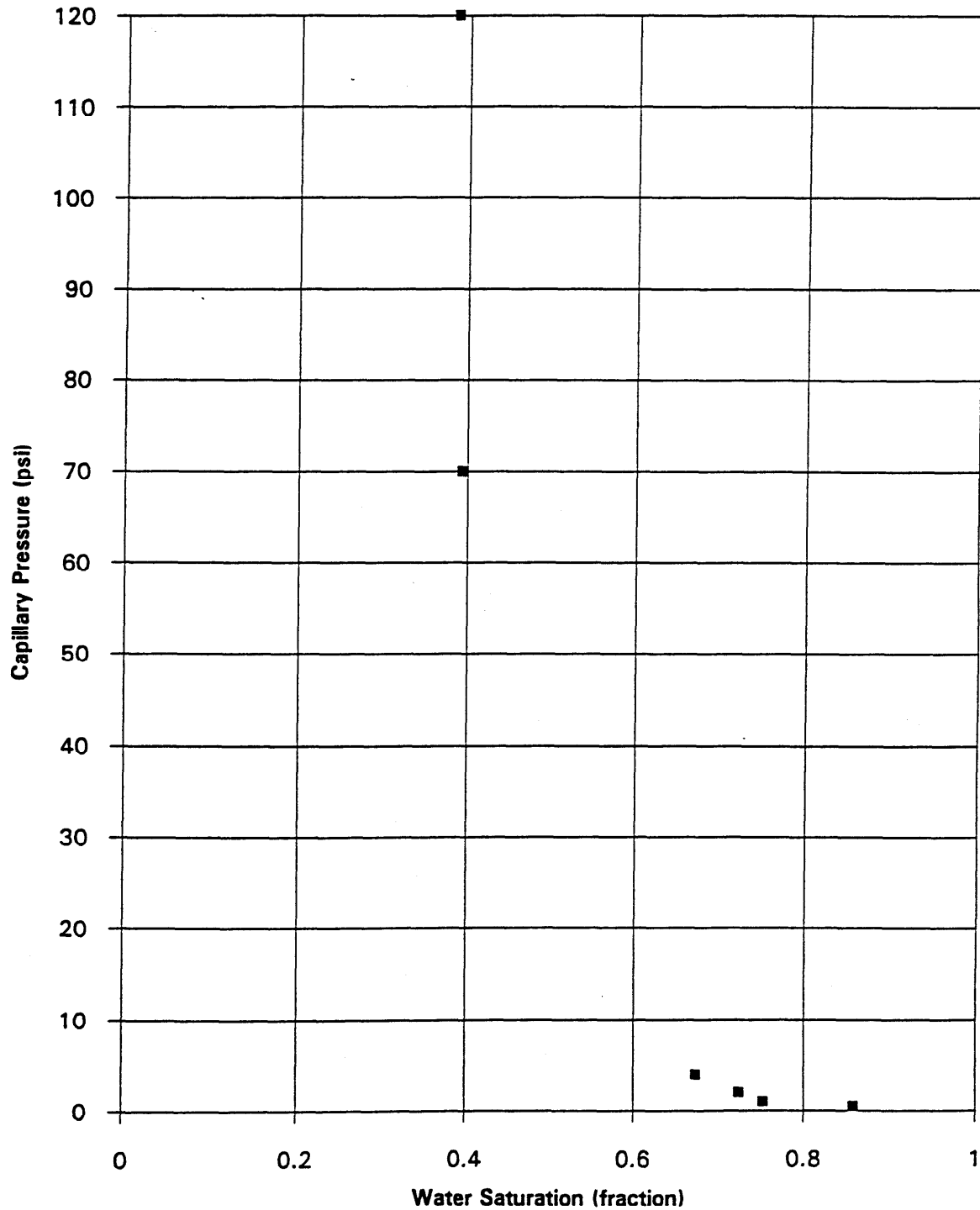Well: **Minerva 1**
Sample: **37**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure **2100 psi**
Phase **1c/d**

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **49**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure **2100 psi**
Phase **1c/d**

