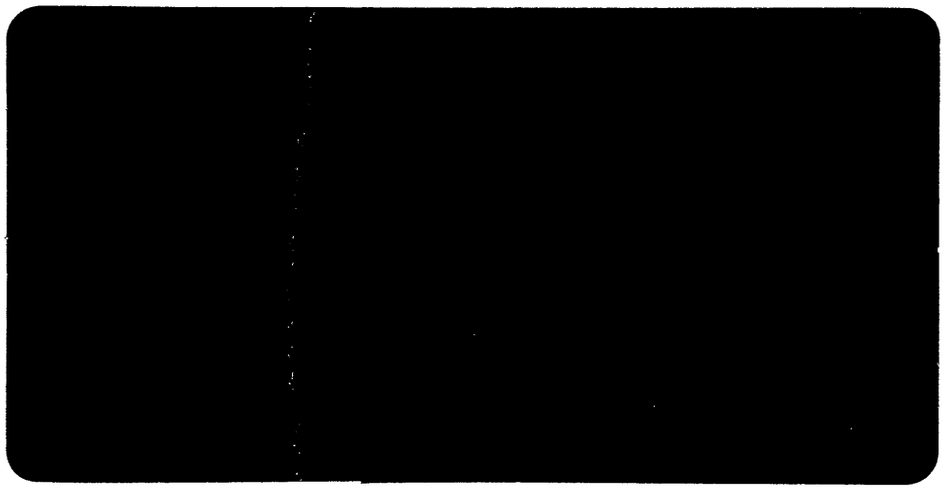

W 864
WYRALLAH-1
ATTACHMENT 9 to WCR

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ATTACHMENT 9

SOURCE ROCK EVALUATION
WYRALLAH NO. 1
VIC/P17

W.C.R.

BY: AMDEL

The Australian Mineral Development Laboratories

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SA 5063
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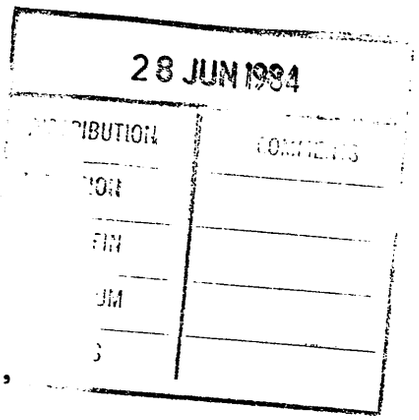
amdel

22 June 1984



F3/422/0
6789/84 - Part 4 (Final)

Australian Aquitaine Petroleum Ltd.,
99 Mount Street,
NORTH SYDNEY NSW 2060

Attention: Claude Lambert

REPORT F6789/84 - Part 4 (Final)

CLIENT REFERENCE:	Transmittal No.014464
TITLE:	Source Rock Evaluation, Wryallah-1, Vic P-17, Gippsland Basin
MATERIAL:	Sidewall cores
LOCALITY:	WRYALLAH-1
SAMPLE IDENTIFICATION:	Sidewall cores 40, 34, 26, 22, 19, 15 and 4
DATE RECEIVED:	8 May 1984
WORK REQUIRED:	TOC and Rock-Eval pyrolysis, vitrinite reflectance and DOM descriptions. Residual oil analysis.

Investigation and Report by: Dr David M. McKirdy, Brian L. Watson and Teresa O'Leary

Chief - Fuels Section: Dr Brian G. Steveson

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cah

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1. INTRODUCTION

Total organic carbon and Rock-Eval pyrolysis data on five sidewall cores from 892-1130 metres depth in Wryallah-1 were forwarded to the client on 17 May 1984. This report formally presents the aforementioned data and incorporates the results of additional analytical work, as follows:

1. Description of dispersed organic matter.
2. Vitrinite reflectance analysis.
3. Analysis of possible residual oil in two additional sidewall cores (Nos.26 and 40).

The above information is used to assess the hydrocarbon generating potential (maturity, organic richness, kerogen type) of the unit sampled.

2. ANALYTICAL PROCEDURE

2.1 Sample Preparation

Sidewall core samples (as received) were ground in a Siebtechnik mill for 20-30 secs.

2.2 Total Organic Carbon (TOC)

Total organic carbon was determined by digestion of a known weight ($\sim$0.2 g) of powdered rock in 50% HCl to remove carbonates, followed by combustion in oxygen in the induction furnace of a Leco IR-12 Carbon Determinator and measurement of the resultant CO_2 by infra-red detection.

2.3 Rock-Eval Analysis

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

2.4 Organic Petrology

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

Reflectance measurements on vitrinite phytoclasts, were made with a Leitz MPV1.1 microphotometer fitted to a Leitz Ortholux microscope and calibrated against synthetic standards. All measurements were taken using oil immersion (n = 1.518) and incident monochromatic light (wavelength 546 nm) at a temperature at 24±1°C. Fluorescence observations were made on the same microscope utilising a 3 mm BG3 excitation filter, a TK400 dichroic mirror and a K510 suppression filter.

