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HYDROCARBON SOURCE ROCK CHARACTERIZATION STUDY VOLADOR No. 1 WELL

Prepared for

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GEOCHEMICAL REPORTS VOLADOR -1

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HYDROCARBON SOURCE ROCK CHARACTERIZATION STUDY VOLADOR No. 1 WELL

SUMMARY

Organic geochemical analyses carried out on sidewall cores, crude oils, water and gas samples from the well interval 3549.9m to 4554m in the Volador No. 1 well have indicated the following:-

- Marginally mature rocks are encountered around 3700m to 3800m and mature rocks are penetrated between 3800m to 4100m. At bottom of the analyzed well interval, 4554m, the sediments are interpreted to still be oil-generative.
- The rocks in well interval 3549.9m to 4039.0m are extremely organic rich, but due to the low thermal maturity of the sediments, it is doubtful that significant petroleum generation and expellsion has occurred.
- The rocks in well interval 4145.3m to 4554m are marginally mature to mature good to excellent petroleum source sediments. In particular those sediments within interval 4526m to 4554m have very favourable oil source characteristics.
- The condensate and crude oils produced from this well are low sulphur, very waxy liquid hydrocarbons. We interpret that the condensate is a result of a natural separation of the crude oil within the reservoirs.
- The good oil source rocks encountered between 4526m to 4554m are similar to these oils and maybe the parent source.
- The three crude oils analyzed from Halibut A-1, Hapuku 1 and Tuna A-2 wells appear to be genetically related, and are also similar to the oils produced from the Volador No. 1 well.

Paul Tybor

PAUL TYBOR
Manager - Operations

INTRODUCTION

Organic geochemical analyses have been performed on sixteen (16) side wall core samples, seventeen (17) crude oil samples, three (3) gas cylinder samples and eighteen (18) water samples from the Volador No. 1 well, drilled in Gippsland Basin, offshore Australia. The crudes, waters and gas samples were recovered during two production tests run on the well. In addition to these samples, three oil samples from the Halibut A1, Hapuku 1 and Tuna A-2 wells were also analyzed for characterization.

This study was undertaken to evaluate the hydrocarbon source quality (oil vs gas) richness and state of thermal maturity (pre oil, oil generative, eometamorphosed) of the sediments penetrated between well interval 3549.9m to 4554m in the Volador No. 1 well. The oils, waters and gases were analyzed to characterize the fluids and gases produced during the testing of the well. The oils were compared to the three oil samples from the Hapuku 1, Halibut A-1 and Tuna A-2 wells to determine if any genetic relationships exists between the samples.

The results of the analyses carried out on these samples are presented in the following:-

Type of Analysis	Figure	Table
Rock Samples		
% Total organic carbon determination	1	1
Pyrolysis analysis	1	1
Extraction and liquid chromatography	2	2
C_{12}+ saturate gas chromatography	3; 4A to 4N	3
Vitrinite reflectance	1 - 3	4
Crude Oils		
API gravity, % sulphur, viscosity, pour point		5
C_{12}+ saturate gas chromatography (Sample 8)	5	6
Whole oil gas chromatography (Volador samples)	6A to 6D	7
Whole oil gas chromatography (Gippsland Oils)	7A to 7C	8

Type of Analysis	Figure	Table
Gas Samples		
Complete gas analysis (3 cylinder samples)		9
Stable carbon isotopic determination		10
Water Samples		
Complete formation water analysis (18 water samples)		11A to 11R

Initially $C_{12}+$ saturate gas chromatography was planned for evaluation of the crude oil samples. However, this approach was reconsidered, and it was decided to carry out whole oil gas chromatography on the samples for better characterisation. Consequently, only crude oil sample No. 8 was submitted to $C_{12}+$ saturate gas chromatography, with whole gas chromatography analysis performed on all crude oil samples.

A description of the analyses performed on the rock and crude oil samples in this well is presented in Appendix I, located at the back of this report.

General Information

Copies of this report have been mailed to Mr. Steve Rigby of Shell Development (Australia) Pty. Ltd. Any questions regarding this study can be directed to either Mr. Paul Tybor or Dr. Garry Woodhouse of Analabs in Perth Western Australia.

All data and interpretations given herein are proprietary to the Shell Development (Australia) Pty. Ltd., and are treated as highly confidential material by all Analabs personnel.

RESULTS AND INTERPRETATIONS

A. Thermal Maturity of Sediments

Based on vitrinite reflectance measurements the sediments from 3549.9m to 3820.3m are marginally mature and are in the early stages of petroleum generation. Below 3820.3m the recorded reflectances are considered mature values and these sediments are interpreted to be oil generative (Figures 1-3; Table 4).

The results for pyrolysis (Tmax and Production Index; Figure 1; Table 1) analysis indicate a slightly less mature geothermal history for this sedimentary sequence. The following breaks out the maturation zones of this interval, as determined by pyrolysis:

Interval	Tmax Range	P.I. Range	Interpretation
3549.9m - 3691.5m	423° - 429°	0.03 to 0.07	Immature
3799m - 4039m	433° - 441°	0.04 to 0.08	Marginally mature
4145.3m - 4554.0m	443° - 451°	0.14 to 0.26	Mature

The $C_{12}+$ saturate gas chromatography data appears to correspond more closely to maturities determined by pyrolysis than by vitrinite reflectance. The carbon preference index values indicate immaturity (CPI (1) > 1.5) from 3549.9m to 3820.3m, marginally mature (CPI (1) 1.2 - 1.5) from 3820.3m to 4145.3m and mature (CPI (1) 1.0 - 1.2) sediments from 4145.3m to 4554.0m (Figure 3; Table 3). The chromatograms themselves exhibit immature characteristics with isoprenoid pristane predominating over the normal alkanes in samples down to 4360m (Figures 3; 4). This immature feature may also be a function of the type of organic matter contained in these sediments, which give immature $C_{12}+$ saturate characteristics at moderately mature to mature maturation levels. Since these rocks contain large amounts of terrestrial organic matter, more time and temperature may be required before oil generation occurs.

Regardless of which data is utilised in assessing the thermal maturity of the sediments analysed from this well, it appears that marginally mature rocks are encountered around 3700m to 3800m, while mature sediments are penetrated between 3800m to 4100m. At the bottom of the analyzed well interval the sediments are interpreted to still be oil generative.

B. Hydrocarbon Source Characterisation of Sediments

Well Interval 3549.9m to 4039.0m

Well interval 3549.9m to 4039.0m is comprised of very carbonaceous claystones, siltstones and coals that contain extremely rich concentrations of organic matter (% TOC; Figure 1; Table 1). Due to the immature nature of these

B. Hydrocarbon Source Characterisation of Sediments (Cont)...

Well Interval 3549.9m to 4039.0m

rocks and the apparent abundance of terrestrial organic matter types dispersed within these sediments, the majority of the high amounts of free hydrocarbon (S_1; Figure 1; Table 1) and extracted hydrocarbon (Figure 2; Table 2) is predominantly aromatic in nature. Since crude oils are usually comprised of greater than 80% saturate hydrocarbon, and low amounts of aromatic hydrocarbon, it is doubtful that these sediments are capable of generating significant quantities of oil. Presently, these rocks are interpreted to be prospective for large volumes of indigenously generated gas. At more mature levels of thermal maturation, oil generation and expulsion could have occurred.

Well Interval 4145.3m to 4554.0m

The rocks in well interval 4145.3m to 4554.0m contain good to excellent amounts of apparently mixed oil and gas prone organic matter, at moderately mature to mature maturation levels. Good to excellent amounts of extractable organic matter and C_{12}+ total hydrocarbon (Figure 2; Table 2), and good to excellent amounts of free hydrocarbon (S_1; Figure 1; Table 1) were analysed from these sediments. This hydrocarbon contains greater amounts of saturate hydrocarbon than aromatic, and thus appears to have favourable oil generating capabilities. This favourable oil source character is very evident in samples at 4526m, 4536m and 4554m, where the C_{12}+ saturate gas chromatogram configurations approach those of the whole oil gc's of the oils produced from this well, and the other Gippsland oils included in this study (Figures 6 and 7). The oils recovered from this well were produced from intervals 3756m to 3783m and 3911m to 3914m. There are very similar characteristics between these oils and the source rocks encountered at 4524m 4536m and 4554m. These similarities will be compared and discussed in the following section entitled crude oil characterisation.

As a result, the rocks in well interval 4145.3m to 4554.0m are marginally mature to mature, good to excellent petroleum source sediments. In particular, those sediments within interval 4526m to 4554m have a very favourable oil source character ,which appears to be genetically related to the crude oils tested in the upper portion of the well.

C. Crude Oil Characterisation

Two (2) production tests performed over well intervals 3756m to 3783m and 3911m to 3914m recovered crude oil, gas and water. Crude oil sample numners 2 to 10 were recovered in Test 1 (3911m to 3914m) and sample numbers 15 to 28 were obtained in Test 2(3756m to 3783m) (Table 5). Sample G was collected during Test II and believed to be a representative sample from the interval.

C. Crude Oil Characterization (Cont)....

The oils recovered during these tests are medium to high gravity crudes, with some of the higher gravities representing a mixture of very light oil and condensate ($^{\#}_{s}$ 6-8 and $^{\#}_{s}$ 15 - 16). These light oils/condensates from Test 2, appear to have been recovered during the early stages of the test, which suggests that there was some natural liquid chromatographic separation of the oils within the reservoir. As the test proceeded, a medium gravity, waxy crude was produced. Both condensates and crude oils have low sulphur contents and high pour points, indicating their high wax content. Waxy crude oils are generally sourced from terrestrial organic matter, which is very prevalent in the sediments penetrated by this well.

Both the high and medium gravity crudes are deficient in wet gas (C_2 - C_4) and gasoline range (C_5 - C_7) hydrocarbon. This may be a function of the source rocks not being mature enough to generate the more volatile hydrocarbons from the terrestrial organic matter within the sediments.

As mentioned in the previous section on Hydrocarbon Source Characterisation, the samples between 4526m to 4554m have very favourable hydrocarbon source characteristics, and bear a resemblence to some of the oils produced from this well, in particular to samples 26 and G (Figures 6C and 6D). These similarities are shown in the C_{12}^{+} saturate g.c. for rock samples from 4526m to 4554m, and the greater than C_{12}^{+} components from the whole oil g.c.s of oil samples 26 and G. The overall g.c. configurations for the C_{12}^{+} components are similar and suggest that a genetic relationship exists between these rocks and crude oils.

In addition to the oils from this well, three oils from the Halibut A-1, Hapuku 1 and Tuna A-2 wells were analyzed by whole oil gas chromatography. These g.c's traces look similar and also resemble the whole oil g.c's of oil samples 26 and G from Volador No. 1 well. The gc configurations of the good oil source sediments from 4526m to 4554m in the Volador also resemble the gc's of these three crude oils, and indicate a possible genetic relationship between the crudes and the favourable source rocks encountered at the bottom of Volador No. 1 well. Before a crude oil-parent source rock genetic relationship can be established between the Gippsland crudes and the sediments penetrated at the bottom of this well, a more detailed analytical program, utilising GC-MS should be undertaken on these rock and oil samples.

D. Gas Characterization

The three (3) gas cylinder samples were analyzed (Table 9) to contain predominantly C_1 methane, with secondary amounts of CO_2.

D. Gas Characterization (Cont)....

Carbon isotopic analysis (Table 10) indicates a thermal origin for the methane, as opposed to a biogenic origin, and an organic origin for the CO_2, as opposed to a non-organic origin (i.e. carbonate breakdown). Consequently the methane gas reservoired in this well is apparently migrated out-of-place from very thermally mature sediments.

The interpretation parameters for carbon isotopic data is as follows:-

Methane

$\delta^{13}C$	Origin
-85 to -58	Biogenic
-58 to -40	Wetgas associated with oil
-40 to -25	Thermal

The CO_2 is probably sourced from the humic materials contained in these rocks based on the moderately negative $\delta^{13}C$ values obtained from the gases.

E. Water Analysis

Complete water analyses performed on water produced from the two (2) production tests carried out on this well indicate that the waters produced from Test 1 (3911m to 3914m) are considerably richer in salt than the waters produced in Test 2(3756m to 3783m).