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
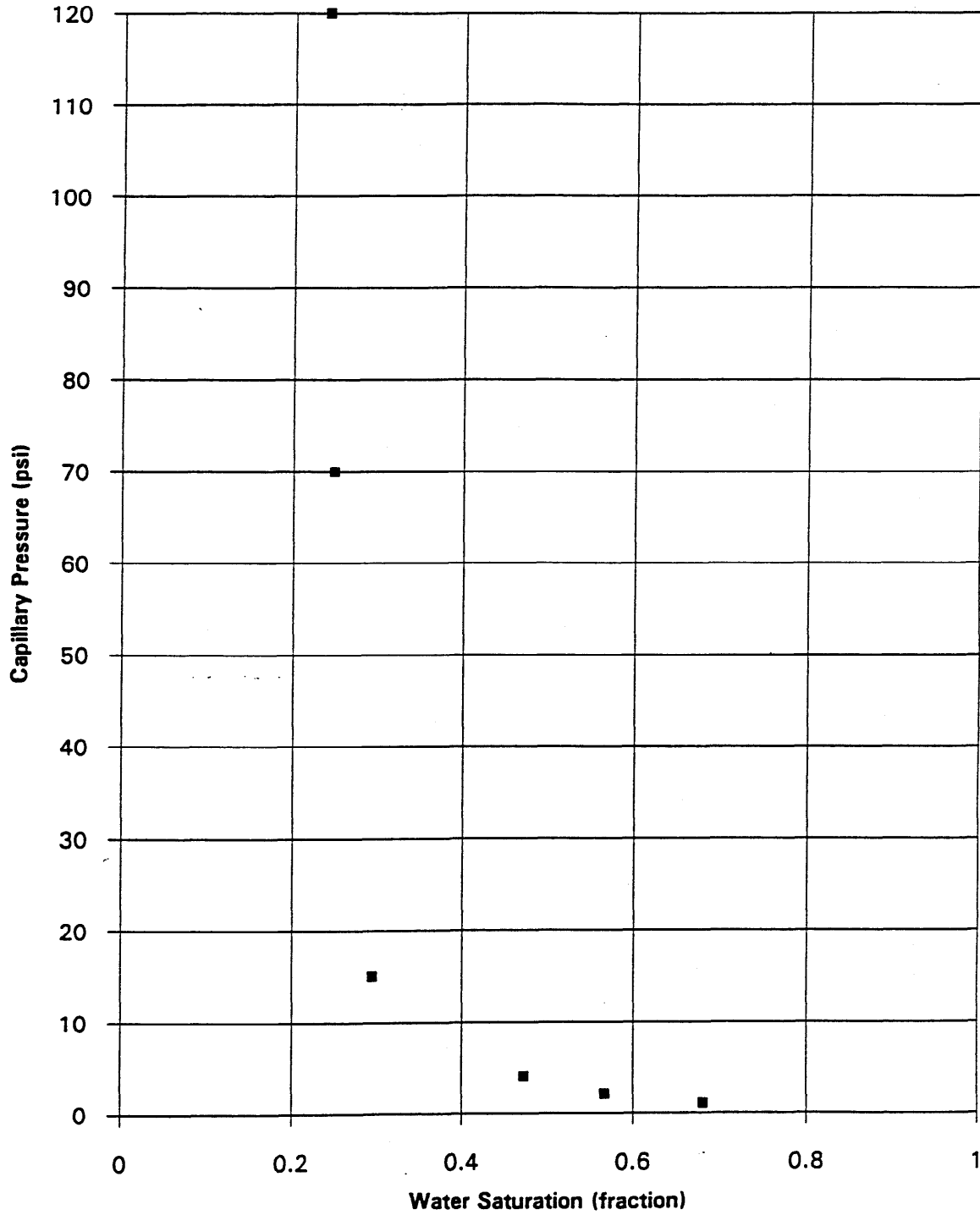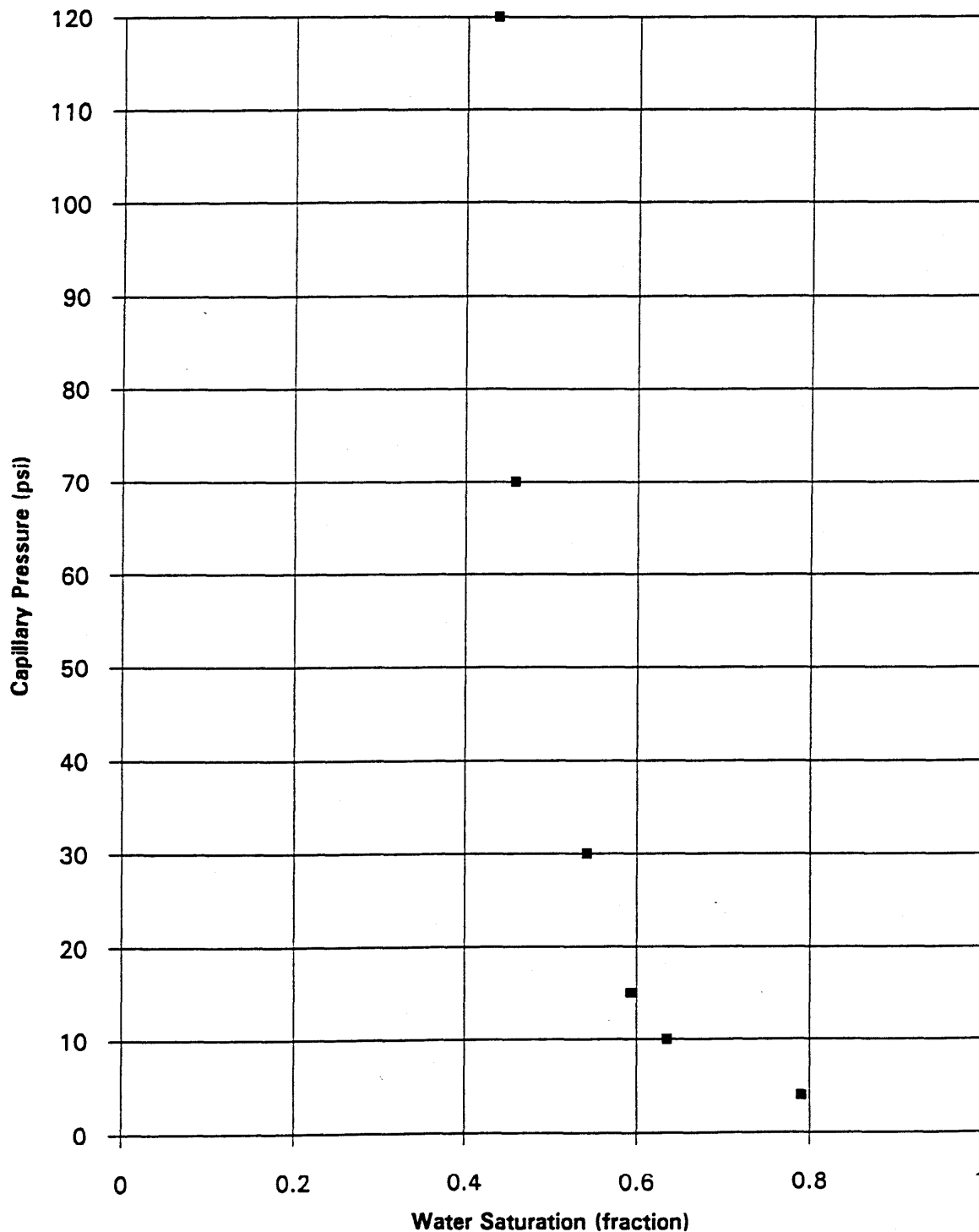Well: **Minerva 1**