2.5 Solvent Extraction

Crushed core (8-31 g) was extracted with azeotropic chloroform/methanol (87:13) in a Soxhlet apparatus for 12 hours. Removal of the solvent by careful rotary evaporation gave the residual extractable organic matter (approx. C_{12+} fraction).

2.6 Liquid and Gas Chromatography

Asphaltenes were precipitated from the oil with petroleum ether (IP method 143/57), and the asphaltene-free fraction separated into saturated hydrocarbons, aromatic hydrocarbons and polar compounds (resins) by liquid chromatography on 20 parts activated alumina under 80 parts activated silica gel. The saturates were eluted with petroleum ether, the aromatics with petroleum ether/methylene chloride (91:9), and the resins with methanol/methylene chloride (65:35) followed by methanol.

The saturated hydrocarbons were examined by gas chromatography using the following instrumental parameters:

Gas chromatography:	Perkin Elmer Sigma 2 fitted with Grob injector.
Column:	25 m x 0.33 mm fused silica, SGE QC3/BP1
Detector:	FID
Injector and detector temperature:	300°C
Carrier gas:	H_2 at 15 psi
Column temperature:	80°C for 4 mins, then 5° per minute to 295°C and held at 295° until all peaks eluted.
Quantitation:	Relative concentrations of individual normal and isoprenoid alkanes obtained by measurement of peak areas above naphthene hump.

3. RESULTS

TOC and Rock-Eval data on the five sidewall cores nominated for source rock analysis are listed in Table 1. Figure 1 is a cross plot of hydrogen index versus Tmax which demonstrates kerogen type and maturity for the Latrobe Group. Vitrinite reflectance (VR) data are given in Table 2. Dispersed organic matter (DOM) descriptions are summarised in Tables 3-5. Histograms of the reflectance measurements may be found in Appendix 1. Extract data on SWC's 26 and 40 may be found in Tables 6 and 7, Figures 2 and 3 (saturates chromatograms) and Figures 4 and 5 (normal are isoprenoid alkane profiles).

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4. DISCUSSION

4.1 Maturity

Tmax values are relatively constant (mostly in the range 412-415°C) over the 892-1040 m depth interval (Table 1). These values are in good agreement with the measured vitrinite reflectance (VR = 0.26-0.42%) and indicate that the rocks are immature.

Although primarily maturation dependent, the Rock-Eval production index is also sensitive to the presence of migrated hydrocarbons. The low production indices ($S_1 + S_2/S_2 < 0.2$) of the samples between 892 and 1040 metres depth suggests there are no migrated hydrocarbons in this interval.

4.2 Source Richness

With only one exception the Wryallah-1 sidewall core samples analysed are extremely organic-rich (Table 1). All but one sample have excellent source richness, indicated by potential hydrocarbon yields ($S_1 + S_2$) of 33-203 kg/tonne (Table 1). In these samples high organic richness and source richness is attributable to the presence of coals.

4.3 Source Quality and Kerogen Type

Hydrogen indices in the range HI = 222-369 (Table 1, Fig. 1) suggest that most of these samples contain organic matter of terrigenous Type II-III composition (Fig. 1). The low hydrogen index of the siltstone from 1130 m show that it contains inertinitic Type IV organic matter.

The moderate hydrogen indices (HI > 200) correspond to gas/condensate-prone vitrinite rich DOM and coals. The highest proportion of exinite (viz. 15% exinite of DOM) was observed in the sample from 991 m depth (Table 3). The major exinites are sporinite, suberinite and resinite (Tables 4, 5). The latter two exinites are thermally labile and may impart some potential for the generation of so called immature oil or condensate.

4.4 Residual Oil

The C_{12+} extractable organic matter (EOM) from SWC's 26 and 40 comprises mostly resins plus asphaltenes (92-95%). The low proportion of hydrocarbons in these extracts suggests that they represent indigenous EOM (presumably derived from small amounts of coal or carbonaceous material), rather than bona fide migrated oil.

5. CONCLUSIONS

Coals and carbonaceous shales of the Latrobe Group from 892-1130 metres depth in Wryallah-1 contain abundant immature Type II-III organic matter comprising mostly vitrinite and exinite (V = 70-90%; E = 5-15%). Appreciable concentrations of resinite and suberinite, particularly in coals from 991 and 1040 metres depth, provide good source potential for light oil and/or condensate where these sediments are laterally continuous into areas of somewhat higher thermal maturity (VR > 0.5%).