FIGURE 4A
VOLADOR #1 3549.9m SWC
SATURATED FRACTION

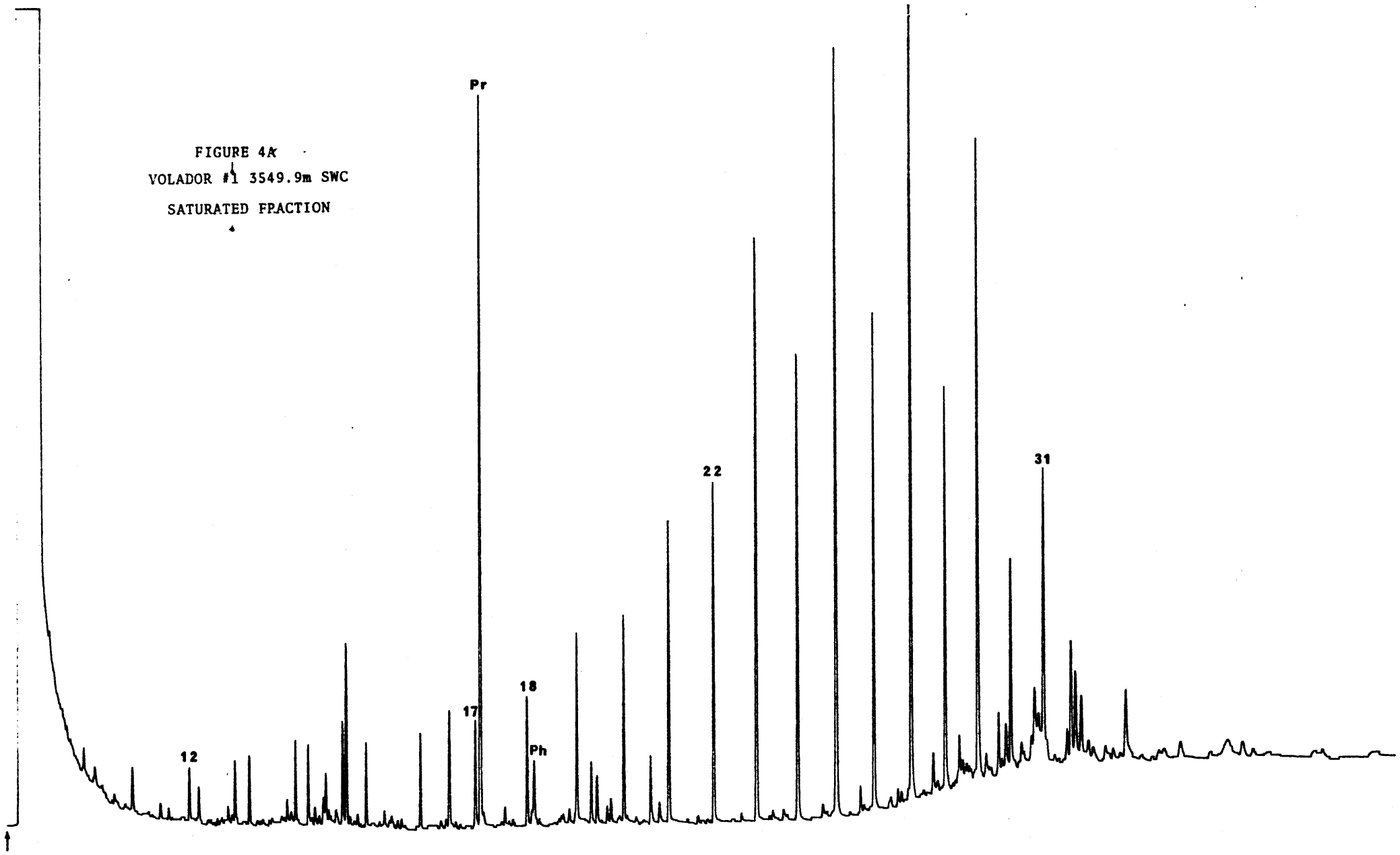


FIGURE 4B

VOLADOR #1 3645.0m SWC

SATURATED FRACTION

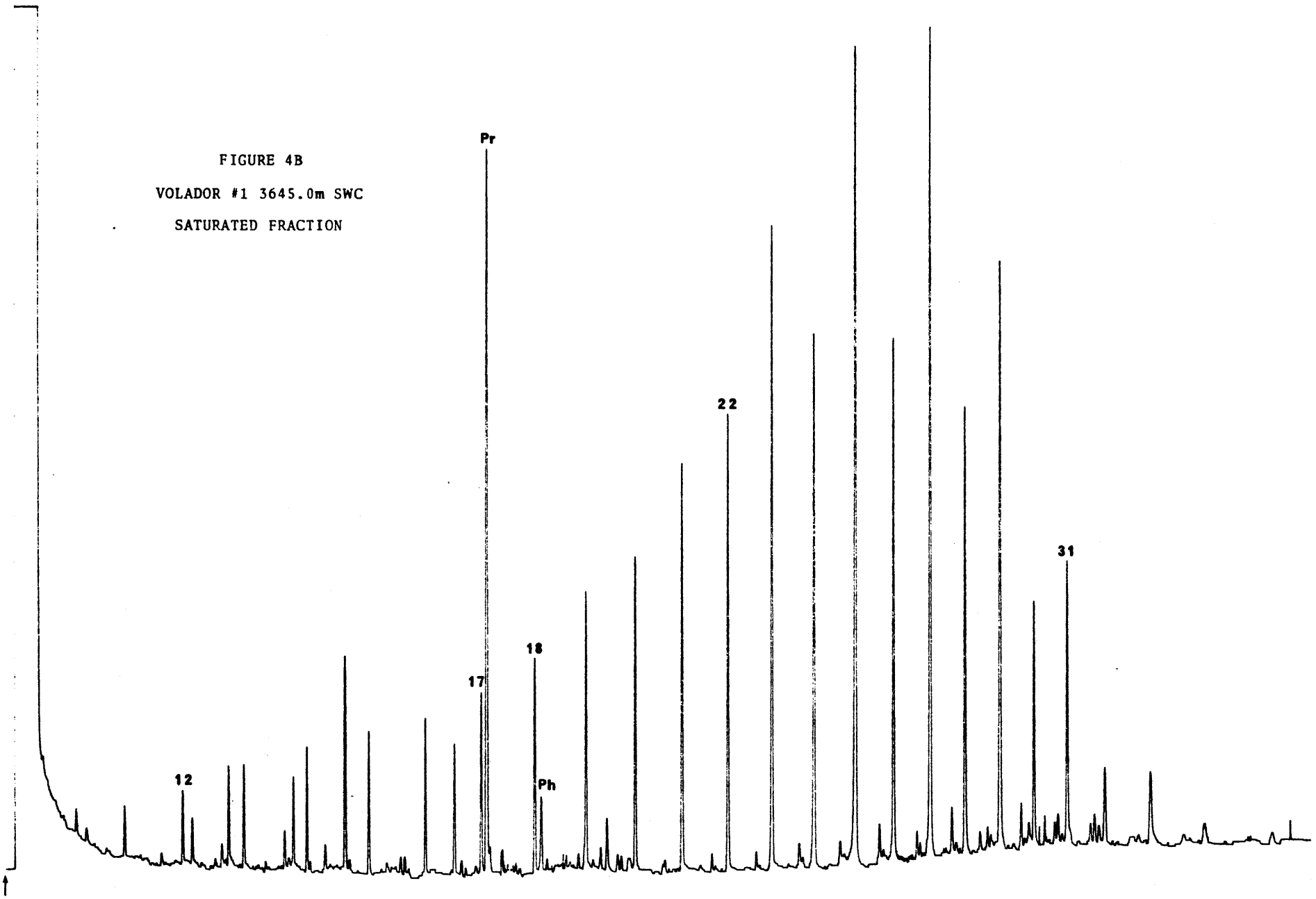


FIGURE 4C

VOLADOR #1 3673.5m SWC

SATURATED FRACTION

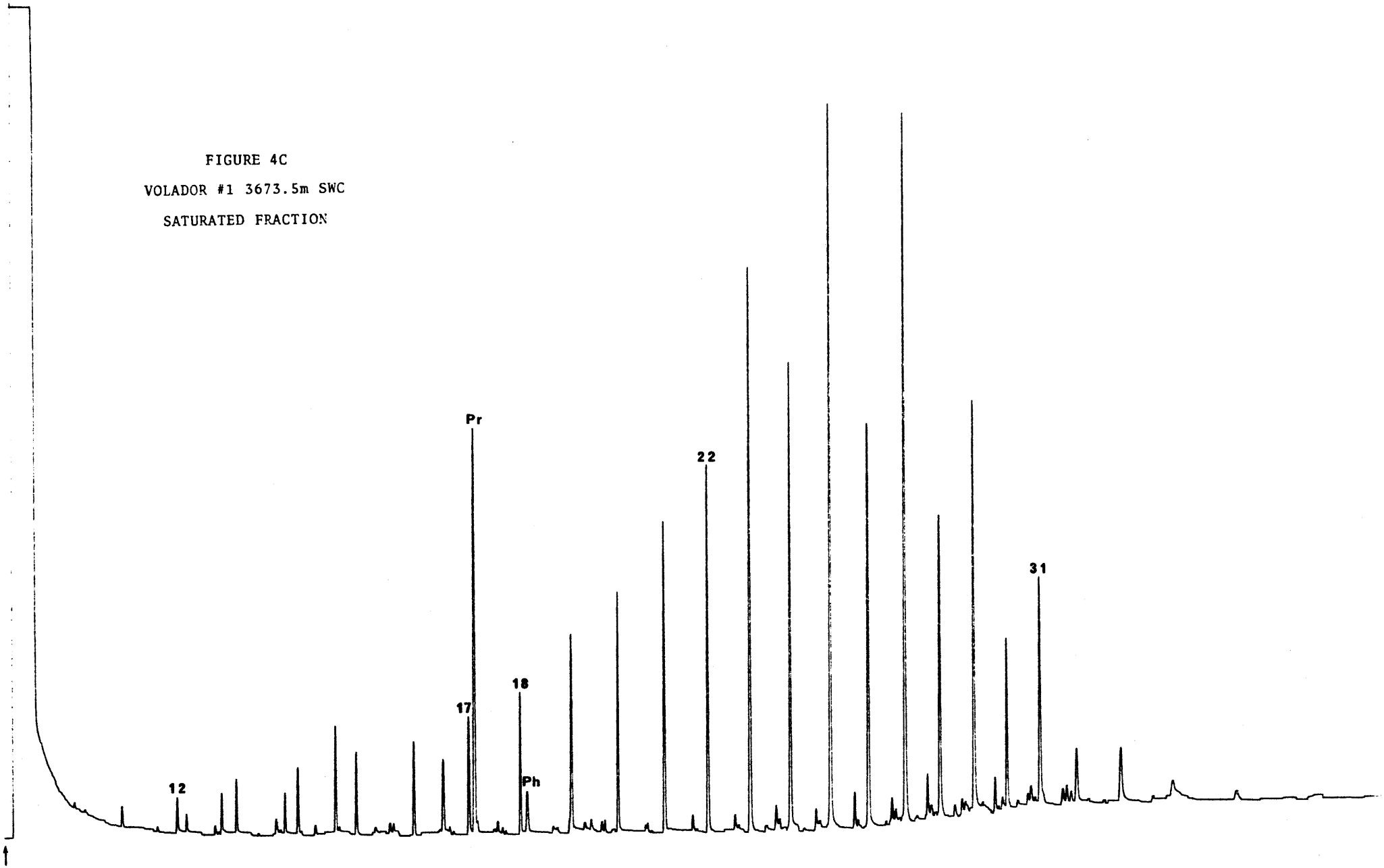


FIGURE 4D

VOLADOR #1 3691.5m SWC

SATURATED FRACTION

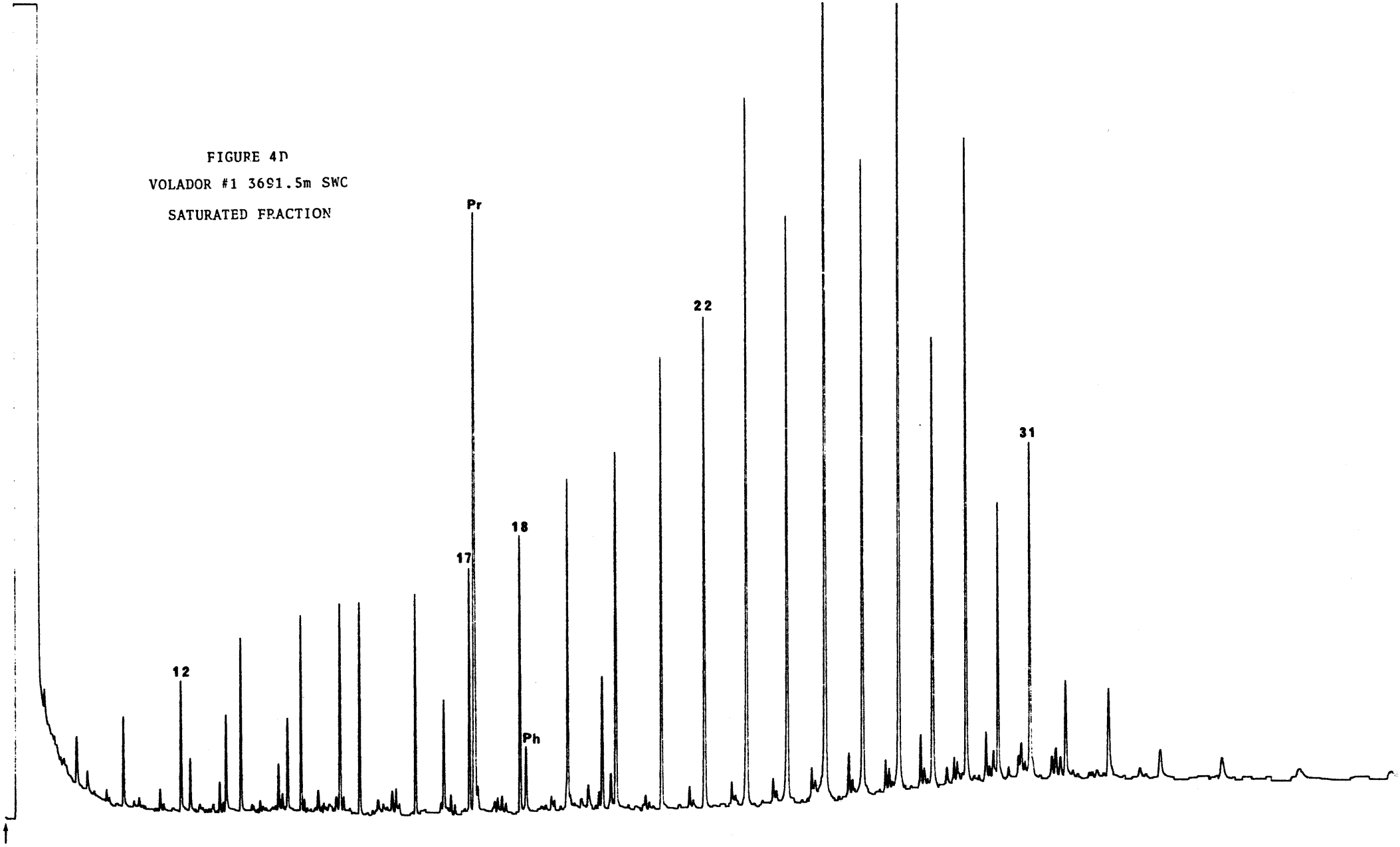


FIGURE 4E

VOLADOR #1 3820.3m SWC

SATURATED FRACTION