Sample: **52**
Test Method: **Porous Plate Air/Brine Drainage**
Overburden Pressure 2100 psi
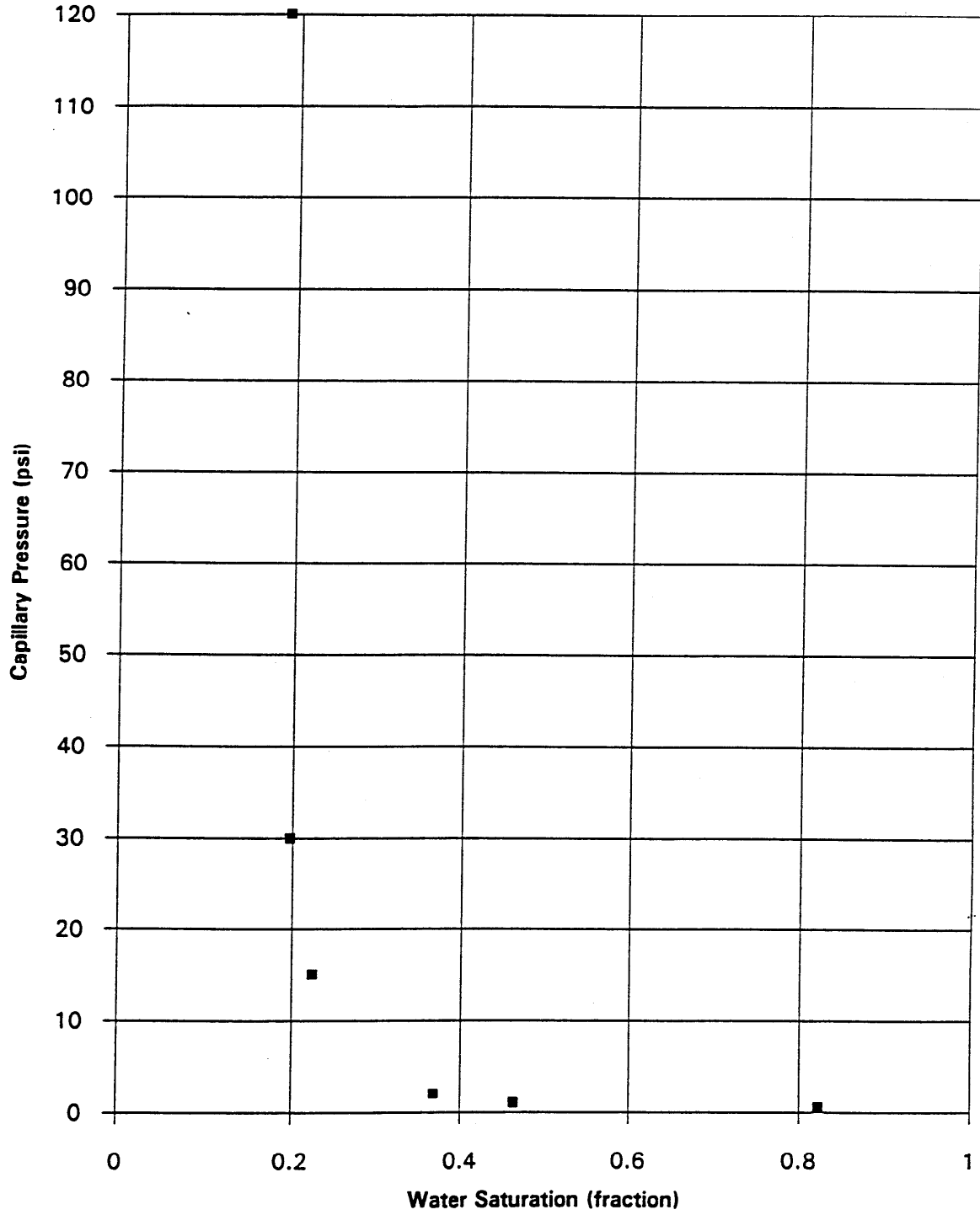**Phase 1c/d**