TABLE 1

5/23

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ROCK EVAL PYROLYSIS

14/06/84

Client AUSTRALIAN AQUITAINE PETROLEUM

Well WRYALLAH #1

DEPTH	T MAX	S1	S2	S3	S1+S2	PI	S2/S3	PC	TOC	HI	OI
892.00	413	6.16	115.15	11.61	121.31	0.05	9.91	10.10	46.40	248	25
979.00	415	1.19	32.47	4.10	33.66	0.04	7.91	2.80	14.60	222	28
991.00	412	16.59	187.01	9.07	203.60	0.08	20.61	16.96	50.70	369	18
1040.00	413	11.02	165.71	7.04	176.73	0.06	23.53	14.72	45.50	364	15
1130.00	430	0.04	0.07	0.03	0.11	0.40	2.33	0.00	0.14	50	21

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	PARAMETER	SPECIFICITY
T max	position of S_2 peak in temperature program (^{o}C)	Maturity/Kerogen type
S_1	kg hydrocarbons (extractable)/tonne rock	Kerogen type/Maturity/Migrated oil
S_2	kg hydrocarbons (kerogen pyrolysate)/tonne rock	Kerogen type/Maturity
S_3	kg CO_2 (organic)/tonne rock	Kerogen type/Maturity *
$S_1 + S_2$	Potential Yield	Organic richness/Kerogen type
PI	Production Index ($S_1/S_1 + S_2$)	Maturity/Migrated Oil
PC	Pyrolysable Carbon (wt. percent)	Organic richness/Kerogen type/Maturity
TOC	Total Organic Carbon (wt. percent)	Organic richness
HI	Hydrogen Index (mg h'c (S_2)/g TOC)	Kerogen type/Maturity
OI	Oxygen Index (mg CO_2(S_3)/g TOC)	Kerogen type/Maturity *

*Also subject to interference by CO_2 from decomposition of carbonate minerals.

TABLE 2: REFLECTANCE MEASUREMENTS, WRYALLAH-1

Depth (m)	Mean Maximum Reflectance (%)	Standard Deviation	Range	Number of Determinations
892	0.26	0.03	0.21-0.36	30
979	0.31	0.03	0.25-0.36	34
991	0.29	0.02	0.24-0.34	27
1040	0.34	0.03	0.29-0.42	35
1130	0.42	-	0.42	1

TABLE 3: PERCENTAGE OF VITRINITE, INERTINITE AND EXINITE, WRYALLAH-1

Depth (m)	Percentage of		
	Vitrinite	Inertinite	Exinite
892	90	<5	5
979	70	25	5
991	80	<5	15
1040	85	<5	10
1130	<<5	95	-

TABLE 4: ORGANIC MATTER TYPE AND ABUNDANCE, WRYALLAH-1

Depth (m)	Relative Maceral Group Proportions	Estimated Volume of		Exinite Macerals
		DOM	Exinite	
892	V >> E > I	20-30%	Ab	spo, sub, res, lipto, cut
979	V > I > E	10-20%	Sp-Co	spo, res, lipto
991	V > E > I	30-40%	Ab-Ma	spo, sub, lipto, res
1040	V >> E > I	30-40%	Ab	spo, res, lipto, sub, cut
1130	I >> V	<0.5	-	-

TABLE 5: EXINITE MACERAL ABUNDANCE AND FLUORESCENCE CHARACTERISTICS, WRYALLAH-1

Depth (m)	Exinite Macerals	Comments
892	spo(Co;iYG-iY),sub(Co;iYG,mO),res (Sp;iYG,mO),lipto(Sp;iYG-iY),cut (Ra;iY).	Coal (vitrite/clarite)
979	spo(Sp-Co;iYG-iY,mO),res(Sp;iYG-iY, mO),lipto(Ra;iYG-iY).	Carbonaceous shale/siltstone
991	spo(Ab;iYG-iY),sub(Ab;mO-dO),lipto (Co-Ab;iYG-iY),res(Co;iYG-iO).	Coal (clarite); inertinite is sclerotinite.
1040	spo(Ab;iY-iO),res(Ab;iYG-iO,dO),sub (Sp-Co;dO),cut(Ra;mY-mO).	Coal (clarite)
1130	-	siltstone; some inertinite is only slightly oxidised.

KEY TO DISPERSED ORGANIC MATTER DESCRIPTIONS

MACERAL GROUPS

V	Vitrinite
I	Inertinite
E	Exinite

EXINITE MACERALS

spo	Sporinite
cut	Cutinite
res	Resinite
sub	Suberinite
lipto	Liptodetrinite
fluor	Fluorinite
exs	Exsudatinite
phyto	Phytoplankton
tela	Telalginite
lama	Lamalginite
bmite	Bituminite
bmen	Bitumen
thuc	Thucholite

ABUNDANCE (by vol.)