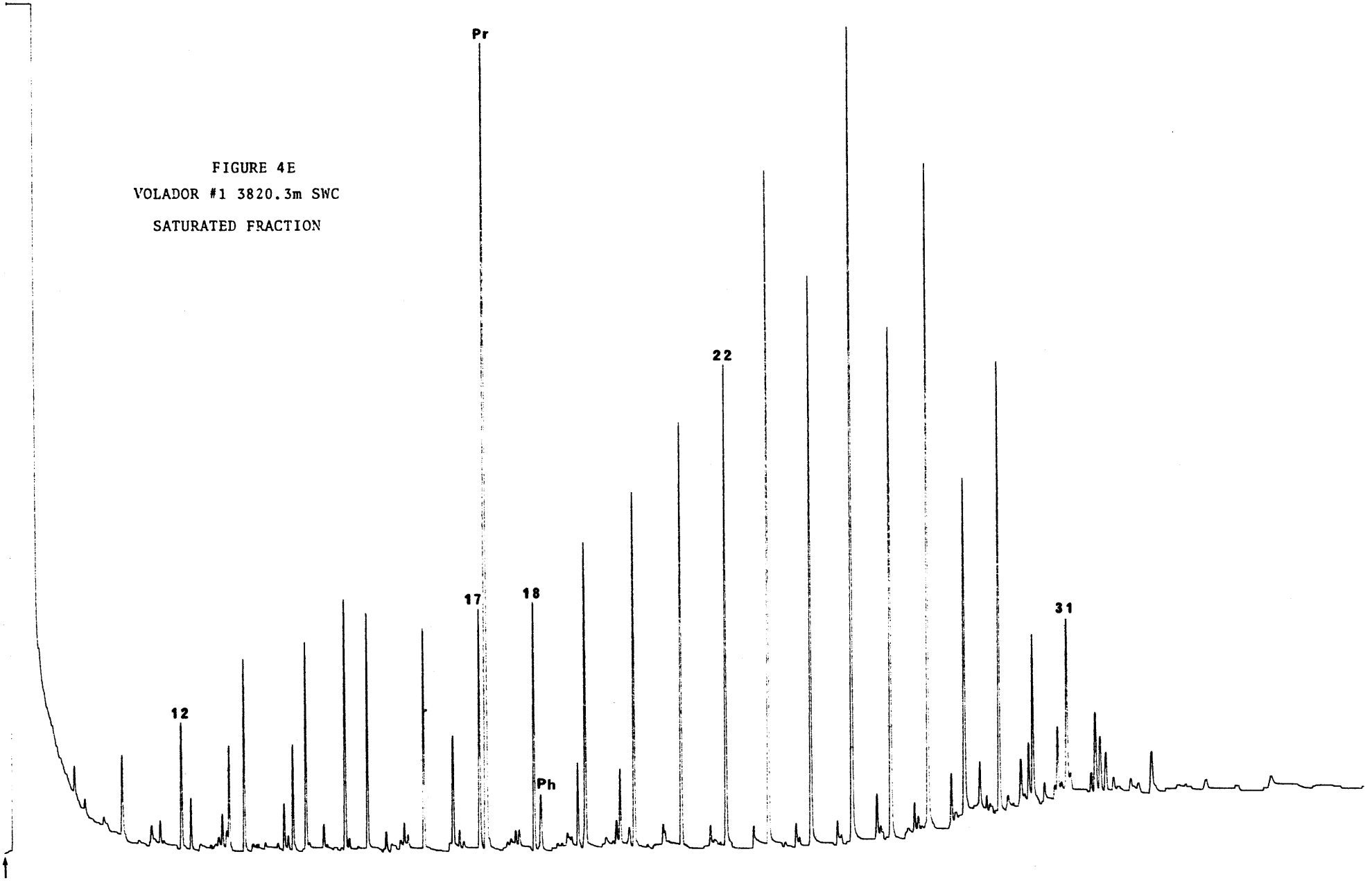


FIGURE 4F

VOLADOR #1 3950.0m SWC

SATURATED FRACTION

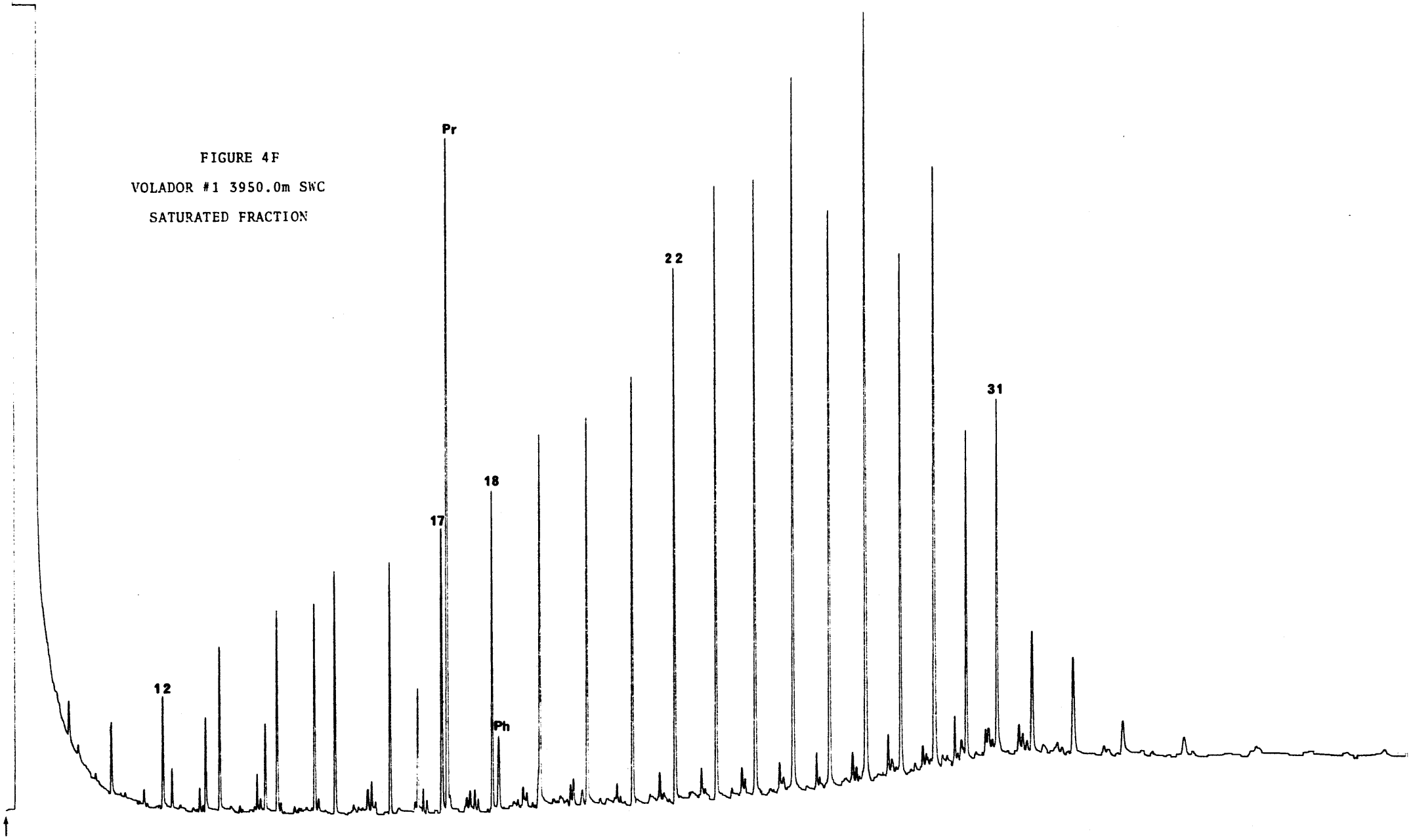


FIGURE 4G

VOLADOR #1 4039.0m SWC

SATURATED FRACTION

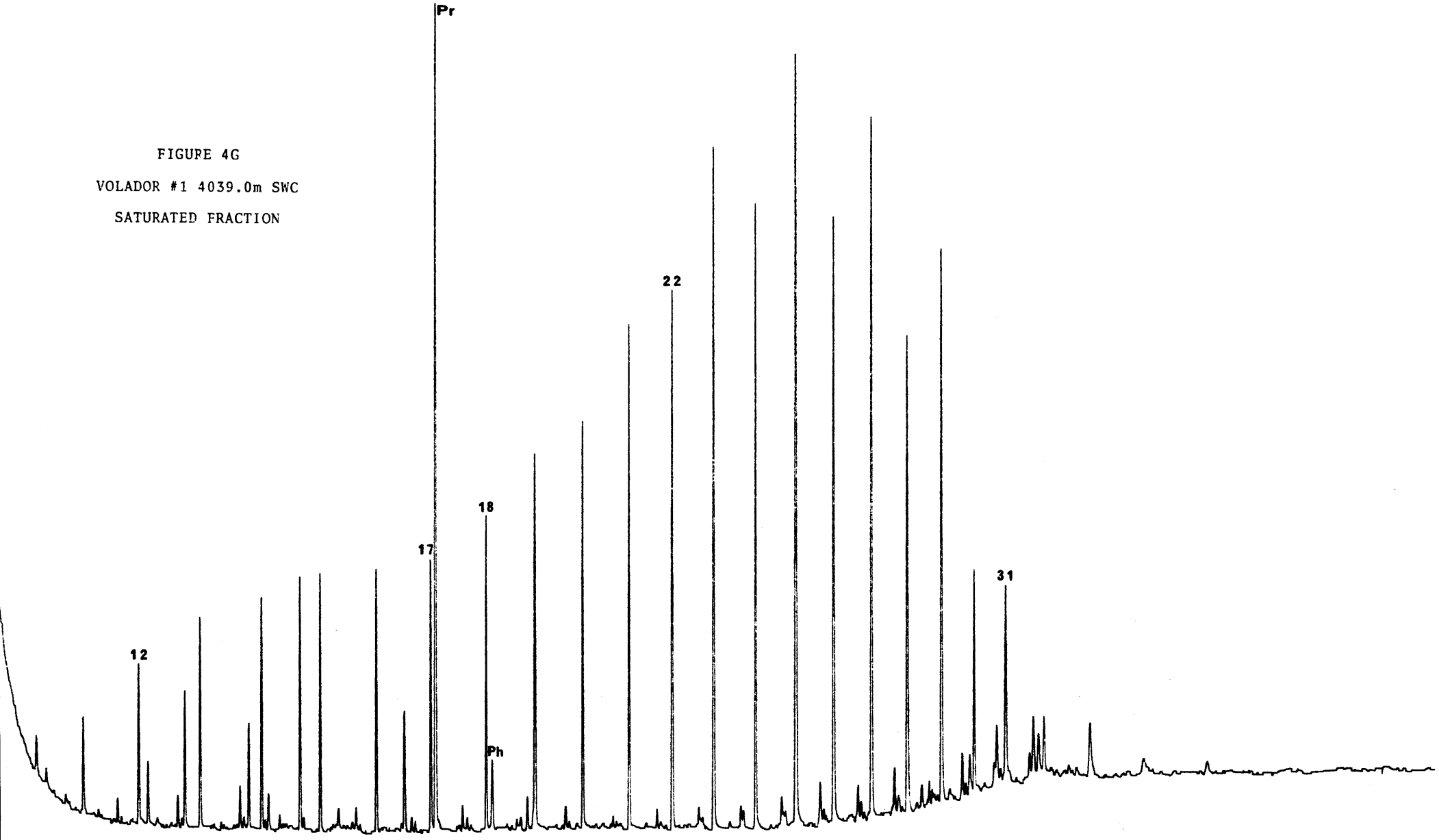


FIGURE 4H

VOLADOR #1 4145.3m SWC

SATURATED FRACTION

$nC_{12}+$ GLC

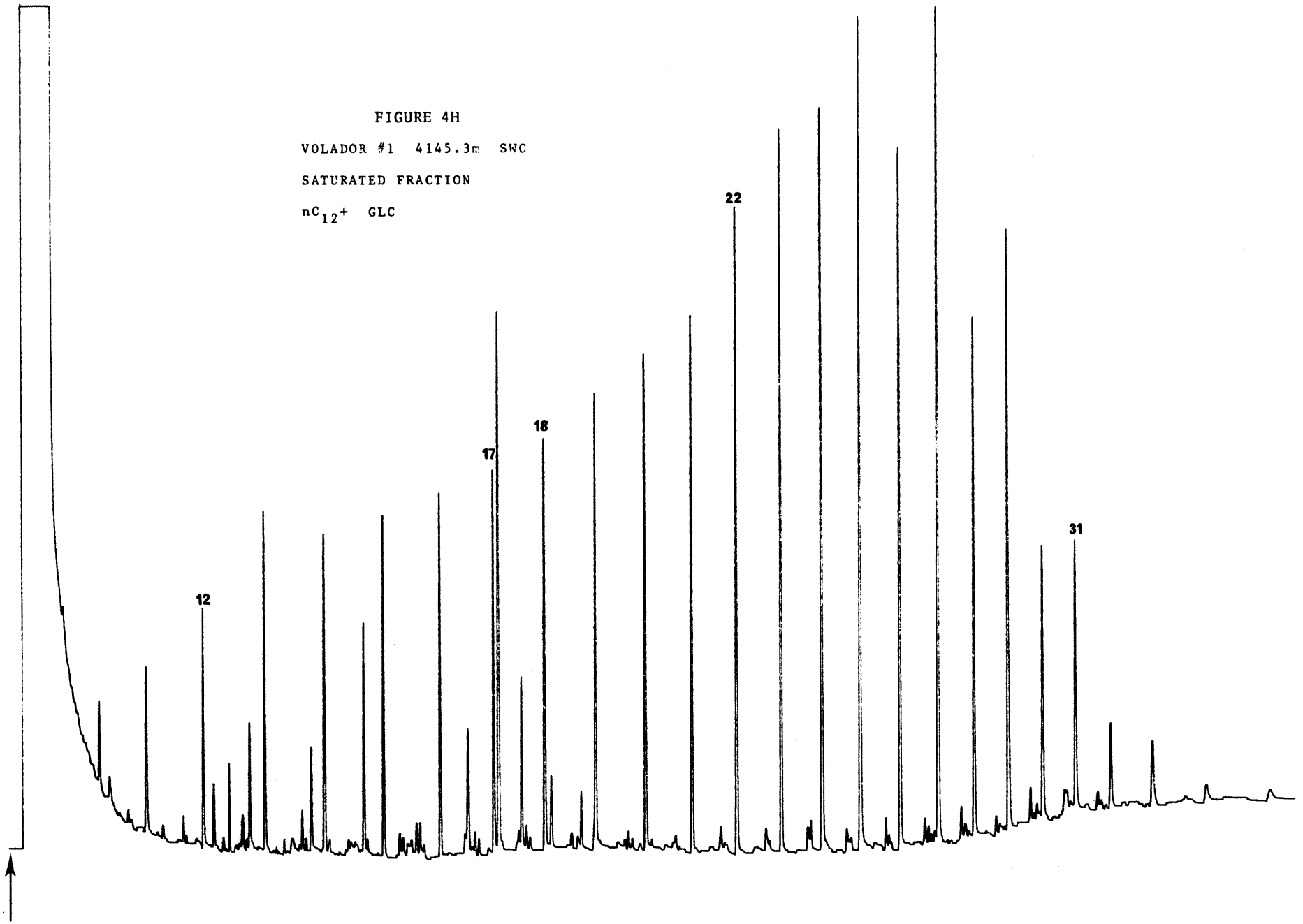


FIGURE 4I

VOLADOR #1 4265.0m SWC

SATURATED FRACTION

$nC_{12}+$ GLC

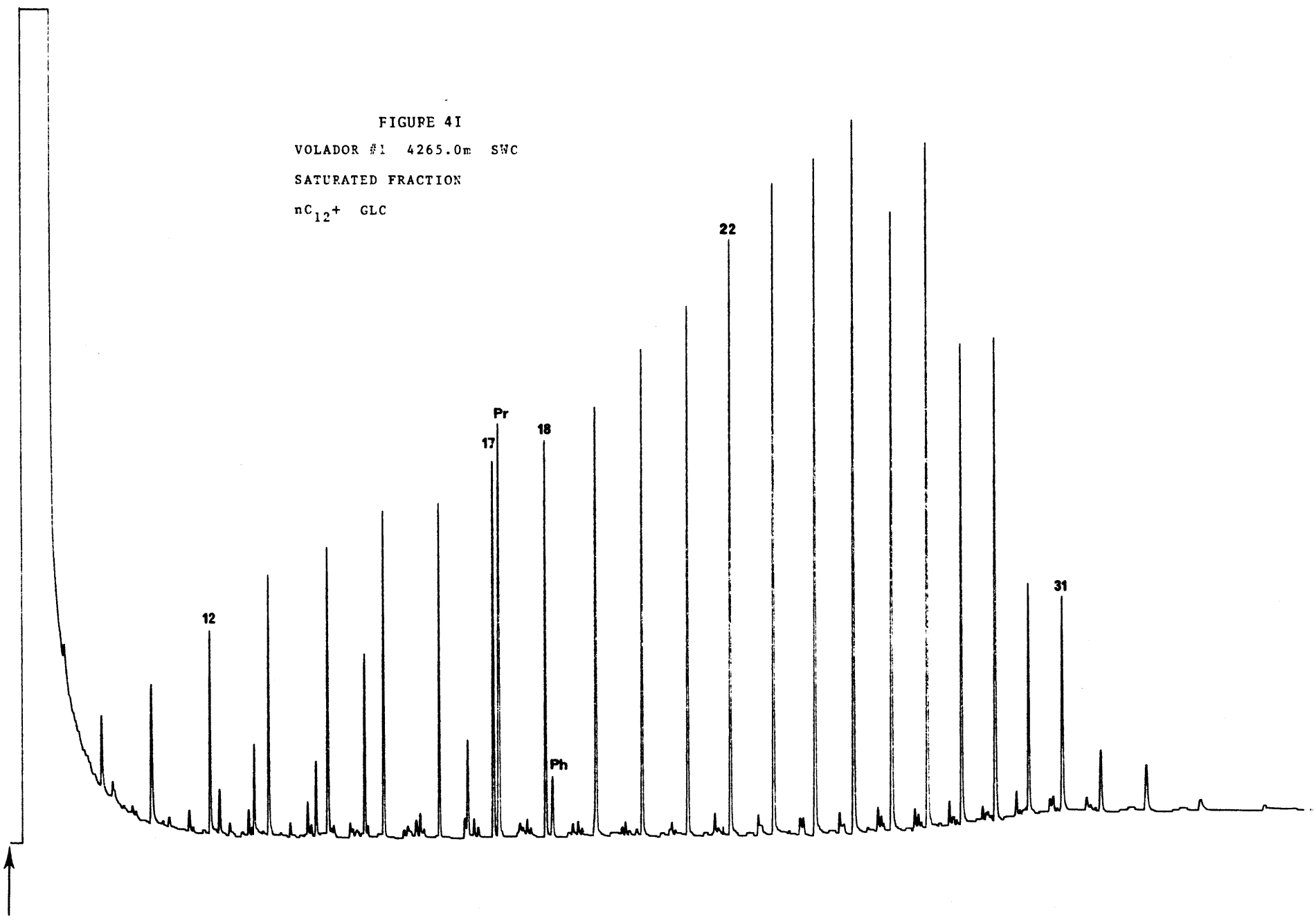