8/225 Minerva 1

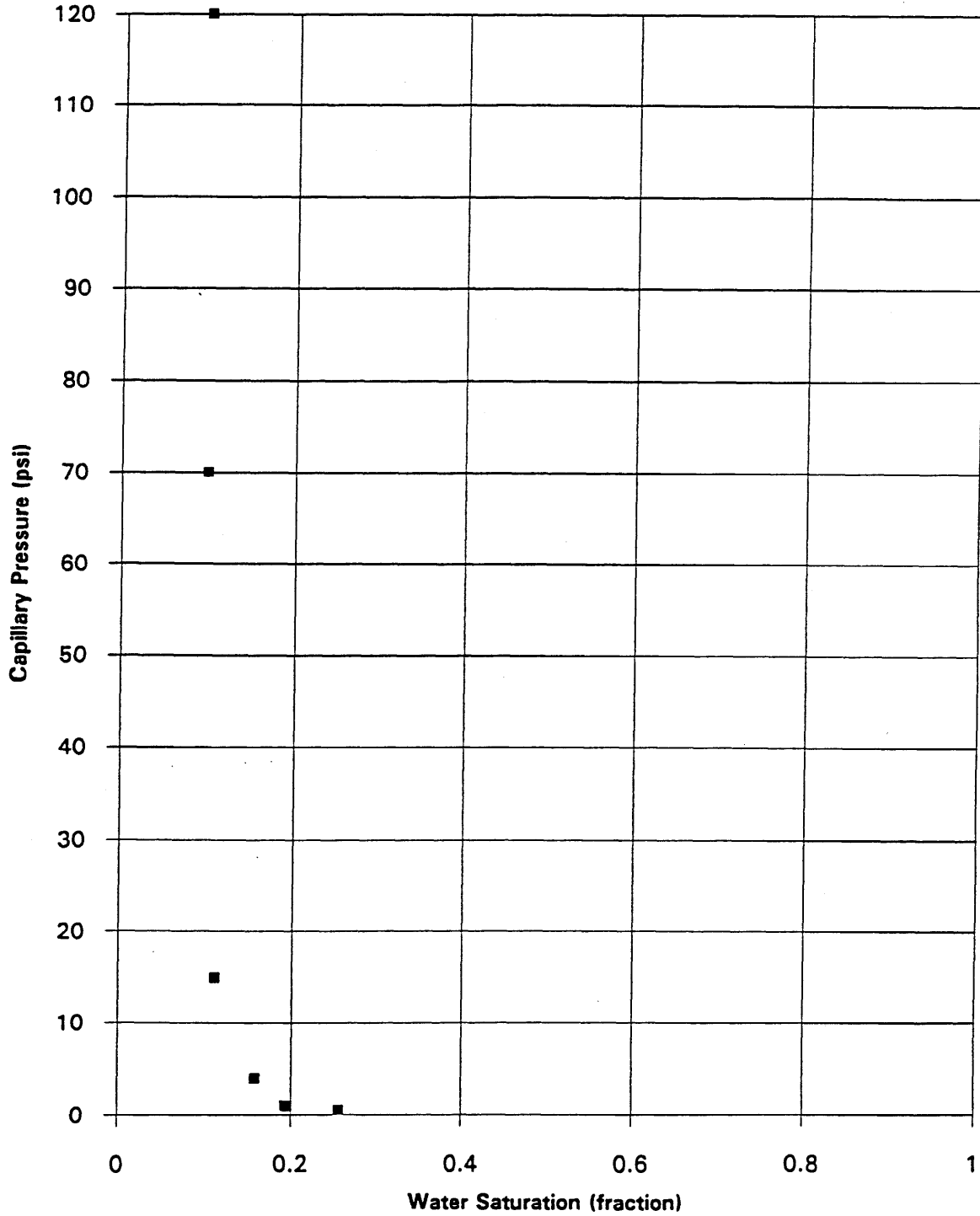# Capillary Pressure

Company: BHP Petroleum Pty Ltd
Well: Minerva 1
Sample: 53
Test Method: Porous Plate Air/Brine Drainage
Overburden Pressure 2100 psi
Phase 1c/d

EFFECTIVE PERMEABILITY TO GAS

Company	BHP Petroleum
Well	Minerva 1

Overburden Pressure   2100 psi

Phase 2a   Table XI

Sample Number	Depth, metres	Permeability to Air, millidarcies	Porosity, fraction	Water Saturation, fraction	Effective Permeability to Gas, millidarcys
21	1830.77	1793	0.108	0.074	1598
24	1831.70	551	0.110	0.083	352
31	1833.80	17.3	0.139	0.339	14.0
50	1840.90	261	0.180	0.187	234
56	1844.05	283	0.146	0.118	253
59	1844.90	1348	0.172	0.104	1214
61	1845.52	3145	0.150	0.085	2740
65	1846.72	1133	0.130	0.086	1014