Ma	Major	>15%
Ab	Abundant	2-15%
Co	Common	1-2%
Sp	Sparse	0.5-1%
Ra	Rare	0.1-0.5%
Vr	Very Rare	∿0.1%
Tr	Trace	<0.1%

FLUORESCENCE COLOUR AND INTENSITY

G	Green	i	Intense
Y	Yellow	m	Moderate
O	Orange	d	Dull
B	Brown		

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RESIDUAL OIL ANALYSIS

WELL: WRYALLAH NO.1

SAMPLE: SWC NO.40

weight of sample extracted	8.56 g
weight of eom	8.4 mg
extracted organic matter	981 ppm

ANALYSIS OF EXTRACTED ORGANIC MATTER, (%)

SATURATES	3.6
AROMATICS	1.2
RESINS	29.8
ASPHALTENES	65.5

N-ALKANE DISTRIBUTION OF SATURATES

C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%
12	.0	17	10.0	22	9.4	27	1.2	32	.0
13	.0	18	12.9	23	6.9	28	.6	33	.0
14	.4	19	13.1	24	4.1	29	.5	34	.0
15	2.8	20	13.7	25	2.7	30	.5	35	.0
16	7.2	21	12.0	26	1.7	31	.2	36	.0

ISOPRENOID DISTRIBUTION IN SATURATES

TMTD/pristane ratio	.11
norpristane/pristane ratio	.34
pristane/phytane ratio	1.66
pristane/c-17 ratio	.43
phytane/c-18 ratio	.20

ODD EVEN PREDOMINANCE

O.E.P. C-17 = .95
O.E.P. C-19 = .95
O.E.P. C-25 = 1.05
O.E.P. C-27 = 1.12

AMDEL

RESIDUAL OIL ANALYSIS

WELL: WRYALLAH NO.1

SAMPLE: SWC NO.26

weight of sample extracted	31.11 g
weight of eom	106.6 mg
extracted organic matter	3427 ppm

ANALYSIS OF EXTRACTED ORGANIC MATTER, (%)

SATURATES	4.5
AROMATICS	3.0
RESINS	28.6
ASPHALTENES	63.9

N-ALKANE DISTRIBUTION OF SATURATES

C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%	C-NO.	%
12	.2	17	17.7	22	2.6	27	1.0	32	.0
13	2.1	18	14.6	23	1.8	28	.3	33	.0
14	8.3	19	1.2	24	.9	29	.8	34	.0
15	16.2	20	7.4	25	1.3	30	.1	35	.0
16	18.3	21	4.7	26	.4	31	.2	36	.0

ISOPRENOID DISTRIBUTION IN SATURATES

TMTD/pristane ratio	.53
norpristane/pristane ratio	.33
pristane/phytane ratio	6.01
pristane/c-17 ratio	.65
phytane/c-18 ratio	.13

ODD EVEN PREDOMINANCE

O.E.P. C-17 = .94
O.E.P. C-19 = .33
O.E.P. C-25 = 2.19
O.E.P. C-27 = 3.04

Client : AUSTRALIAN AQUITAINE PETROLEUM
Well name : WRYALLAH #1
Interval : LATROBE GROUP