FIGURE 4J

VOLADOR #1 4360.0m SWC

SATURATED FRACTION

$nC_{12}+$ GLC

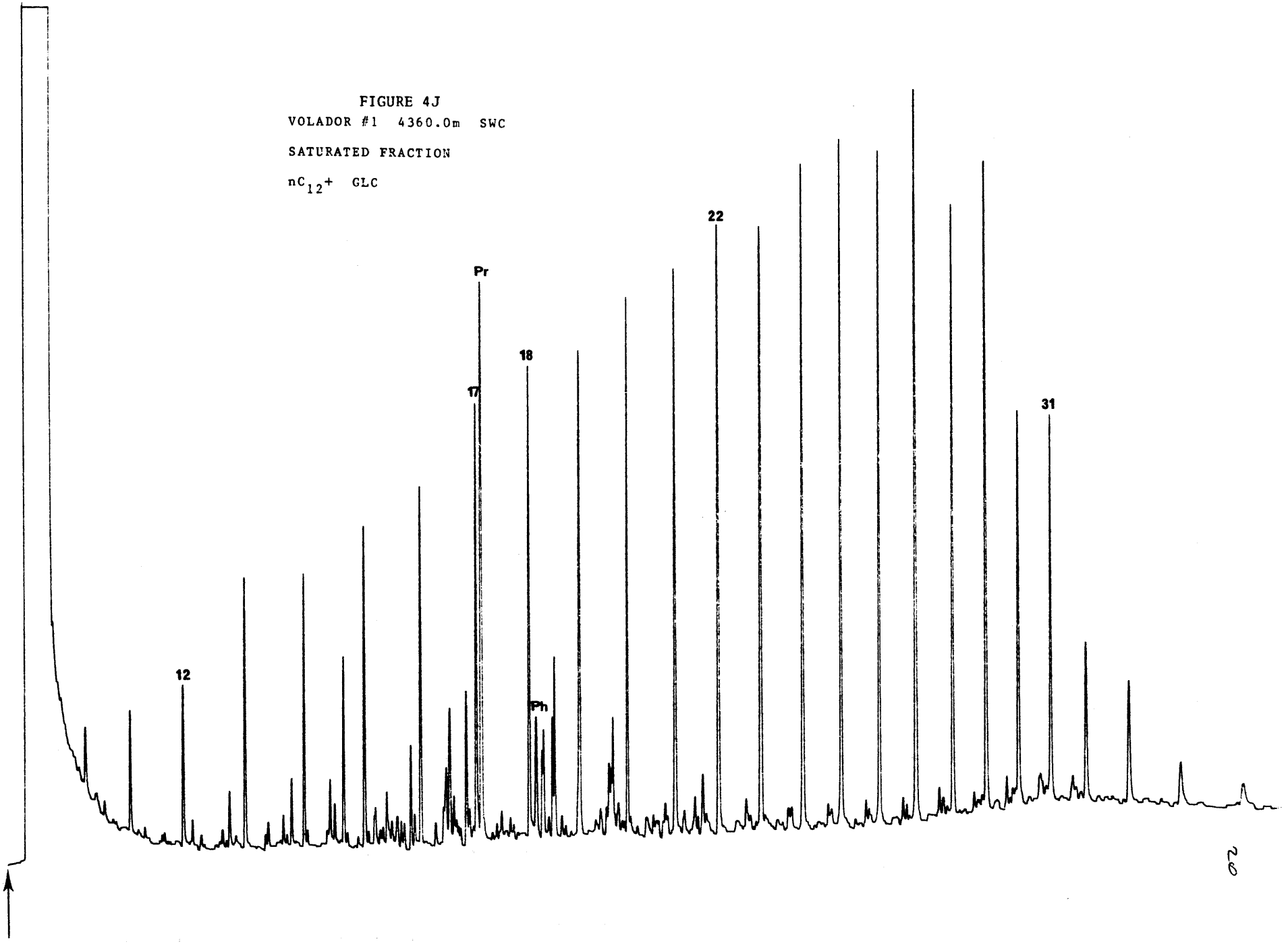


FIGURE 4K

VOLADOR #1 4383.0m SWC

SATURATED FRACTION

nC_{12}^{+} GLC

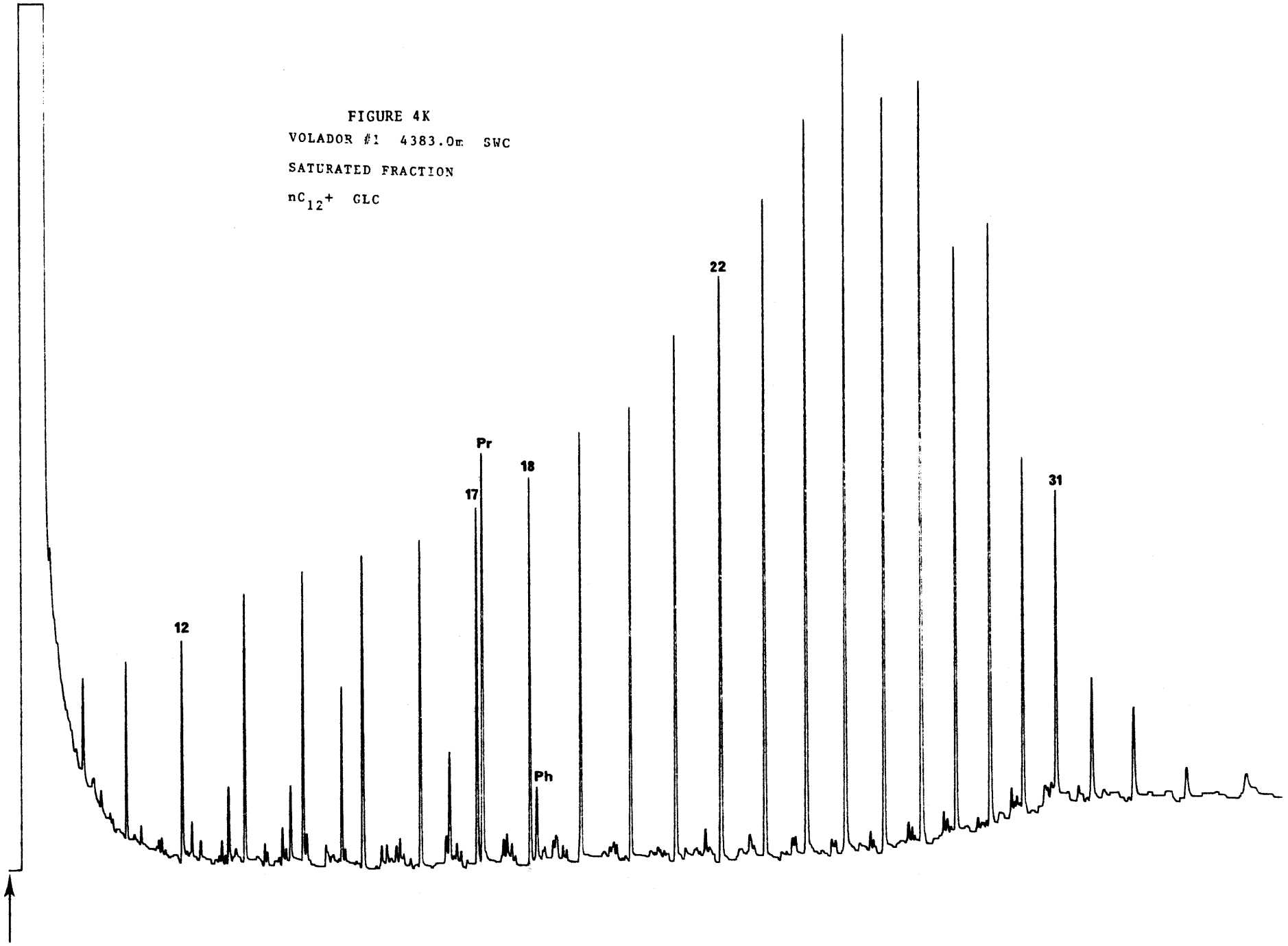


FIGURE 4L

VOLADOR #1 4526 M

SATURATED FRACTION

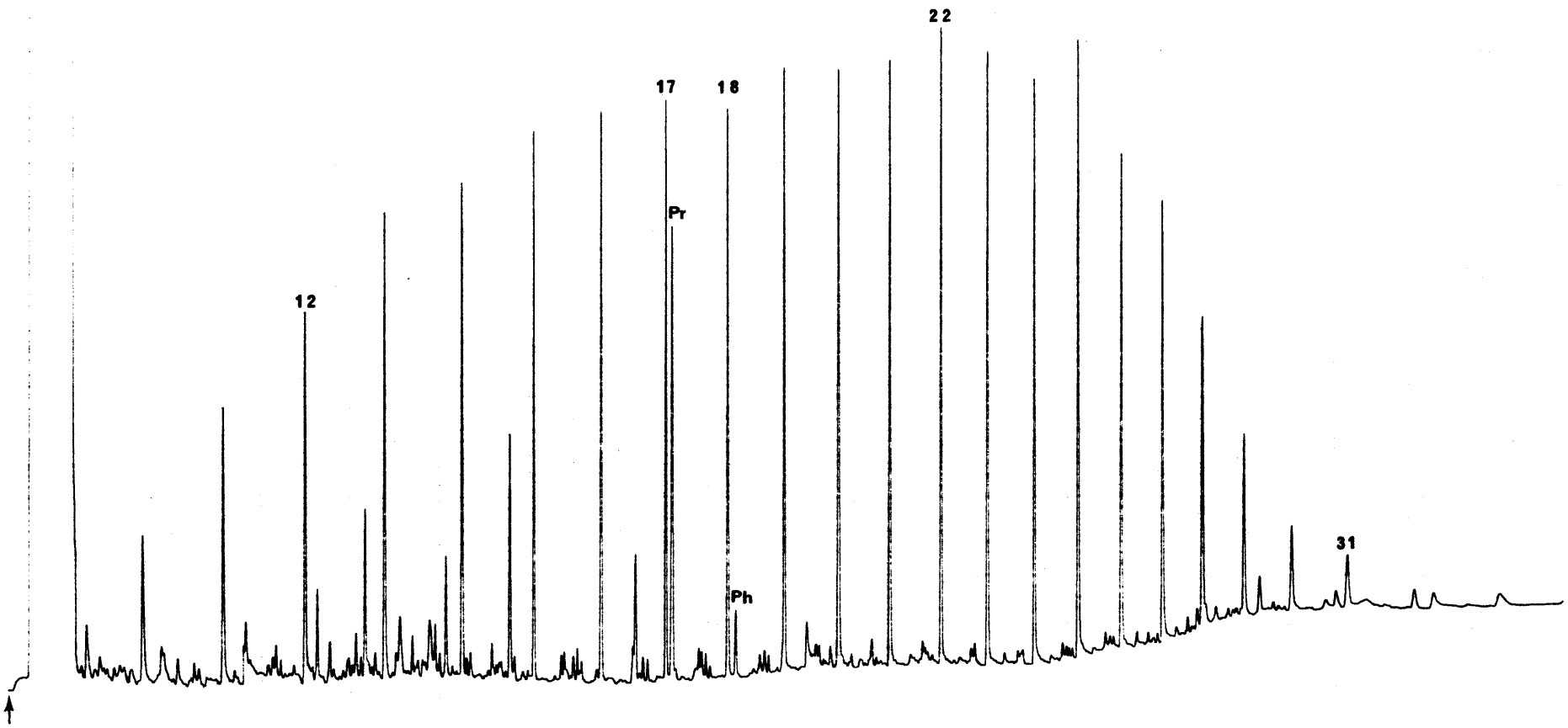


FIGURE 4M

VOIADOR #1 4536 M

SATURATED FRACTION

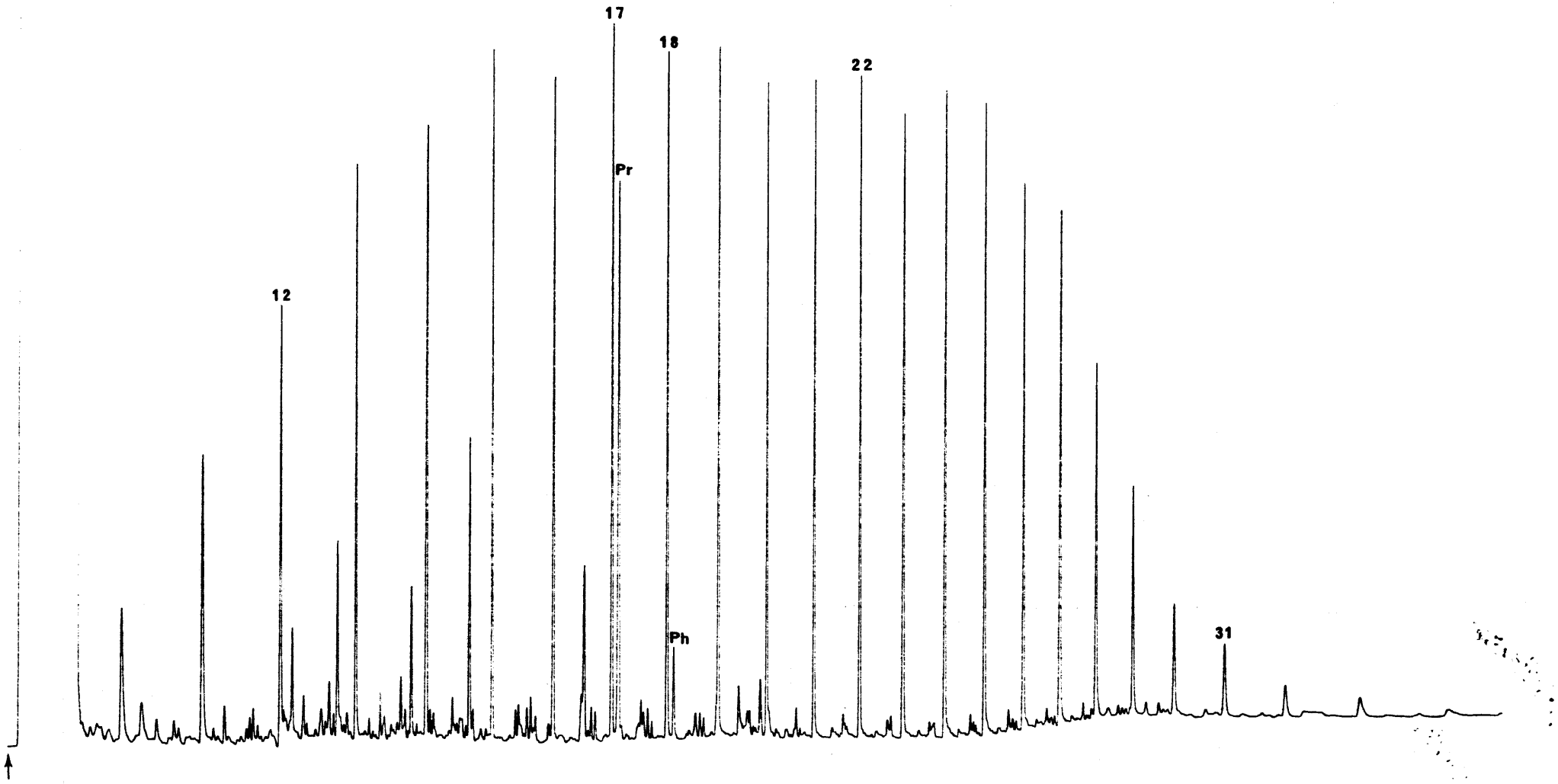
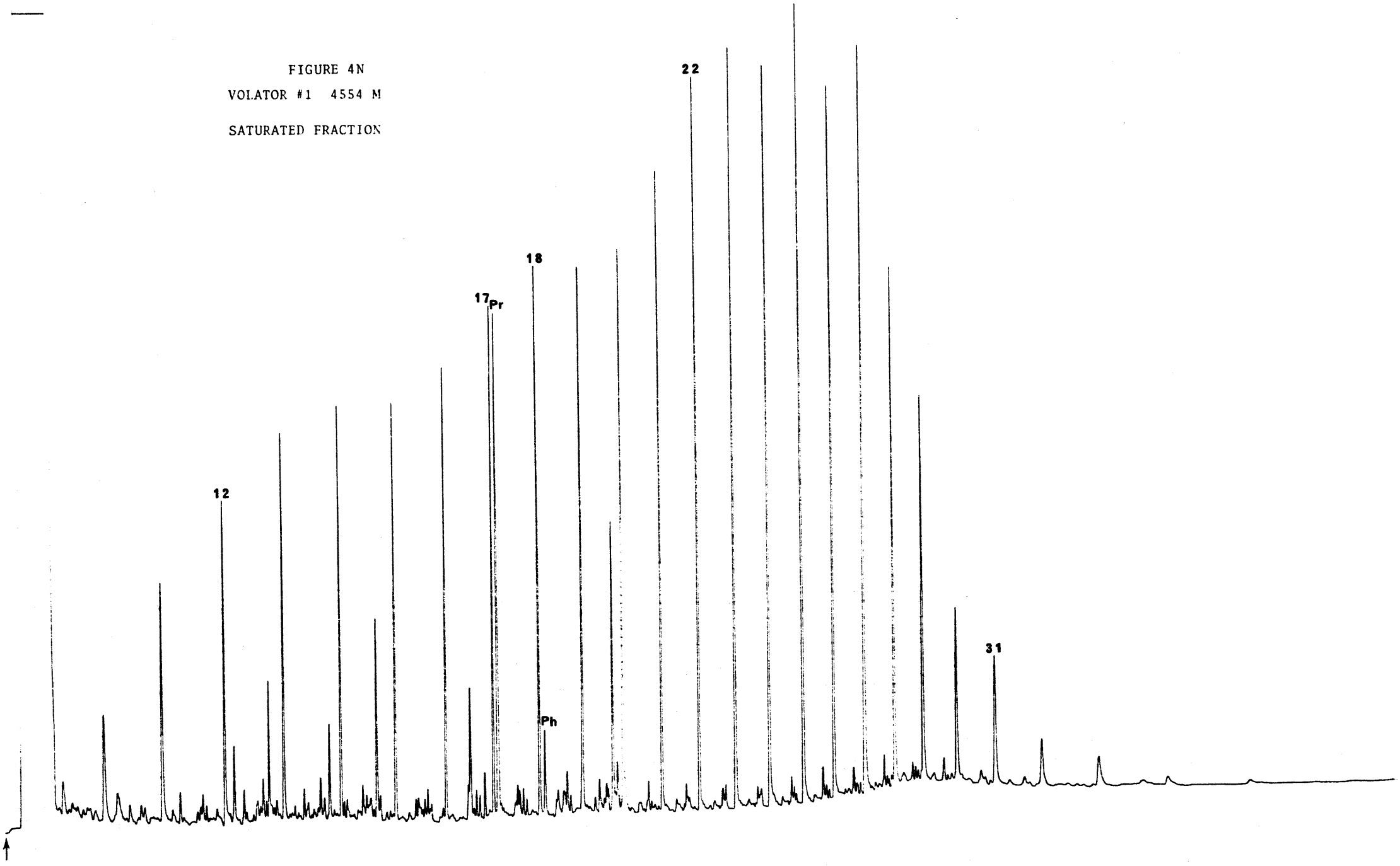