Effective Permeability to Gas vs Water Saturation

Company: BHP Petroleum Pty Ltd
Well: Minerva 1

Overburden Pressure 2100 psi
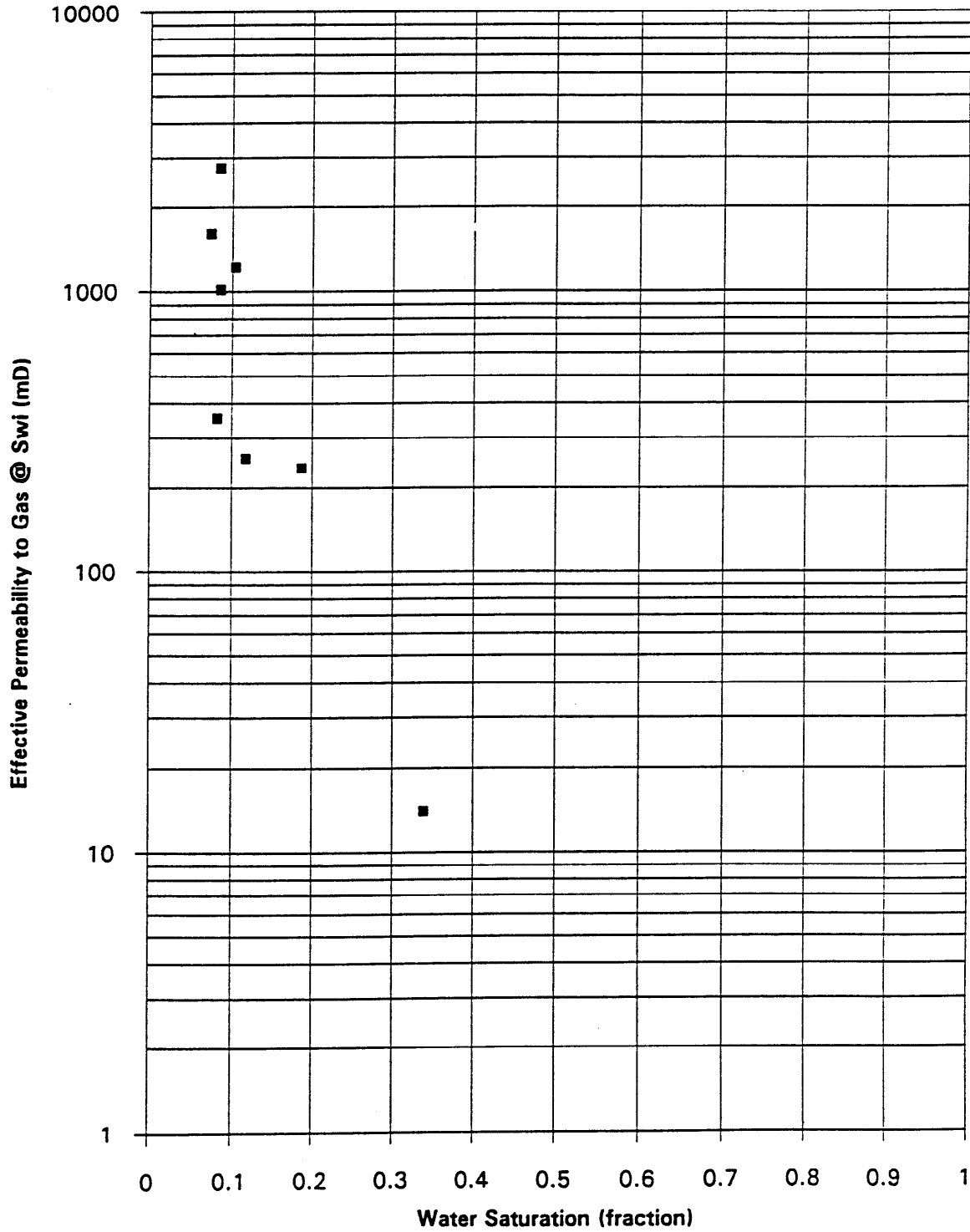
Phase 2a

RESIDUAL GAS SATURATION

Company   BHP Petroleum
Well   Minerva 1

Test Method   Centrifuge Brine Imbibition

Ambient

Phase 2b(i)   Table XII

Sample Number	Capillary Pressure, psi	Permeability to Air, millidarcys	Porosity, fraction	Gas Saturation, fraction
24	-77.8	701	0.120	0.131
50	-93.5	318	0.187	0.180
59	-93.6	1601	0.177	0.218
61	-93.7	5641	0.157	0.133

Permeability to Air vs Water Saturation or (1-Sg)
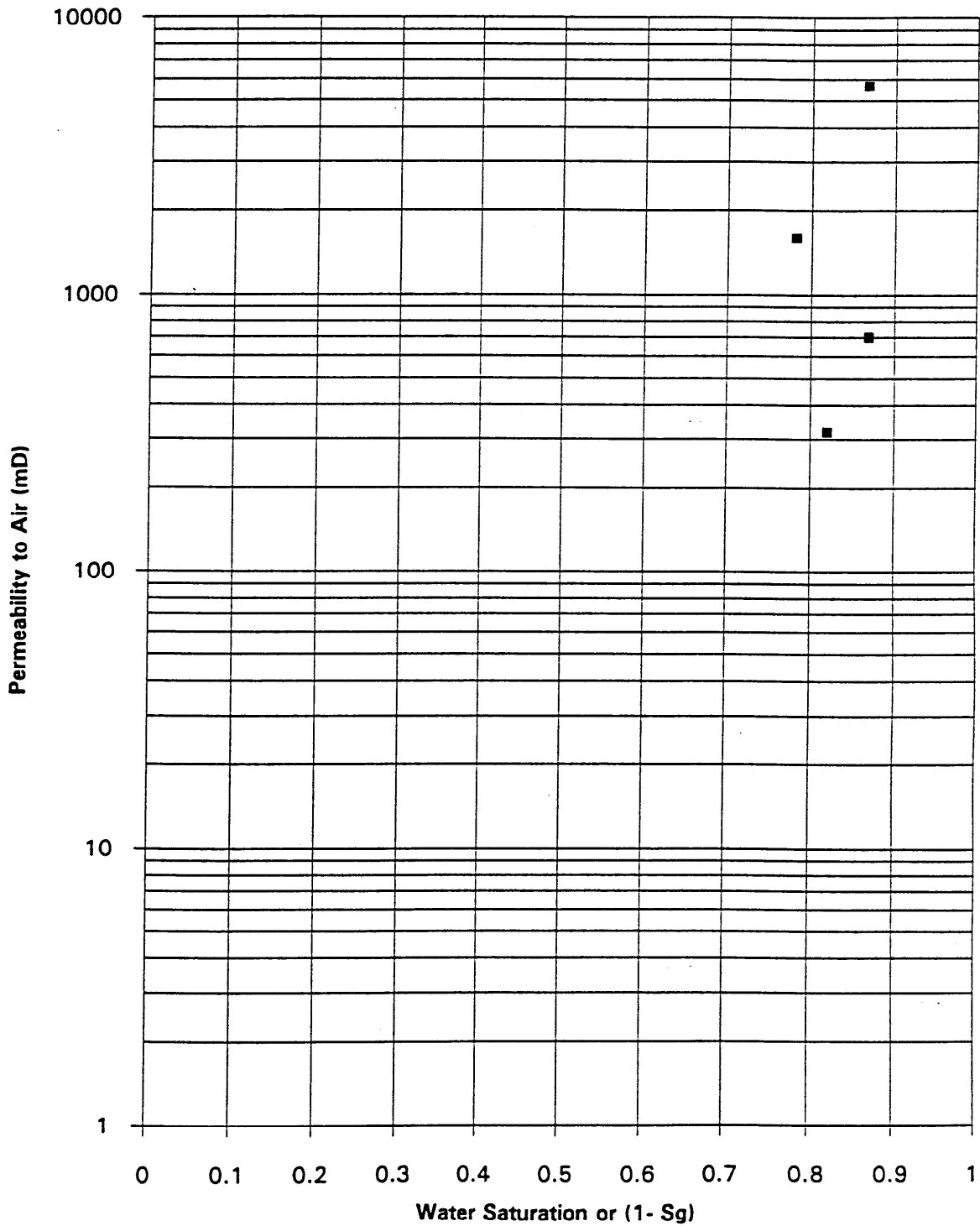
Company: BHP Petroleum Pty Ltd
Well: Minerva 1
Test Method: Air/Brine Imbibition Centrifuge
Ambient