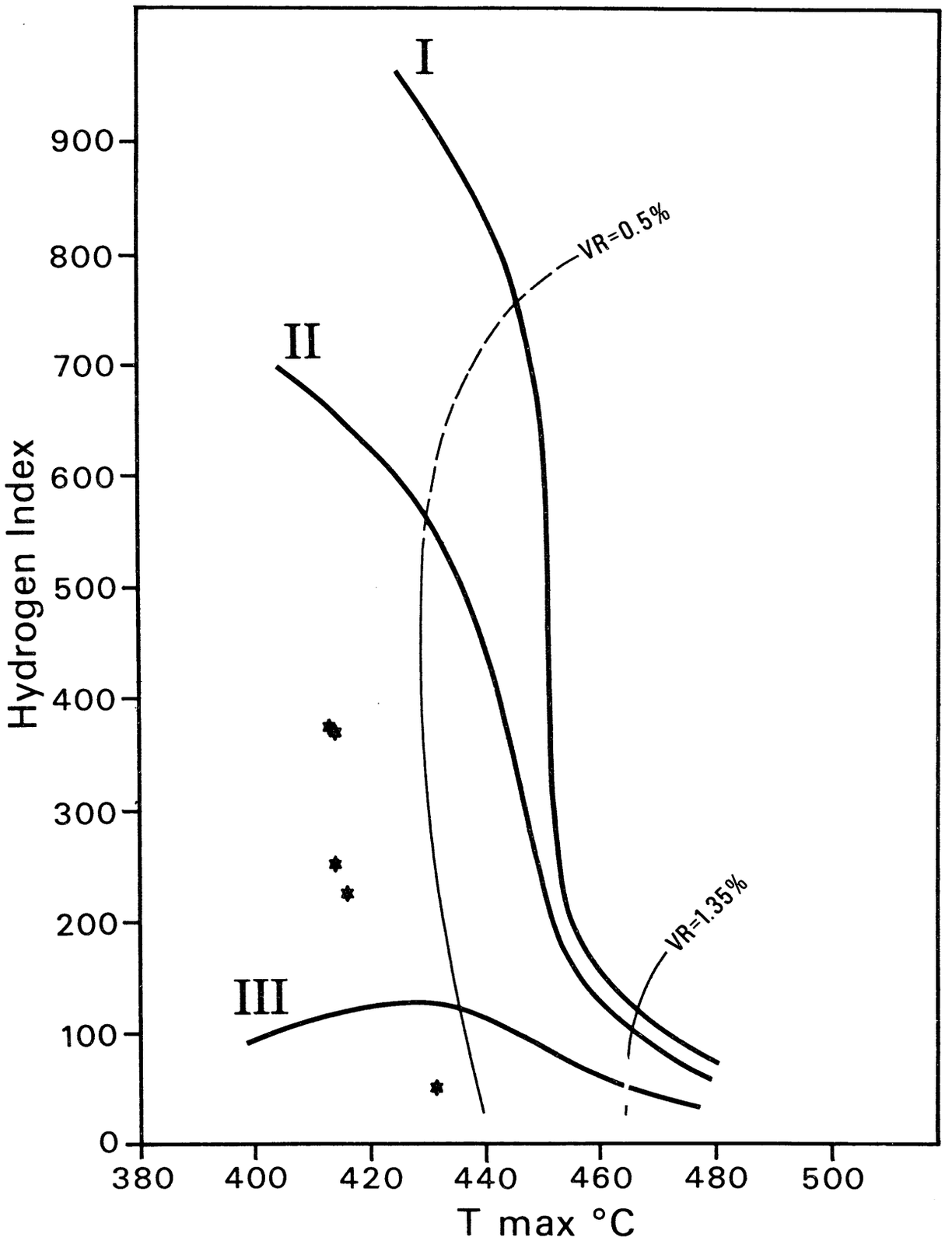

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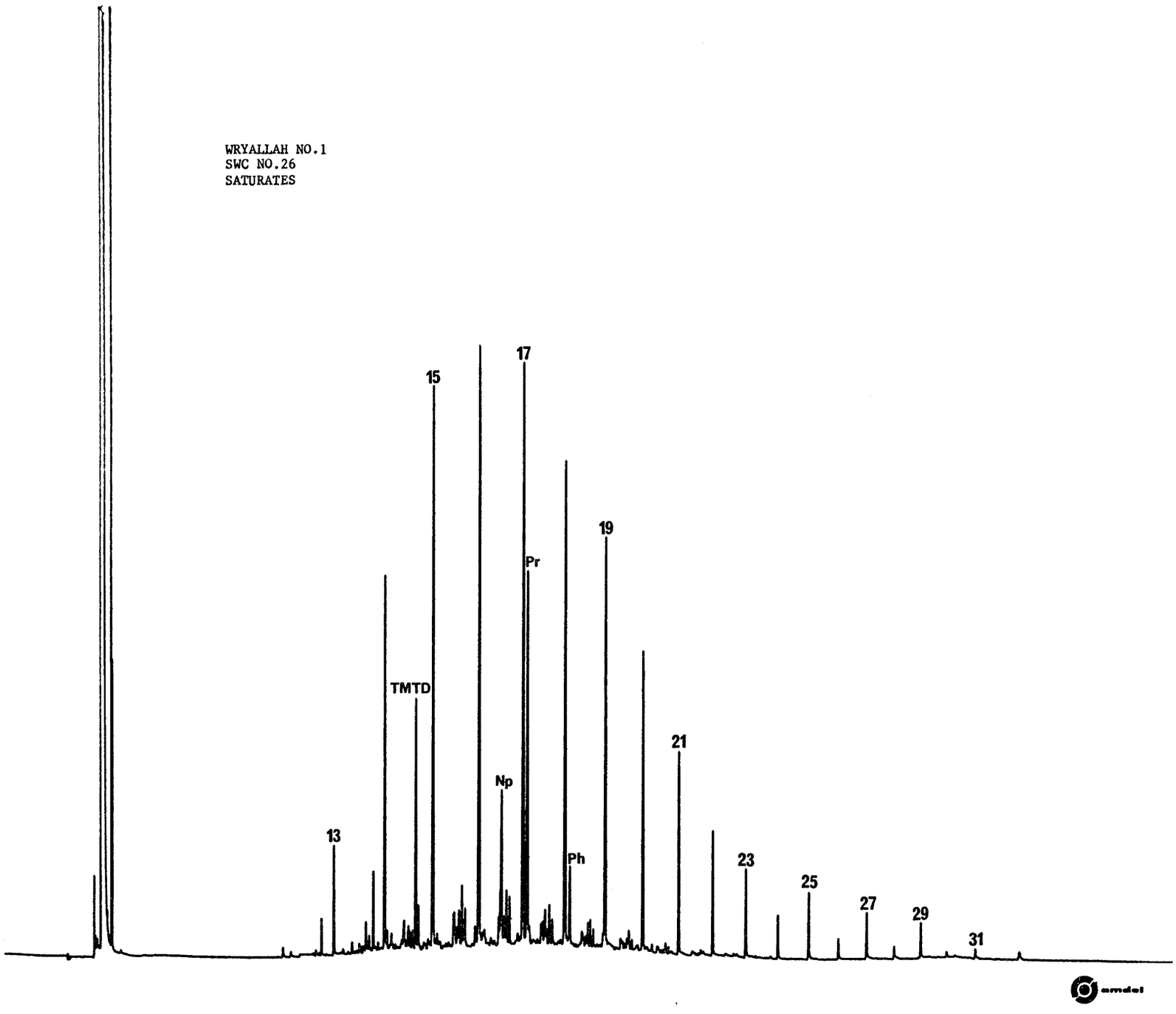
FIGURE 2