FIGURE 4N

VOLATOR #1 4554 M

SATURATED FRACTION



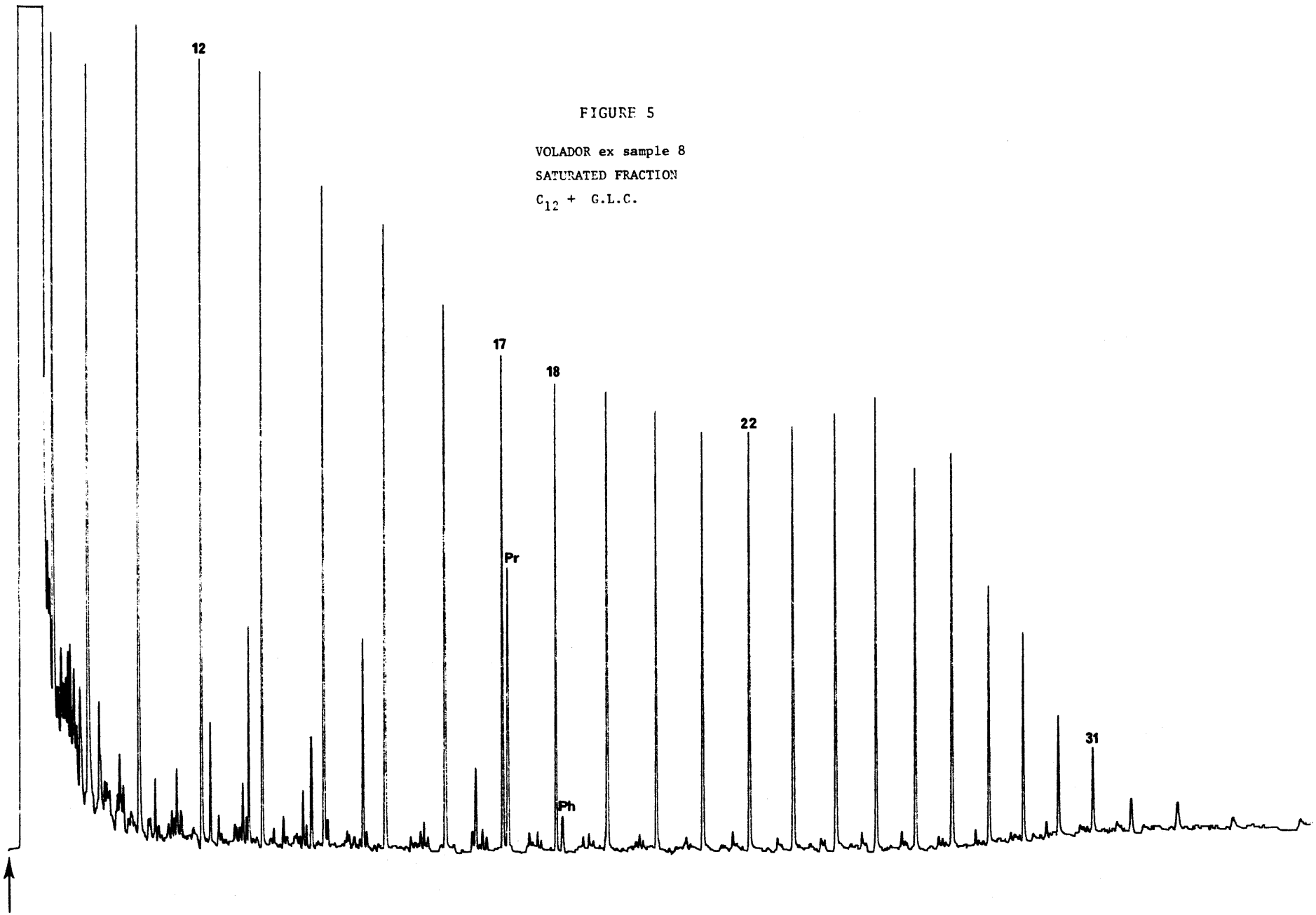


FIGURE 5

VOLADOR ex sample 8

SATURATED FRACTION

C_{12} + G.L.C.