Phase 2b(i)

EFFECTIVE PERMEABILITY

Company   BHP Petroleum
Well   Minerva 1

Overburden Pressure   2100 psi

Phase 2b(i)   Table XIII

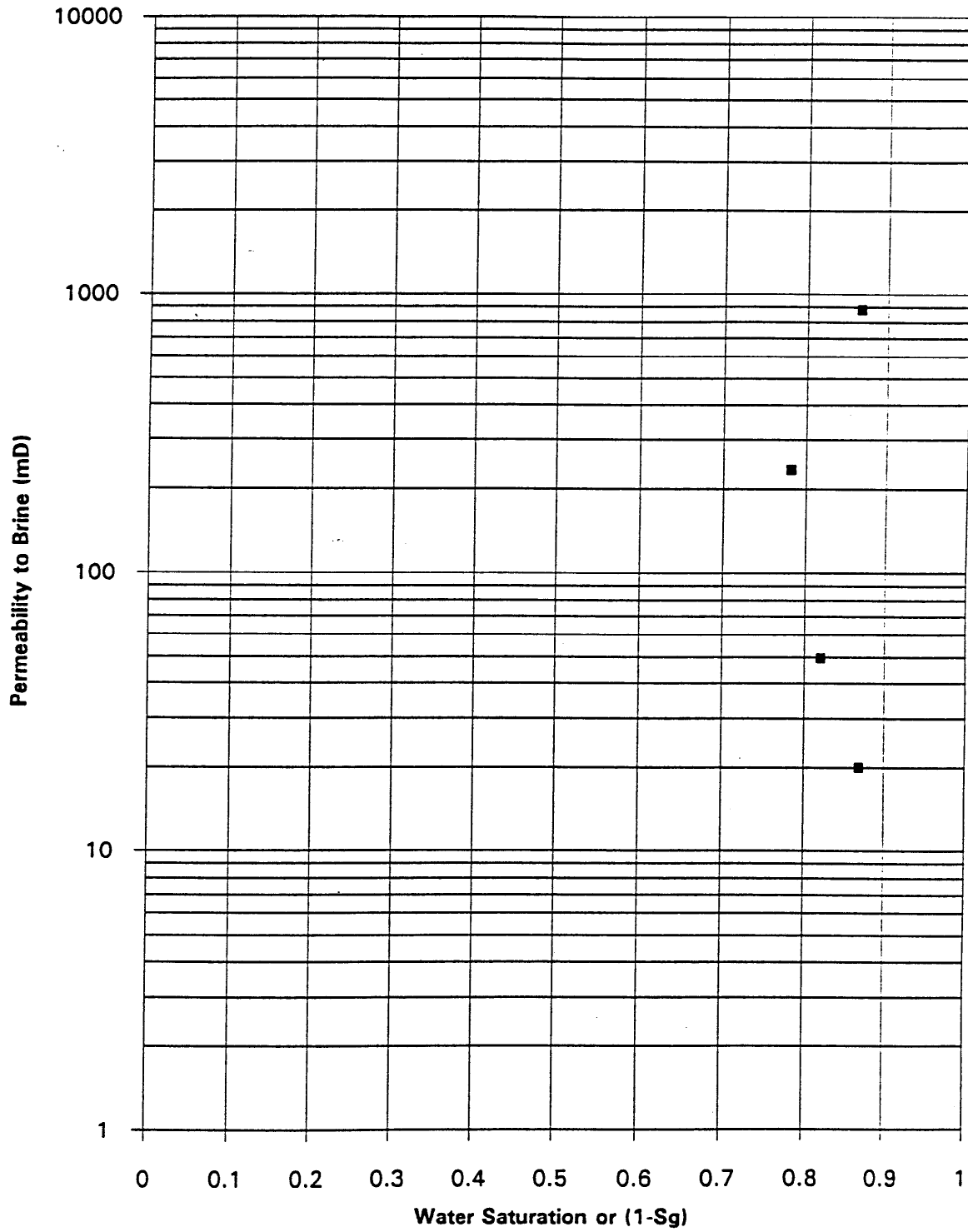| Sample Number	Depth, metres	Permeability to Air, millidarcys	Porosity, fraction	Gas Saturation, fraction	Effective Permeability to Brine, millidarcys
24	1831.70	551	0.110	0.131	20.0
50	1840.90	261	0.180	0.180	49.6
59	1844.90	1348	0.172	0.218	235
61	1845.52	3145	0.150	0.133	881