15/23

FIGURE 3

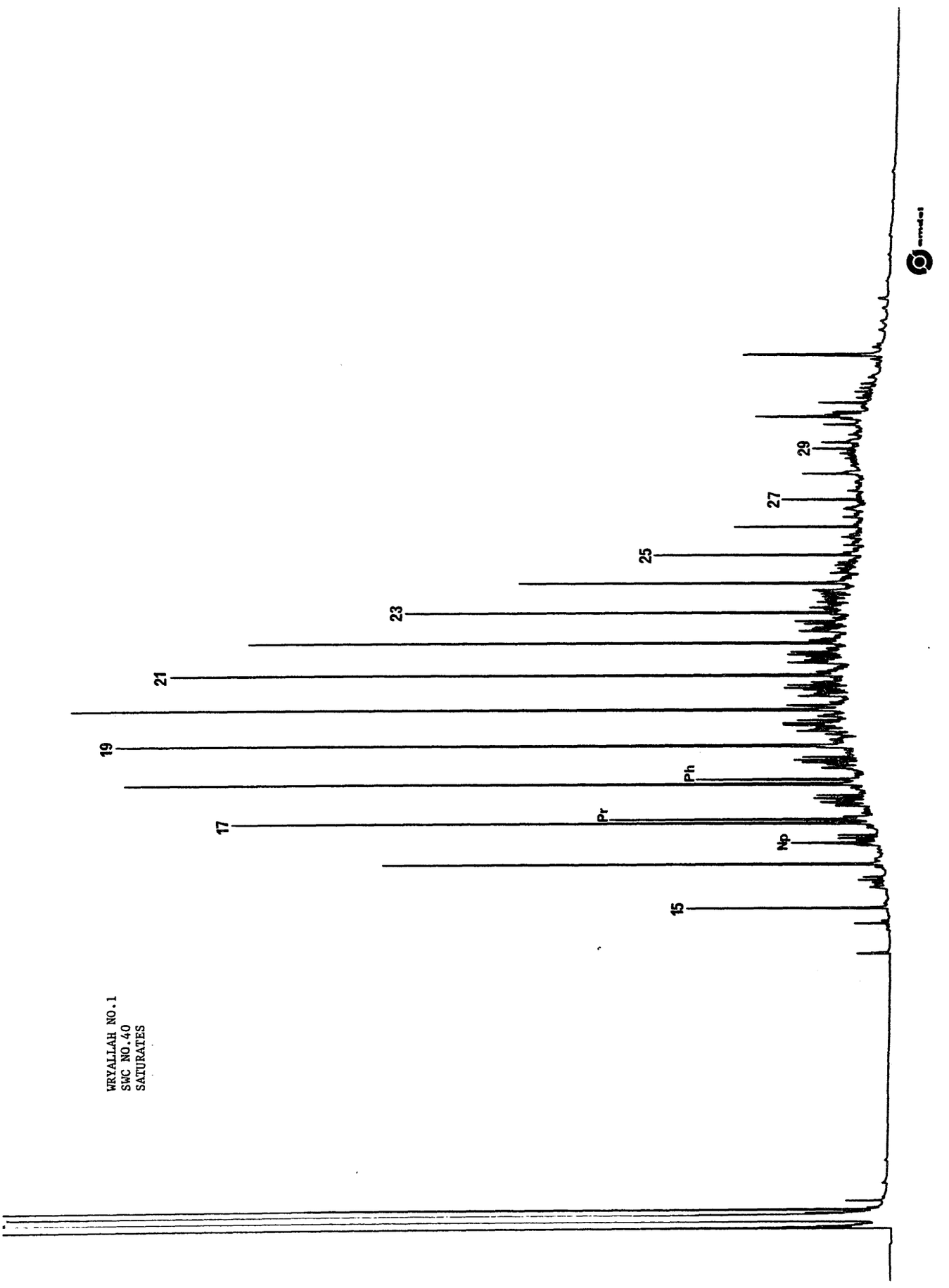


FIGURE 4

WRYALLAH NO.1
SWC NO.26

HISTOGRAM OF N-ALKANE