FIGURE 6A

VOLADOR - 8

WHOLE OIL

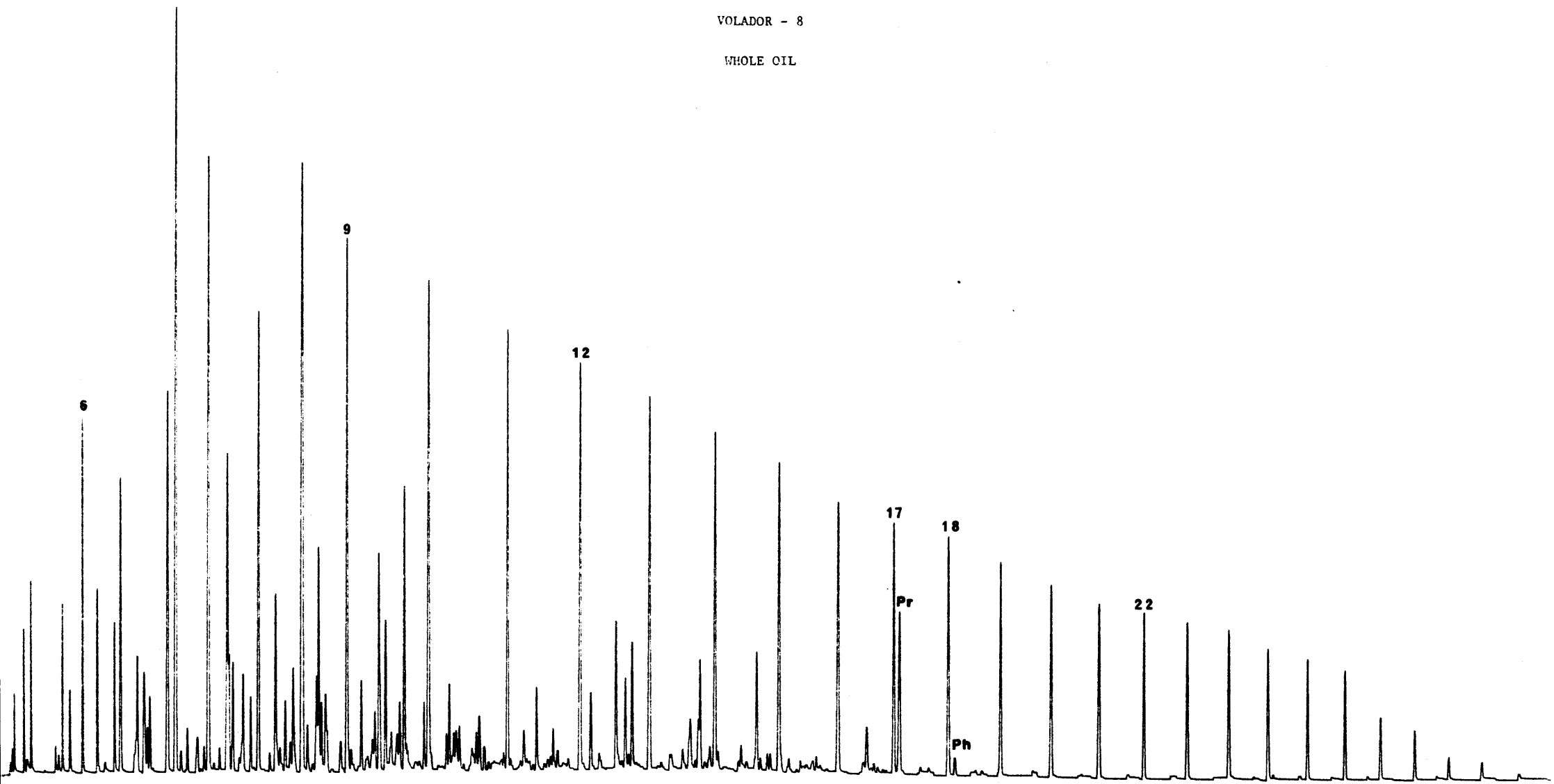


FIGURE 6B

VOLADOR - 17

WHOLE OIL

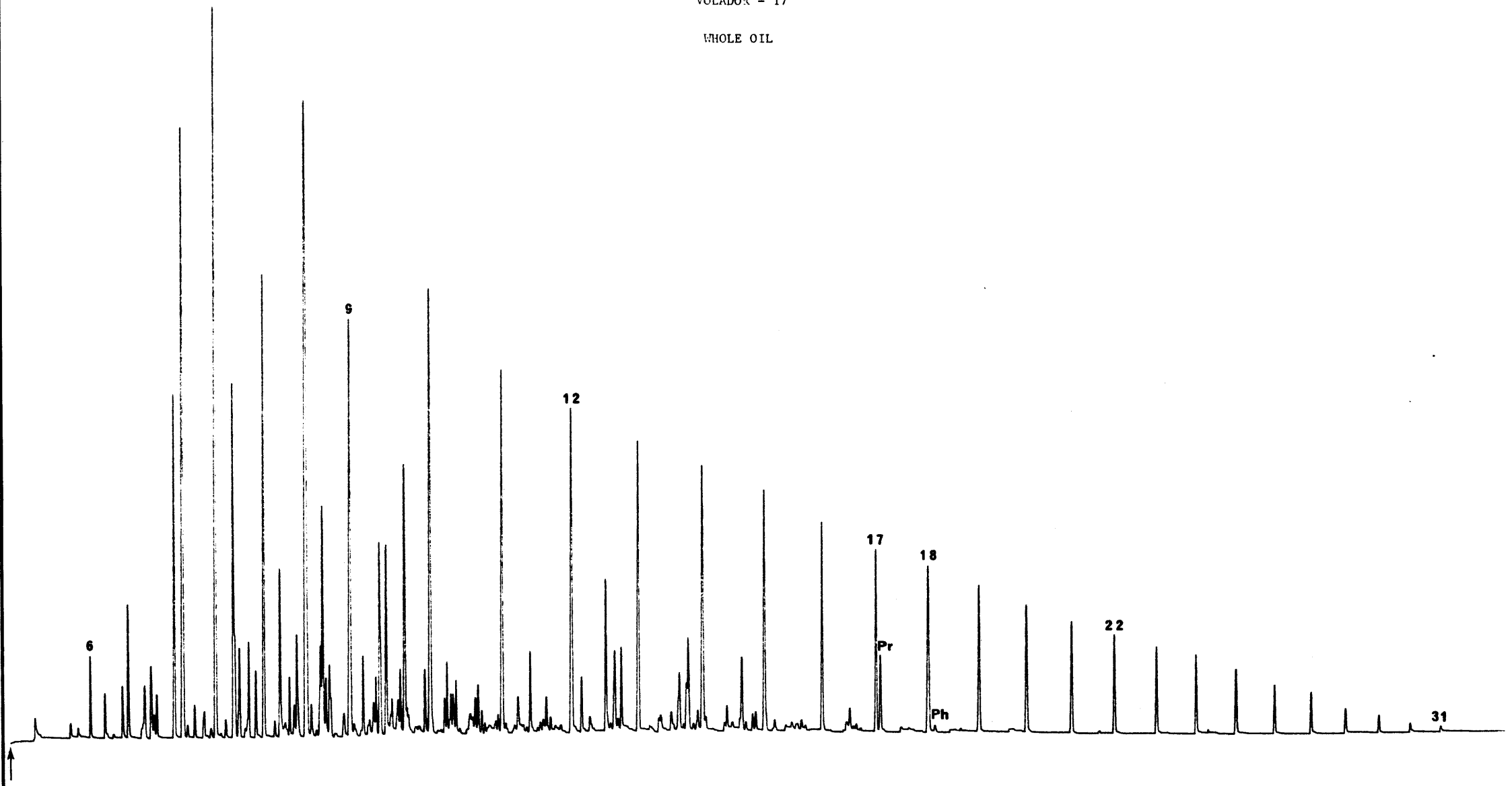


FIGURE 6C

VOLADOR - 26

WHOLE OIL

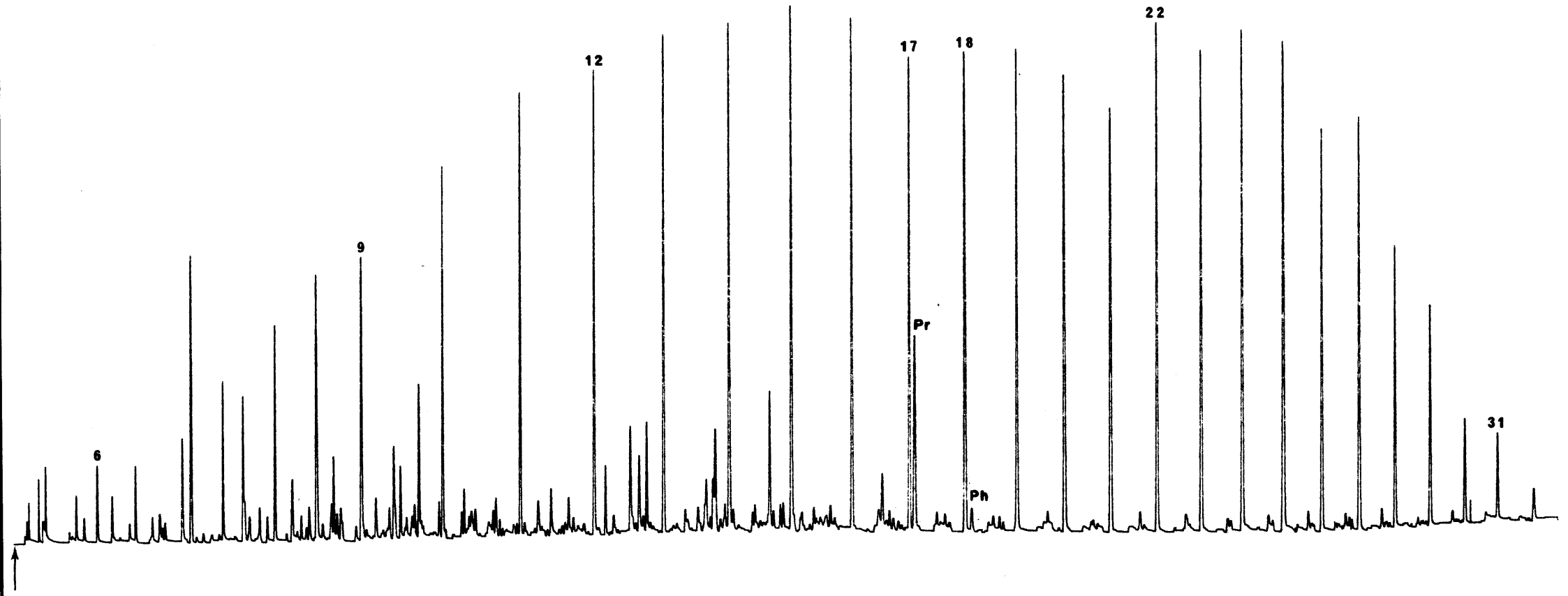


FIGURE 6D

VOLADOR - G

WHOLE OIL

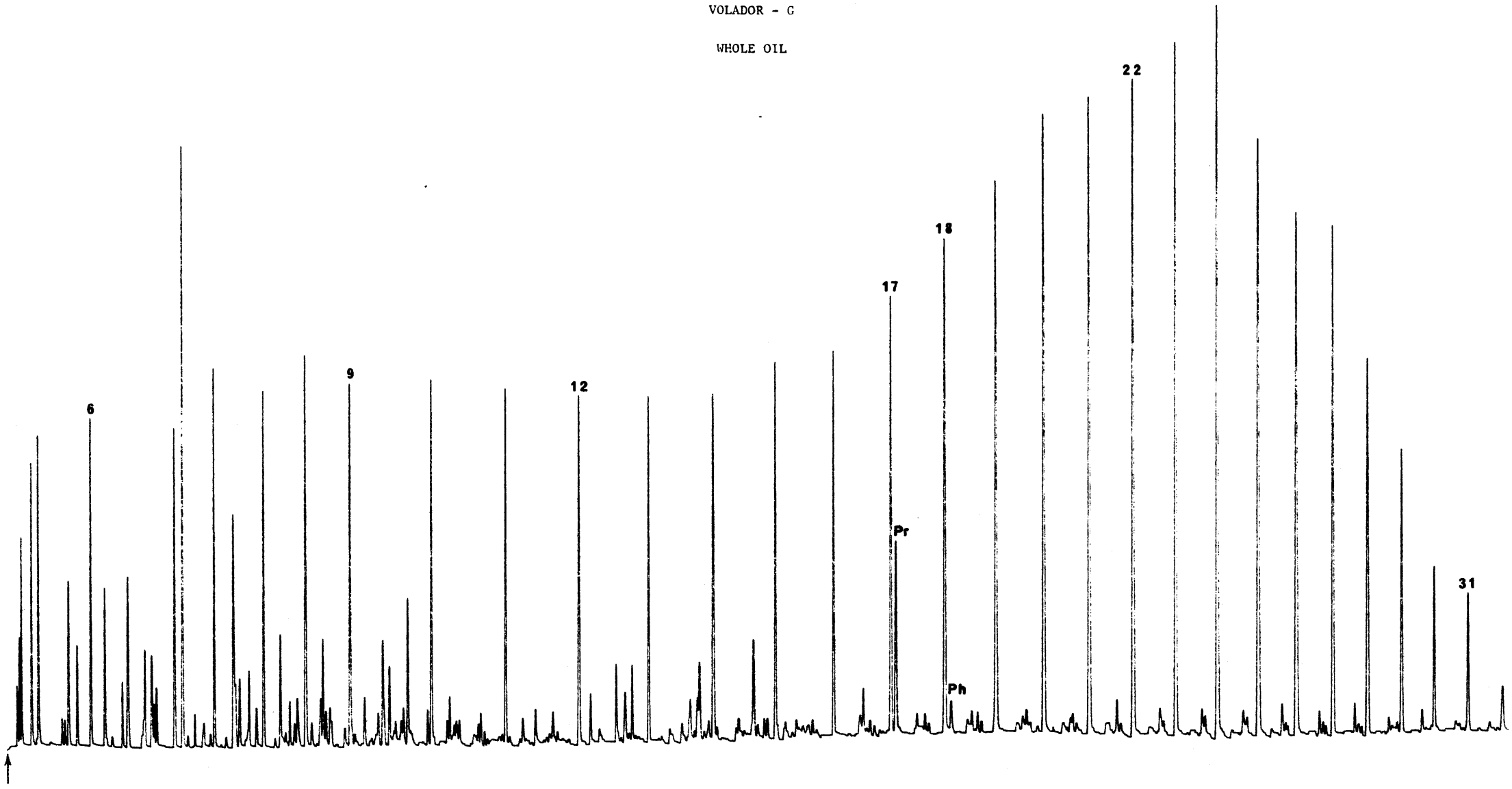


FIGURE 7A

HALIBUT A-1 WELLHEAD SAMPLE 2382m

WHOLE OIL

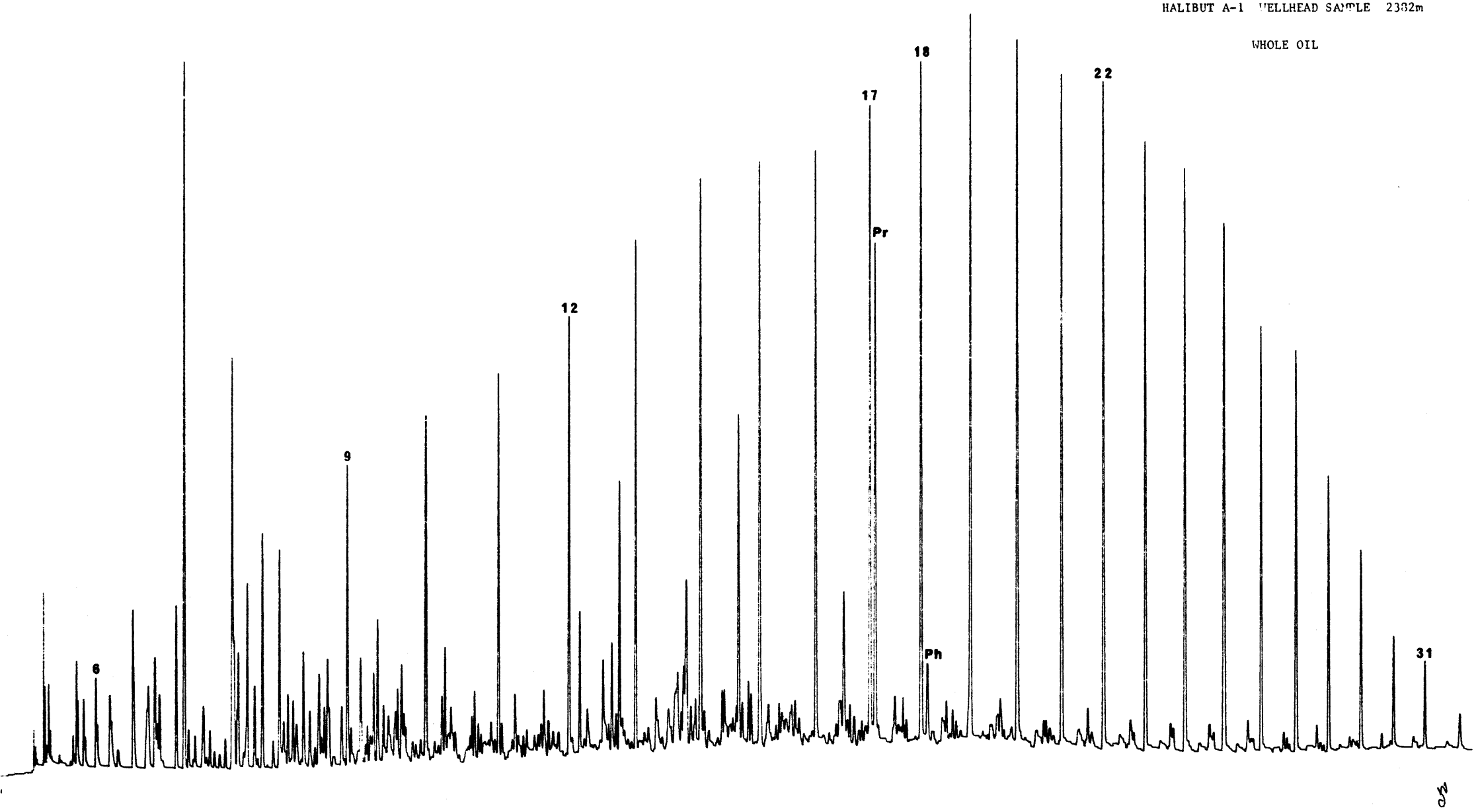


FIGURE 7B

HAPUKU #1 FIT #5 2837m

WHOLE OIL

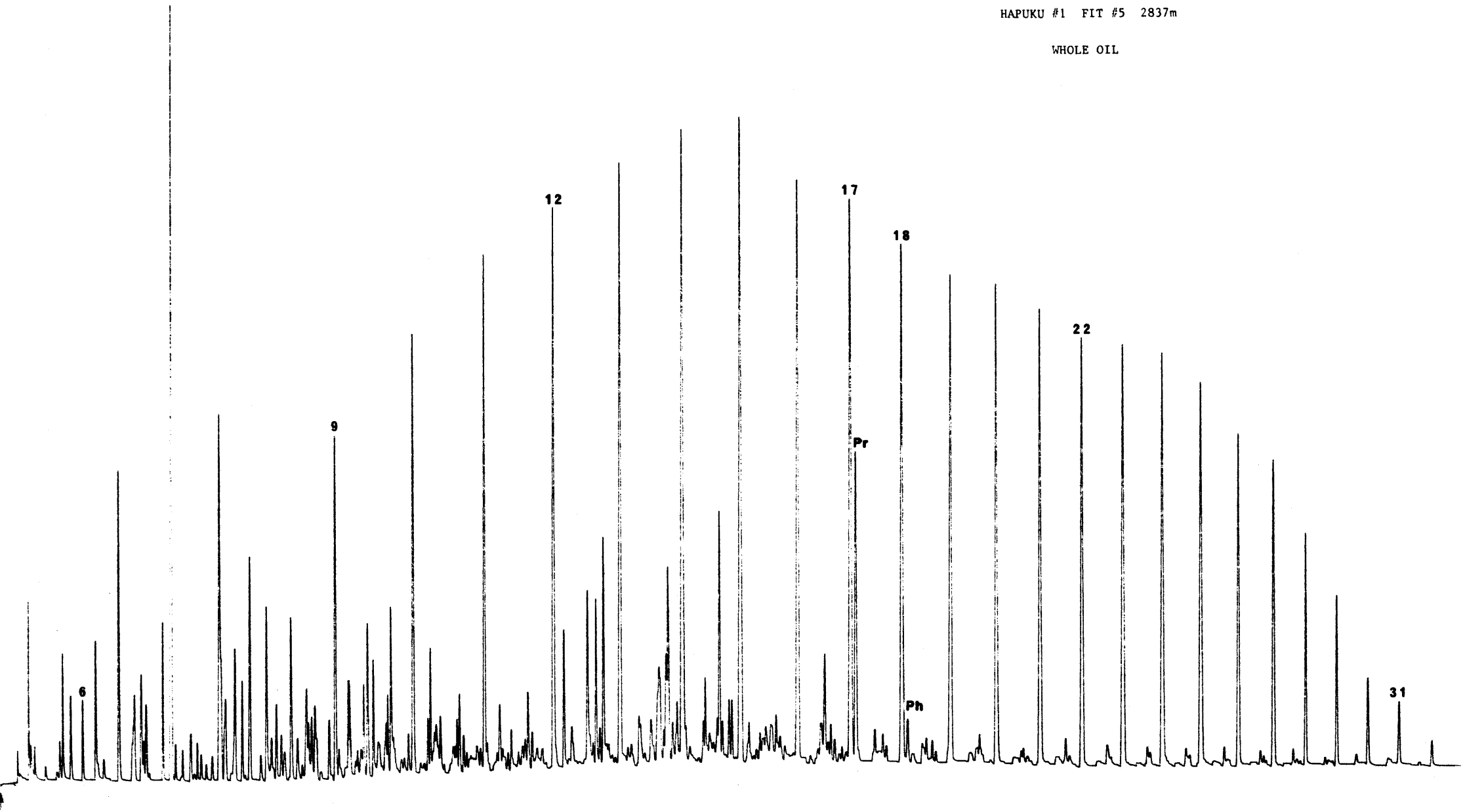


FIGURE 7C

TUNA A-2 WELLHEAD SAMPLE

1996 - 2005m

WHOLE OIL

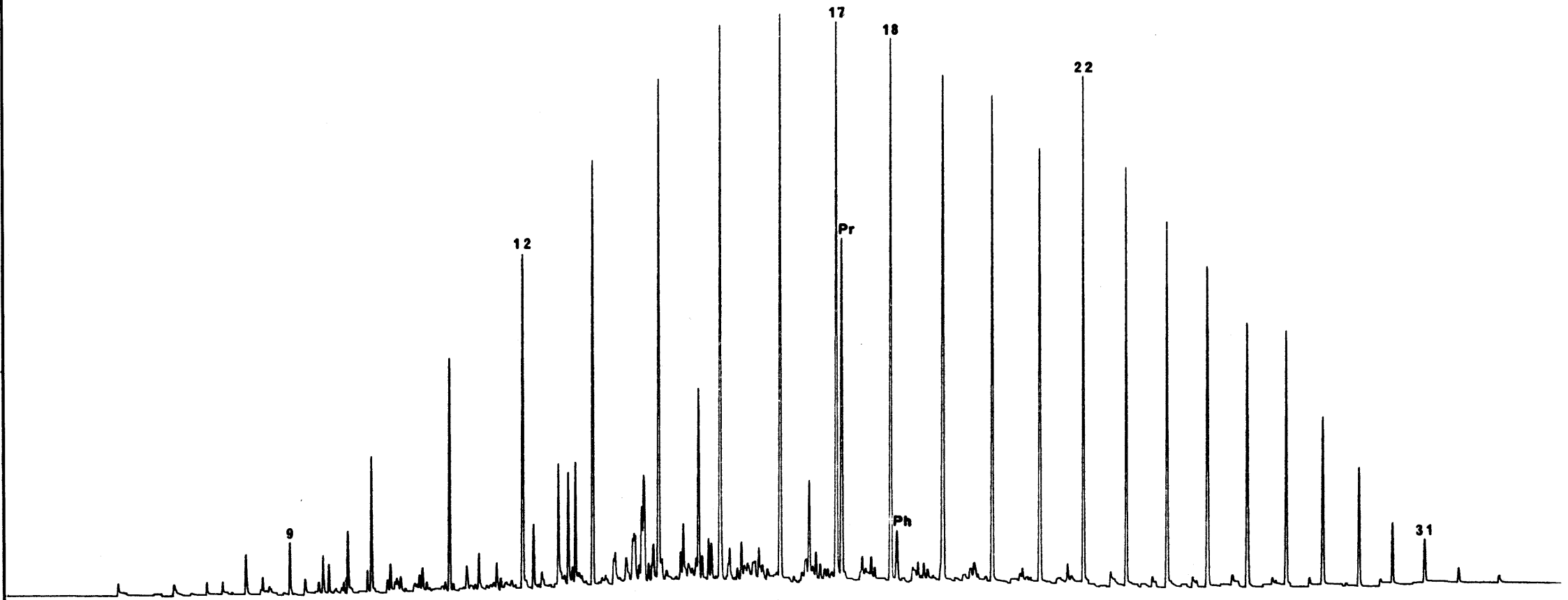


TABLE 1

ROCK-EVAL PYROLYSIS DATA (one run)