Effective Permeability to Brine vs Water Saturation or (1-Sg)

Company: BHP Petroleum Pty Ltd
Well: Minerva 1

Overburden Pressure 2100 psi

Phase 2b(i)

RESIDUAL GAS SATURATION

Company   BHP Petroleum
Well   Minerva 1

Test Method   Spontaneous Brine Imbibition

Ambient

Phase 2b(ii)   Table XIV

Sample Number	Depth, metres	Permeability to Air, millidarcys	Porosity, fraction	Gas Saturation, fraction
21	1830.77	2502	0.118	0.283
31	1833.80	23.3	0.147	0.235
56	1844.05	402	0.152	0.366
65	1846.72	1371	0.144	0.321

Permeability to Air vs Water Saturation or (1-Sg)

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Test Method: **Spontaneous Imbibition of Brine**
Ambient

Phase 2b(ii)
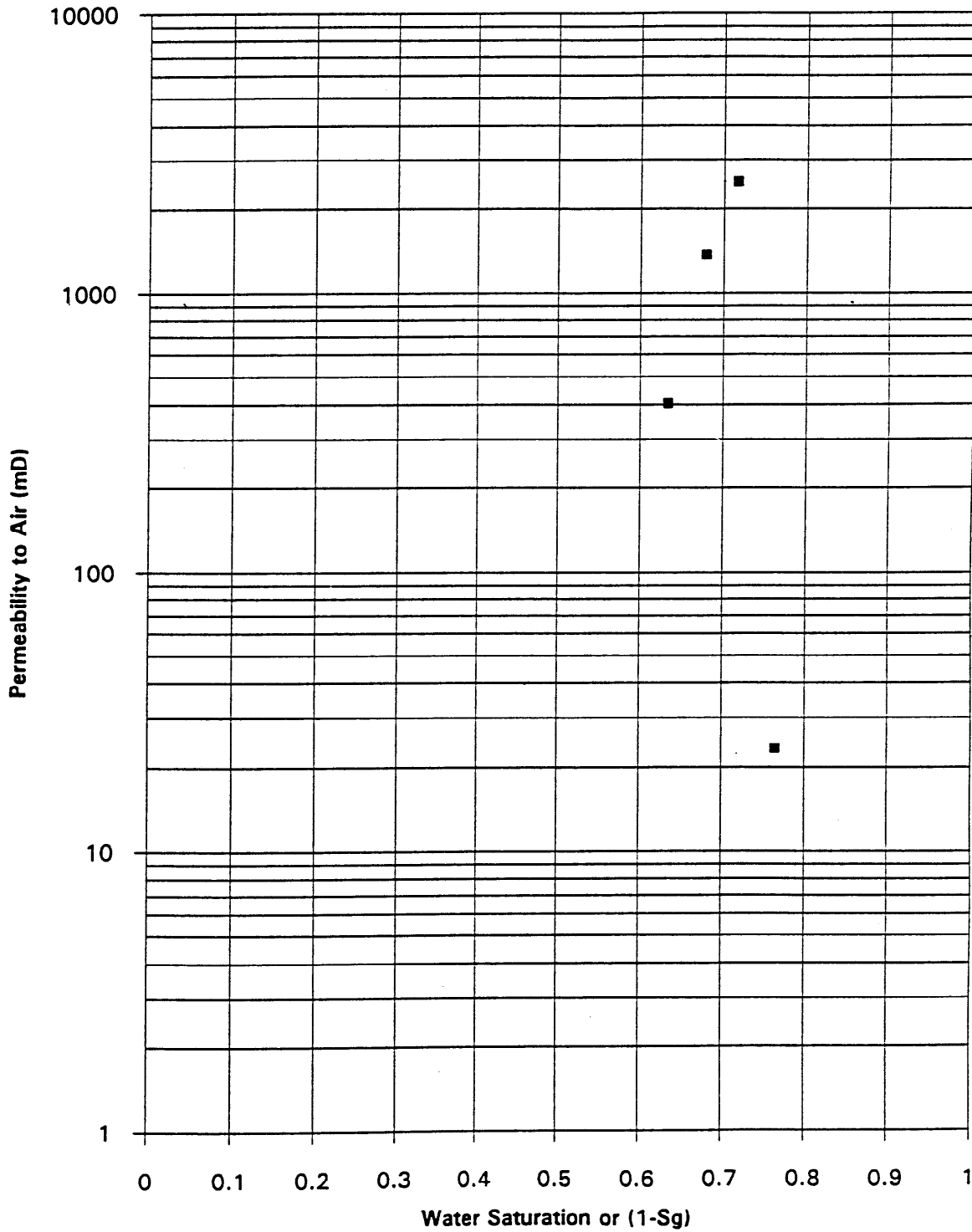
EFFECTIVE PERMEABILITY

Company   BHP Petroleum
Well   Minerva 1

Overburden Pressure   2100 psi

Phase 2b(ii)   Table XV

Sample Number	Depth, metres	Permeability to Air, millidarcys	Porosity, fraction	Gas Saturation, fraction	Effective Permeability to Brine, millidarcies
21	1830.77	1793	0.108	0.283	321
31	1833.80	17.3	0.139	0.235	1.78
56	1844.05	283	0.146	0.366	22.2
65	1846.72	1133	0.138	0.321	124