DISTRIBUTION OF SATURATES

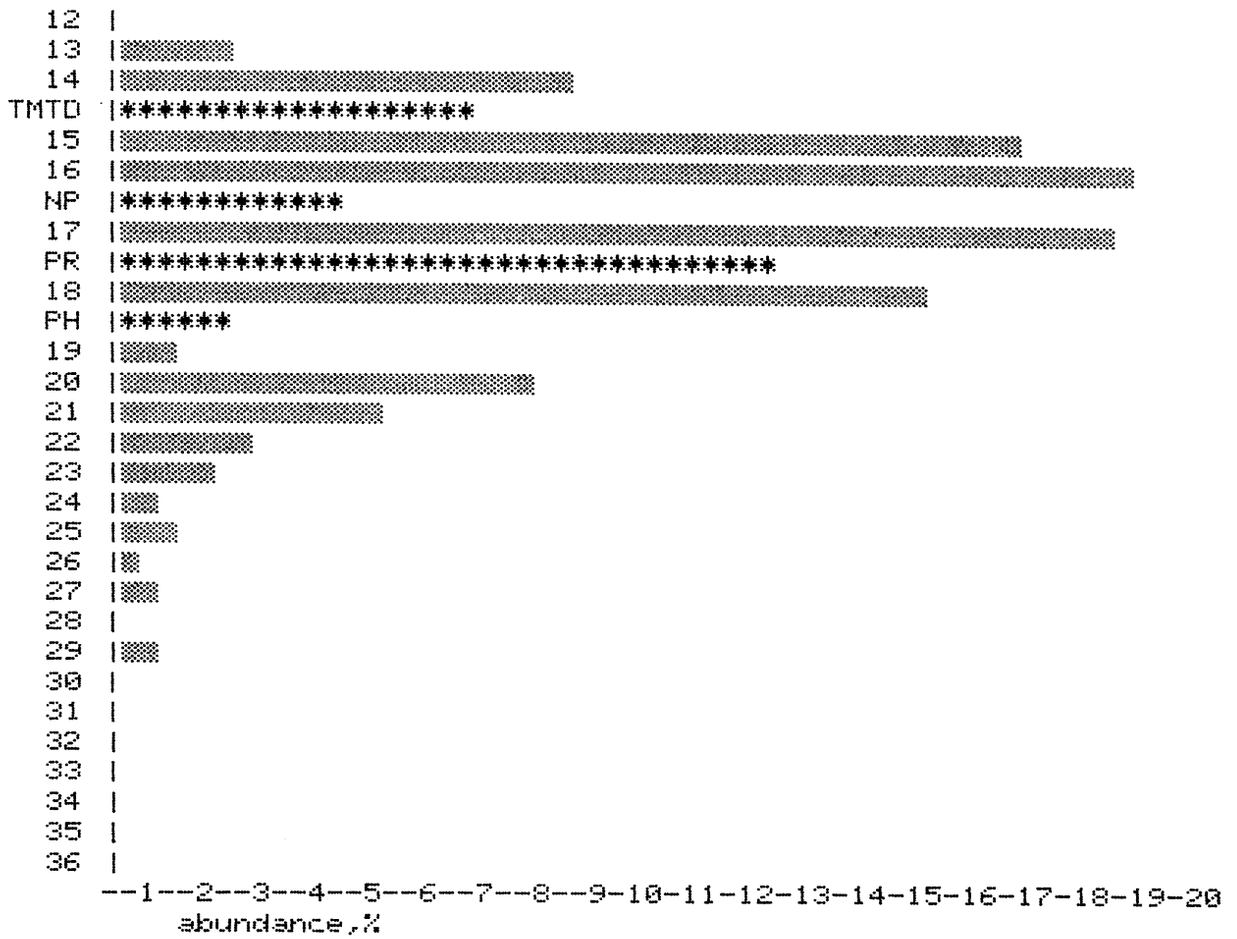
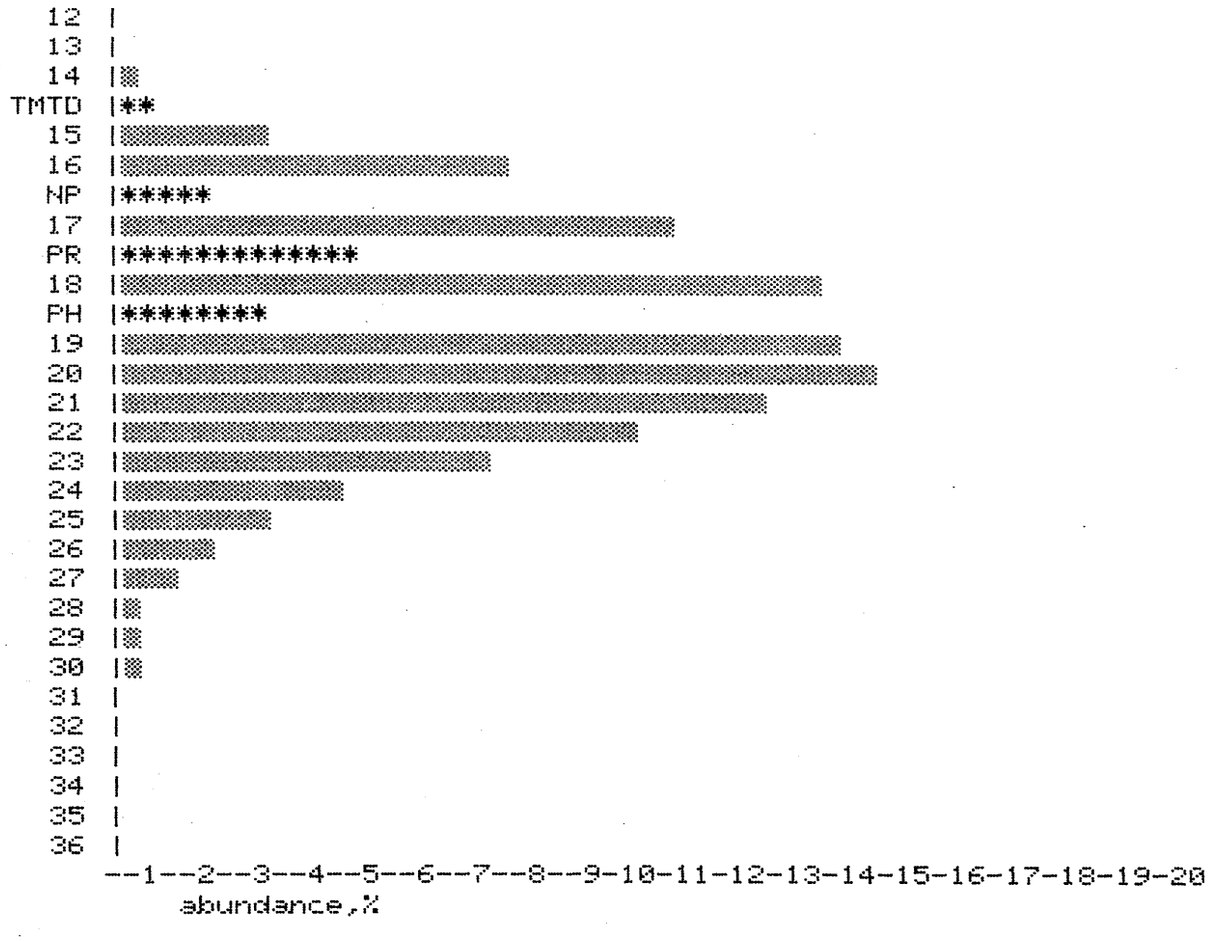