WELLNAME = VOLADOR #1 DATE OF JOB = APRIL, 1983

DEPTH(m)	TMAX	S1	S2	S3	S1+S2	S2/S3	PI	PC	TOC	HI	OI
3549.9	423	15.64	213.26	2.67	228.90	79.87	0.07	19.00	64.30	331	4
3645.0	427	2.09	51.45	2.63	53.54	19.56	0.04	4.44	17.00	302	15
3673.5	428	3.29	91.95	2.98	95.24	30.86	0.03	7.90	31.30	293	9
3691.5	429	1.60	38.12	2.50	39.72	15.25	0.04	3.30	13.90	274	17
3799.0	433	11.28	180.76	7.94	192.04	22.77	0.06	15.94	68.80	262	11
3820.3	433	13.04	214.49	5.21	227.53	41.17	0.06	18.88	73.50	291	7
3920.0	437	7.85	184.76	9.52	192.61	19.41	0.04	15.99	73.90	250	12
3950.0	441	1.27	14.72	2.63	15.99	5.60	0.08	1.33	8.60	171	30
4039.0	437	11.11	178.47	5.55	189.58	32.16	0.06	15.74	80.90	220	6
4145.3	443	0.89	4.88	1.69	5.77	2.89	0.15	0.48	3.22	151	52
4265.0	446	0.80	2.88	1.04	3.68	2.77	0.22	0.31	2.34	123	44
4360.0	444	0.74	2.07	0.85	2.81	2.44	0.26	0.23	1.80	115	47
4383.0	447	0.90	2.76	1.91	3.66	1.45	0.25	0.30	2.31	119	82
4526.0	451	8.65	52.88	2.11	61.53	25.06	0.14	5.11	21.71	243	9
4536.0	451	3.56	20.68	1.81	24.24	11.43	0.15	2.01	10.83	190	16
4554.0	448	0.87	4.48	3.39	5.35	1.32	0.16	0.44	4.28	104	79

TMAX = Max. temperature S2 S1 = Volatile hydrocarbons (HC) S2 = HC generating potential
S1+S2 = Potential yield S3 = Organic carbon dioxide PI = Production index
PC = Pyrolysable carbon TOC = Total organic carbon HI = Hydrogen index
OI = Oxygen Index nd = no data

TABLE 2

Summary of Extraction and Liquid Chromatography

Wellname: VOLADOR #1 Date of Job: APRIL, 1983

A. Concentrations of Extracted Material

				-------Hydrocarbons--------			-----Nonhydrocarbons-----		
Depth(m)	Weight of Rock Extd. (grams)	Total Extract (ppm)	Loss on Column (ppm)	Saturates (ppm)	Aromatics (ppm)	HC Total (ppm)	NSO's (ppm)	Asphaltenes (ppm)	NonHC Total (ppm)
3549.9	9.4	11766.0	2010.6	2414.9	5478.7	7893.6	957.4	904.3	1861.7
3645.0	15.8	2613.9	278.5	696.2	1019.0	1715.2	303.8	316.5	620.3
3673.5	18.8	4319.1	287.2	1893.6	1457.4	3351.1	292.6	388.3	680.9
3691.5	20.4	1995.1	647.1	500.0	529.4	1029.4	225.5	93.1	318.6
3820.3	8.4	12250.0	1369.0	3392.9	4773.8	8166.7	1131.0	1583.3	2714.3
3950.0	6.7	3134.3	522.4	671.6	820.9	1492.5	776.1	343.3	1119.4
4039.0	8.4	9369.0	1738.1	2547.6	3023.8	5571.4	797.6	1261.9	2059.5
4145.3	10.9	1917.4	568.8	532.1	211.0	743.1	275.2	330.3	605.5
4265.0	9.1	1681.3	703.3	318.7	142.9	461.5	274.7	241.8	516.5
4360.0	3.9	1615.4	nd	nd	nd	nd	nd	nd	nd
4383.0	11.3	2123.9	539.8	654.9	336.3	991.2	398.2	194.7	592.9
4526.0	4.8	19187.5	3770.8	2375.0	1958.3	4333.3	5520.8	5562.5	11083.3
4536.0	25.0	7732.0	3395.9	1155.4	883.9	2039.3	1614.7	682.1	2296.8
4554.0	13.9	2244.6	798.6	402.9	273.4	676.3	518.0	251.8	769.8

TABLE 2

Summary of Extraction and Liquid Chromatography

Wellname: VOLADOR #1 Date of Job: APRIL, 1983

B. Compositional Data

	-----Hydrocarbons------			-----Nonhydrocarbons------			EOM(mg)	SAT(mg)	SAT	ASPH	HC
Depth(m)	%SAT.	%AROM.	%HC's	%NSO's	%ASPH.	%Non HC's	TOC(g)	TOC(g)	AROM	NSO	Non HC
3549.9	24.8	56.2	80.9	9.8	9.3	19.1	18.3	3.8	.44	.94	4.2
3645.0	29.8	43.6	73.4	13.0	13.6	26.6	15.4	4.1	.68	1.04	2.8
3673.5	47.0	36.1	83.1	7.3	9.6	16.9	13.8	6.0	1.30	1.33	4.9
3691.5	37.1	39.3	76.4	16.7	6.9	23.6	14.4	3.6	.94	.41	3.2
3820.3	31.2	43.9	75.1	10.4	14.6	24.9	16.7	4.6	.71	1.40	3.0
3950.0	25.7	31.4	57.1	29.7	13.1	42.9	36.4	7.8	.82	.44	1.3
4039.0	33.4	39.6	73.0	10.5	16.5	27.0	11.6	3.1	.84	1.58	2.7
4145.3	39.5	15.6	55.1	20.4	24.5	44.9	59.5	16.5	2.52	1.20	1.2
4265.0	32.6	14.6	47.2	28.1	24.7	52.8	71.9	13.6	2.23	.88	.9
4360.0	nd	nd	nd	nd	nd	nd	89.7	nd	nd	nd	nd
4383.0	41.3	21.2	62.6	25.1	12.3	37.4	91.9	28.3	1.95	.49	1.7
4526.0	15.4	12.7	28.1	35.8	36.1	71.9	88.4	10.9	1.21	1.01	.4
4536.0	26.6	20.4	47.0	37.2	15.7	53.0	71.4	10.7	1.31	.42	.9
4554.0	27.9	18.9	46.8	35.8	17.4	53.2	52.4	9.4	1.47	.49	.9

na = not applicable nd = no data

TABLE 3

Summary of Gas Chromatography Data

Wellname: VOLADOR #1 Date of Job:APRIL, 1983

A. Alkane Compositional Data

Depth(m)	Prist./Phyt.	Prist./n-C17	Phyt./n-C18	CPI(1)	CPI(2)	(C21+C22)/(C28+C29)
3549.9	10.47	8.90	.71	1.77	1.71	.58
3645.0	8.18	5.00	.54	1.63	1.60	.80
3673.5	10.05	4.37	.35	1.77	1.74	.87
3691.5	8.21	3.32	.37	1.67	1.63	.83
3820.3	14.00	4.41	.30	1.51	1.48	1.10
3950.0	9.17	3.11	.29	1.26	1.21	.80
4039.0	12.06	3.94	.30	1.31	1.26	.98
4145.3	7.23	1.79	.24	1.24	1.18	.99
4265.0	6.37	1.38	.20	1.19	1.13	1.08
4360.0	4.68	1.94	.36	1.11	1.06	.89
4383.0	4.83	1.50	.29	1.13	1.08	.85
4526.0	6.79	.96	.14	1.07	1.05	2.03
4536.0	6.41	1.00	.15	1.06	1.05	1.91
4554.0	5.94	1.19	.20	1.11	1.07	1.33

TABLE 3

Summary of Gas Chromatography Data

Wellname: VOLADOR #1 Date of Job:APRIL, 1983

B. n-Alkane Distributions

DEPTH(m)	nC12	nC13	nC14	nC15	nC16	nC17	iC19	nC18	iC20	nC19	nC20	nC21	nC22	nC23	nC24	nC25	nC26	nC27	nC28	nC29	nC30	nC31
3549.9	.7	.9	1.0	1.1	1.2	1.3	11.9	1.6	1.1	2.6	2.7	3.8	4.5	7.6	6.3	10.7	6.7	13.1	5.6	8.7	3.0	4.0
3645.0	.7	1.1	1.2	1.4	1.6	2.0	10.0	2.3	1.2	3.2	3.5	4.5	5.2	8.4	6.7	11.3	6.6	10.7	5.2	7.0	2.8	3.3
3673.5	.5	.7	.9	1.2	1.3	1.7	7.4	2.1	.7	3.0	3.4	4.6	5.7	9.2	7.3	12.4	6.7	12.6	4.9	6.9	2.8	3.7
3691.5	1.1	1.5	1.7	1.9	2.0	2.3	7.6	2.5	.9	3.4	3.5	4.6	5.3	8.4	6.8	11.4	6.5	10.7	5.0	6.9	2.7	3.3
3820.3	1.3	2.0	2.3	2.4	2.3	2.7	11.8	2.8	.8	3.6	4.0	4.9	5.7	7.9	6.8	9.8	6.1	8.6	4.2	5.5	2.1	2.2
3950.0	1.1	1.6	2.0	2.4	2.5	2.8	8.7	3.3	.9	4.0	4.1	4.7	5.4	6.3	6.6	8.0	6.7	8.6	5.8	6.8	3.7	4.2
4039.0	1.6	2.0	2.3	2.5	2.5	2.8	11.1	3.1	.9	3.9	4.1	5.1	5.7	7.0	6.7	8.3	6.7	8.2	4.9	6.1	2.4	2.1
4145.3	1.9	2.7	2.8	2.9	3.0	3.4	6.0	3.5	.8	4.2	4.3	5.1	5.9	6.8	7.0	8.2	6.8	8.1	5.2	5.8	2.6	2.9
4265.0	1.9	2.3	2.7	3.0	3.1	3.5	4.9	3.8	.8	4.5	4.8	5.5	6.2	7.0	7.3	7.9	7.0	7.7	5.2	5.7	2.5	2.6
4360.0	1.3	2.1	2.2	2.6	3.0	3.5	6.8	4.0	1.4	4.6	4.7	5.2	5.5	6.2	6.5	6.9	6.6	7.3	6.0	6.1	3.7	3.9
4383.0	1.8	2.3	2.5	2.8	2.9	3.2	4.7	3.4	1.0	4.1	4.3	4.9	5.6	6.5	7.0	8.0	7.4	8.1	6.3	6.2	3.4	3.5
4526.0	3.8	4.5	4.9	5.1	5.2	5.4	5.1	5.4	.8	5.8	5.7	5.9	6.1	6.1	6.0	6.0	5.1	4.9	3.5	2.4	1.3	1.0
4536.0	4.1	4.9	5.4	5.5	5.4	5.5	5.5	5.7	.9	5.9	5.3	5.5	5.6	5.7	5.6	5.7	4.9	4.7	3.3	2.5	1.4	.9
4554.0	3.1	3.3	3.4	3.5	3.7	4.3	5.1	4.3	.9	4.9	4.8	5.4	6.3	6.7	6.9	7.3	6.5	6.8	4.8	4.0	2.1	2.0

na = not applicable nd = no data

TABLE 4

RESULTS OF VITRINITE REFLECTANCE

Depth (m)	R_v Max	Range
3549.9	0.61	0.50 - 0.68
3645	0.71	0.60 - 0.80
3673.5	0.72	0.66 - 0.86
3691.5	0.82	0.63 - 0.93
3799	0.75	0.66 - 0.89
3820.3	0.76	0.67 - 0.88
3920	0.85	0.75 - 0.93
3950	0.94	0.75 - 1.05
4039	0.89	0.82 - 0.96
4152	0.85	0.72 - 0.95
4170	0.88	0.68 - 1.03
4191	0.89	0.75 - 1.01
4218	0.85	0.72 - 0.98
4264	0.83	0.70 - 0.94
4372	0.88	0.75 - 0.99
4526	0.90	0.81 - 0.98
4536	0.89	0.77 - 1.02
4554	0.89	0.74 - 1.01

****

TABLE 5

PHYSICAL PROPERTY DATA - VOLADOR #1 OILS

Sample	API Gravity(60°F)	% Sulphur(w/w)	Viscosity(25°C)	Viscosity(60°C)	Viscosity(100°C)	Pour Point (°C)
2	39.6	-	-	-	-	-
6	42.8	-	-	-	-	-
7	42.8	-	-	-	-	-
8	41.1	0.047	16.06	1.90	-	+27
10	39.6	-	-	-	-	-
15	43.6	0.067	1.82	1.17	-	+12
17	43.6	-	-	-	-	-
18	36.8	-	-	-	-	-
20	37.2	-	-	-	-	-
21	36.3	-	-	-	-	-
22	36.3	-	-	-	-	-
23	36.6	-	-	-	-	-
24	34.1	-	-	-	-	-
25	33.3	-	-	-	-	-
26	33.7	0.069	-	5.00	2.63	+33
28	34.5	-	-	-	-	-
G	37.2	0.062	-	3.75	2.12	+36

N.B. Units for viscosity are centistokes.