Effective Permeability to Brine vs Water Saturation or (1-Sg)

Company: BHP Petroleum Pty Ltd
Well: Minerva 1

Overburden Pressure 2100 psi
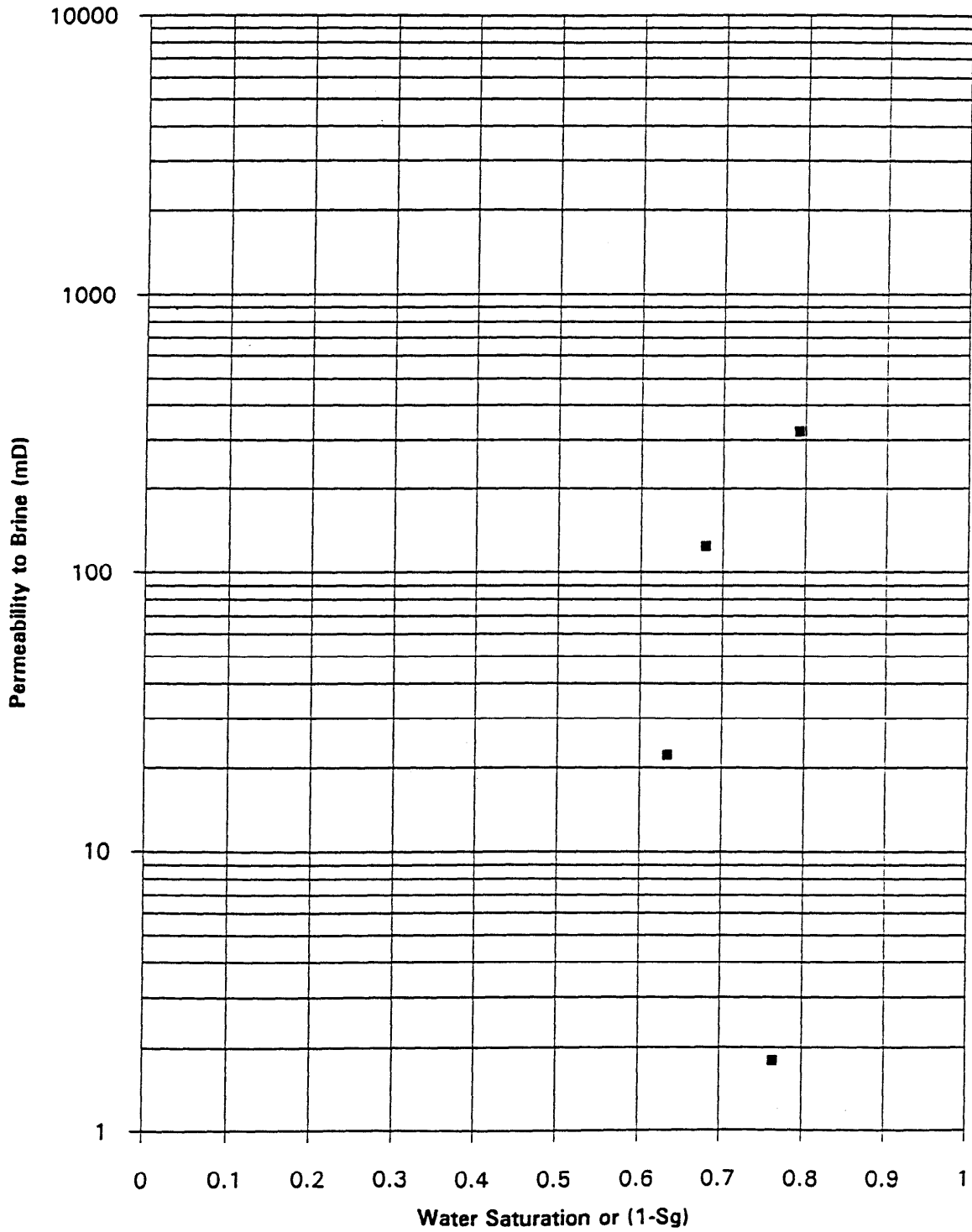
Phase 2b(ii)

RESIDUAL GAS SATURATION

Company   BHP Petroleum
Well   Minerva 1

Test Method   Centrifuge Brine/Air Imbibition

Ambient

Phase 2b(iii)   Table XVI

Sample Number	Capillary Pressure, psi	Permeability to Air, millidarcies	Porosity, fraction	Saturation, fraction
21	-0.4	2502	0.118	0.224
	-1.8			0.207
	-5.4			0.176
	-11.0			0.146
	-24.9			0.129
	-44.2			0.117
31	-0.5	23.3	0.147	0.210
	-2.1			0.197
	-6.6			0.183
	-13.4			0.171
	-30.1			0.157
	-53.5			0.152
56	-0.5	402	0.152	0.338
	-2.1			0.319
	-6.5			0.308
	-13.4			0.298
	-30.1			0.284
	-53.4			0.276
65	-0.5	1371	0.144	0.296
	-2.1			0.289
	-6.5			0.260
	-13.4			0.246
	-30.0			0.230
	-53.4			0.222

Capillary Pressure

Company: **BHP Petroleum Pty Ltd**
Well: **Minerva 1**
Sample: **21**
Test Method: **Centrifuge Air/Brine Imbibition**

Phase 2b(iii)