FIGURE 5

WRYALLAH NO.1
SWC NO.40

HISTOGRAM OF N-ALKANE DISTRIBUTION OF SATURATES



APPENDIX 1

HISTOGRAMS OF VITRINITE MEASUREMENTS

WR'FALLAH-1

892M

SORTED LIST

.21	.21	.22	.23	.23	.23	.24	.25	.25	.25
.25	.25	.25	.25	.25	.25	.25	.25	.26	.26
.26	.26	.26	.27	.27	.28	.28	.3	.3	.36

0
Number of values= 30

MEAN OF VALUES .256
STD DEVIATION .029

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

```
21 - 23    | ▒▒▒▒▒▒▒
24 - 26    | ▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
27 - 29    | ▒▒▒▒▒▒
30 - 32    | ▒▒▒
33 - 35    |
36 - 38    | ▒
```

WRVALLAH—1

979M

SORTED LIST

.25	.26	.27	.27	.27	.28	.28	.28	.28	.29
.29	.29	.29	.29	.3	.3	.3	.31	.31	.31
.31	.32	.32	.33	.33	.33	.33	.33	.33	.33
.34	.35	.36	.36						

Number of values= 34

MEAN OF VALUES .306
STD DEVIATION .028

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

```
25 - 27    | ▒▒▒▒▒
28 - 30    | ▒▒▒▒▒▒▒▒▒▒▒▒▒
31 - 33    | ▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
34 - 36    | ▒▒▒▒▒
```

WRVALLAH-1

991M

SORTED LIST

.24	.24	.27	.27	.27	.28	.28	.28	.28	.29
.29	.29	.29	.29	.29	.3	.3	.3	.3	.3
.31	.31	.31	.31	.32	.32	.33	.34		

Number of values= 28

MEAN OF VALUES .293
STD DEVIATION .023

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100

```
24 - 26    | ▒▒
27 - 29    | ▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒
30 - 32    | ▒▒▒▒▒▒▒▒▒▒▒▒▒
33 - 35    | ▒▒
```

WR'YALLAH—1

1040M

SORTED LIST

.29	.3	.3	.3	.3	.31	.31	.31	.31	.32
.32	.33	.33	.33	.33	.34	.34	.34	.35	.35
.35	.35	.36	.36	.36	.36	.36	.36	.37	.37
.37	.38	.38	.39	.42					

Number of values= 35

MEAN OF VALUES .341
STD DEVIATION .03

HISTOGRAM OF RESULTS
Values are reflectance multiplied by 100