TABLE 6

COMPOSITIONAL DATA

OILNAME	%SAT	%AROM	%NSO	PRIST/PHYT	PRIST/NC17	PHYT/NC18	AROM/SAT	CPI(1)	CPI(2)	21+22/28+29
VOLADOR EX SAMPLE 8	82.3	15.1	2.6	6.79	.73	.11	0.18	1.08	1.06	1.6

N-ALKANE DISTRIBUTIONS

OILNAME	CN12	CN13	CN14	CN15	CN16	CN17	CN18	CN19	CN20	CN21	CN22	CN23	CN24	CN25	CN26	CN27	CN28	CN29	CN30	CN31
VOLADOR EX SAMPLE 8	8.1	7.7	7.4	6.7	6.0	5.6	5.3	5.2	4.9	4.8	5.0	5.1	5.1	5.3	4.6	4.7	3.4	2.6	1.4	1.0

TABLE 7

COMPOSITIONAL DATA - VOLADOR #1 OILS

Carbon Number	Sample G	Sample 8	Sample 17	Sample 26
1 - 3	0.39	0.04	<0.01	<0.01
4	0.98	0.24	0.01	0.04
5	1.7	1.1	0.02	0.54
6	3.9	5.2	2.1	1.5
7	7.0	13.9	14.4	3.9
8	8.3	18.0	23.4	6.6
9	4.6	9.9	12.7	5.5
10	3.6	6.6	7.7	5.0
11	2.9	5.4	5.9	4.9
12	3.2	5.7	6.4	5.9
13	3.2	4.6	5.4	5.9
14	3.3	3.9	4.1	5.7
15	3.4	6.5	3.3	5.0
16	3.0	3.5	2.5	4.6
17	3.9	3.0	2.6	5.3
18	3.4	1.8	1.8	3.7
19	3.6	1.5	1.4	3.3
20	4.0	1.4	1.1	3.4
21	4.2	1.1	1.0	3.3
22	4.5	1.1	0.80	3.5
23	4.6	1.0	0.72	3.5
24	4.7	1.0	0.64	3.6
25	4.6	0.90	0.53	3.6
26	3.6	0.74	0.39	3.2
27	3.6	0.72	0.37	3.1
28	2.3	0.48	0.25	2.1
29	1.8	0.34	0.21	1.6
30	1.0	0.18	0.11	1.0
31	0.84	0.13	0.08	0.72

N.B. All values expressed as weight %

TABLE 8

COMPOSITIONAL DATA - GIPPSLAND OILS

Carbon Number	Halibut A-1	Hapuku #1	Tuna A-2
1 - 3	<0.01	<0.01	<0.01
4	0.14	0.05	<0.01
5	0.34	0.16	<0.01
6	2.5	2.4	0.12
7	6.2	6.0	0.27
8	9.2	7.9	1.6
9	5.8	5.8	3.3
10	4.7	5.1	3.4
11	4.2	5.0	4.4
12	5.1	6.7	7.1
13	5.7	7.3	9.5
14	5.2	7.5	9.0
15	4.7	5.4	6.6
16	4.5	5.0	10.4
17	6.5	5.6	6.3
18	4.1	3.9	5.5
19	4.2	3.4	5.1
20	4.0	3.0	4.6
21	3.4	2.9	4.2
22	3.3	2.7	3.8
23	3.1	2.6	3.4
24	2.8	2.4	3.0
25	2.6	2.4	2.5
26	2.0	1.9	2.1
27	2.0	1.8	1.4
28	1.4	1.2	1.1
29	0.96	0.79	0.55
30	0.56	0.48	0.41
31	0.43	0.31	0.44

N.B. All values expressed as weight %.

TABLE 9

GAS ANALYSIS DATA - VOLADOR #1

Component	Cylinder A 4974	Cylinder 5283	Cylinder 13764
N_2	2.90	2.52	1.98
O_2 + Ar	0.22	0.62	0.49
CO_2	36.0	15.2	14.2
Methane	46.0	72.0	71.6
Ethane	6.1	5.6	8.0
Propane	5.5	2.4	2.7
iso-Butane	0.94	0.35	0.29
n-Butane	1.28	0.58	0.43
neo-Pentane	0.0025	0.0016	0.0014
iso-Pentane	0.15	0.16	0.107
n-Pentane	0.013	0.174	0.098
hexanes	0.0062	0.135	0.052
heptanes	0.0044	0.126	0.046
octanes	0.00607	0.092	0.023

N.B. Values expressed as volume %

****

TABLE 10

Carbon Isotope Data

Bottle No.	$\delta^{13}C$ Hydrocarbons	$\delta^{13}C$ Carbon Dioxide
A 4974	- 30.2	-21.2
13764	- 32.2	-12.7
5283	- 34.8	-19.2

N.B. Values expressed relative to PDB limestone.

****

TABLE 11A

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		1	
pH		7.46	
Conductivity(u siemens/cm)		230800	
T.F.R. (calculated)		147700	
		mg/l	m equiv/l
Sodium	Na+	49000	2131
Potassium	K+	405	10.36
Calcium	Ca++	600	29.94
Magnesium	Mg++	1325	109
Soluble Iron	Fe	1.75	-
Chloride	Cl-	76680	2160
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	457.5	7.5
Sulphate	SO4--	3265	68.02
Nitrate	NO3-	1.439	0.0232

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11B

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		2	
pH		7.58	
Conductivity(u siemens/cm)		235300	
T.F.R. (calculated)		150600	
		mg/l	m equiv/l
Sodium	Na+	53000	2305
Potassium	K+	375	9.591
Calcium	Ca++	600	29.94
Magnesium	Mg++	1350	111.1
Soluble Iron	Fe	1.5	-
Chloride	Cl-	83210	2344
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	433.1	7.1
Sulphate	SO4--	3000	62.5
Nitrate	NO3-	2.773	0.0447

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11C

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.
Chemical Data		3
pH		7.4
Conductivity(u siemens/cm)		224000
T.F.R. (calculated)		143400
		mg/l
Sodium	Na+	51000
Potassium	K+	405
Calcium	Ca++	600
Magnesium	Mg++	1350
Soluble Iron	Fe	1.6
Chloride	Cl-	80660
Carbonate	CO3--	<0.3
Bi-Carbonate	HCO3-	457.5
Sulphate	SO4--	3105
Nitrate	NO3-	1.661

		m equiv/l
Sodium	Na+	2218
Potassium	K+	10.36
Calcium	Ca++	29.94
Magnesium	Mg++	111.1
Soluble Iron	Fe	-
Chloride	Cl-	2272
Carbonate	CO3--	-
Bi-Carbonate	HCO3-	7.5
Sulphate	SO4--	64.69
Nitrate	NO3-	0.0268

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11D

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Developement
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 6.05.83

Description of Samples: Five water samples were received on the 20.04.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		No4	
pH		6.55	
Conductivity(u siemens/cm)		245300	
T.F.R. (calculated)		157000	
		mg/l	m equiv/l
Sodium	Na+	55800	2427
Potassium	K+	440	11.25
Calcium	Ca++	470	23.45
Magnesium	Mg++	1300	107
Soluble Iron	Fe	47	-
Chloride	Cl-	86340	2432
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	1659	27.2
Sulphate	SO4--	3050	63.54
Nitrate	NO3-	3.062	0.0494

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11E

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		5	
pH		7.28	
Conductivity(u siemens/cm)		235300	
T.F.R. (calculated)		150600	
		mg/l	m equiv/l
Sodium	Na+	53000	2305
Potassium	K+	395	10.1
Calcium	Ca++	600	29.94
Magnesium	Mg++	1375	113.2
Soluble Iron	Fe	1.6	-
Chloride	Cl-	82360	2320
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	463.6	7.6
Sulphate	SO4--	2895	60.31
Nitrate	NO3-	1.439	0.0232

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11F

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		6	
pH		6.29	
Conductivity(u siemens/cm)		264000	
T.F.R. (calculated)		169000	
		mg/l	m equiv/l
Sodium	Na+	57000	2479
Potassium	K+	395	10.1
Calcium	Ca++	525	26.2
Magnesium	Mg++	1350	111.1
Soluble Iron	Fe	135	-
Chloride	Cl-	88320	2488
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	201.3	3.3
Sulphate	SO4--	3105	64.69
Nitrate	NO3-	13.29	0.2143

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.

Analytical Chemist

TABLE 11G

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		7	
pH		6.5	
Conductivity(u siemens/cm)		256800	
T.F.R. (calculated)		164300	
		mg/l	m equiv/l
Sodium	Na+	57000	2479
Potassium	K+	385	9.847
Calcium	Ca++	500	24.95
Magnesium	Mg++	1325	109
Soluble Iron	Fe	140	-
Chloride	Cl-	87190	2456
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	286.7	4.7
Sulphate	SO4--	3790	78.96
Nitrate	NO3-	14.39	0.2321

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11H

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		8	
pH		6.17	
Conductivity(u siemens/cm)		257000	
T.F.R. (calculated)		164500	
		mg/l	m equiv/l
Sodium	Na+	57000	2479
Potassium	K+	385	9.847
Calcium	Ca++	500	24.95
Magnesium	Mg++	1325	109
Soluble Iron	Fe	145	-
Chloride	Cl-	90880	2560
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	317.2	5.2
Sulphate	SO4--	3895	81.15
Nitrate	NO3-	17.71	0.2857

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11I

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		9	
pH		6.31	
Conductivity(u siemens/cm)		255500	
T.F.R. (calculated)		163500	
		mg/l	m equiv/l
Sodium	Na+	59500	2588
Potassium	K+	395	10.1
Calcium	Ca++	475	23.7
Magnesium	Mg++	1300	107
Soluble Iron	Fe	100	-
Chloride	Cl-	90310	2544
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	347.7	5.7
Sulphate	SO4--	3265	68.02
Nitrate	NO3-	17.71	0.2857

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11J

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		10	
pH		6.45	
Conductivity(u siemens/cm)		254000	
T.F.R. (calculated)		162600	
		mg/l	m equiv/l
Sodium	Na+	59500	2588
Potassium	K+	405	10.36
Calcium	Ca++	450	22.46
Magnesium	Mg++	1225	100.8
Soluble Iron	Fe	49	-
Chloride	Cl-	89890	2532
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	512.4	8.4
Sulphate	SO4--	3580	74.58
Nitrate	NO3-	13.29	0.2143

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11K

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Developement
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 6.05.83

Description of Samples: Five water samples were received on the 20.04.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		No11	
pH		7.72	
Conductivity(u siemens/cm)		195000	
T.F.R. (calculated)		124800	
		mg/l	m equiv/l
Sodium	Na+	44100	1918
Potassium	K+	570	14.58
Calcium	Ca++	50	2.495
Magnesium	Mg++	680	55.96
Soluble Iron	Fe	2.9	-
Chloride	Cl-	64750	1824
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	2218	36.36
Sulphate	SO4--	3200	66.67
Nitrate	NO3-	<0.05	-

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.

Analytical Chemist

TABLE 11L

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No. 12	
Chemical Data			
pH		8.58	
Conductivity(u siemens/cm)		110500	
T.F.R. (calculated)		70720	
		mg/l	m equiv/l
Sodium	Na+	24000	1044
Potassium	K+	475	12.15
Calcium	Ca++	130	6.487
Magnesium	Mg++	280	23.04
Soluble Iron	Fe	3.5	-
Chloride	Cl-	34360	968
Carbonate	CO3--	147	4.9
Bi-Carbonate	HCO3-	3892	63.8
Sulphate	SO4--	2485	51.77
Nitrate	NO3-	10.52	0.1696

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11M

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Developement
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272

Your ref:

Date: 6.05.83

Description of Samples: Five water samples were received on the 20.04.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		No14	
pH		8.25	
Conductivity(u siemens/cm)		45750	
T.F.R. (calculated)		29280	
		mg/l	m equiv/l
Sodium	Na+	9825	427.4
Potassium	K+	360	9.207
Calcium	Ca++	30	1.497
Magnesium	Mg++	60	4.937
Soluble Iron	Fe	0.25	-
Chloride	Cl-	14200	400
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	2223	36.44
Sulphate	SO4--	900	18.75
Nitrate	NO3-	0.3062	0.004

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.

Analytical Chemist

TABLE 11N

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Developement
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272

Your ref:

Date: 6.05.83

Description of Samples: Five water samples were received on the 20.04.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		No16	
pH		8.38	
Conductivity(u siemens/cm)		45000	
T.F.R. (calculated)		28800	
		mg/l	m equiv/l
Sodium	Na+	9075	394.7
Potassium	K+	350	8.951
Calcium	Ca++	50	2.495
Magnesium	Mg++	55	4.526
Soluble Iron	Fe	0.05	-
Chloride	Cl-	13060	368
Carbonate	CO3--	13.2	0.44
Bi-Carbonate	HCO3-	1952	32
Sulphate	SO4--	720	15
Nitrate	NO3-	0.2165	0.003

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.

Analytical Chemist

TABLE 11 0

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Developement
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 6.05.83

Description of Samples: Five water samples were received on the 20.04.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		No27	
pH		7.98	
Conductivity(u siemens/cm)		115000	
T.F.R. (calculated)		73600	
		mg/l	m equiv/l
Sodium	Na+	22200	965.6
Potassium	K+	410	10.49
Calcium	Ca++	520	25.95
Magnesium	Mg++	1300	107
Soluble Iron	Fe	1	-
Chloride	Cl-	37490	1056
Carbonate	CO3--	<0.3	-
Bi-Carbonate	HCO3-	380.6	6.24
Sulphate	SO4--	2940	61.25
Nitrate	NO3-	0.4046	0.006

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11 P

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		B	
pH		8.87	
Conductivity(u siemens/cm)		38130	
T.F.R. (calculated)		24400	
		mg/l	m equiv/l
Sodium	Na+	8100	352.3
Potassium	K+	365	9.335
Calcium	Ca++	53	2.645
Magnesium	Mg++	35	2.88
Soluble Iron	Fe	0.6	-
Chloride	Cl-	9088	256
Carbonate	CO3--	267	8.9
Bi-Carbonate	HCO3-	5893	96.6
Sulphate	SO4--	475	9.896
Nitrate	NO3-	<0.05	-

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11Q

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272
Your ref:
Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		E	
pH		8.39	
Conductivity(u siemens/cm)		41750	
T.F.R. (calculated)		26720	
		mg/l	m equiv/l
Sodium	Na+	8350	363.2
Potassium	K+	325	8.312
Calcium	Ca++	100	4.99
Magnesium	Mg++	70	5.76
Soluble Iron	Fe	0.9	-
Chloride	Cl-	11720	330
Carbonate	CO3--	12	0.4
Bi-Carbonate	HCO3-	1964	32.2
Sulphate	SO4--	475	9.896
Nitrate	NO3-	<0.05	-

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.
Analytical Chemist

TABLE 11R

ANALABS

ANALYTICAL CHEMISTS

52 Murray Road
Welshpool
W.A. 6106
Tel: 458 7999

CERTIFICATE OF ANALYSIS

For: Shell Development
140 St George's Terrace
Perth
W.A. 6000

Our ref: 1000.01.27272

Your ref:

Date: 17.05.83

Description of Samples: Thirteen water samples were received on the 9.05.83 for chemical analysis.

Method of Analysis:		Sample No.	
Chemical Data		F	
pH		8.47	
Conductivity(u siemens/cm)		40380	
T.F.R. (calculated)		25840	
		mg/l	m equiv/l
Sodium	Na+	8100	352.3
Potassium	K+	345	8.824
Calcium	Ca++	100	4.99
Magnesium	Mg++	75	6.172
Soluble Iron	Fe	0.15	-
Chloride	Cl-	11720	330
Carbonate	CO3--	18	0.6
Bi-Carbonate	HCO3-	1726	28.3
Sulphate	SO4--	240	5
Nitrate	NO3-	4.429	0.0714

Analyst: M.A. CHAPMAN A.P.T.C., A.R.A.C.I., A.A.I.M.M.

Analytical Chemist

A P P E N D I X I

THEORY AND METHOD

1. PREPARATION OF SEDIMENT SAMPLES FOR EXTRACTION

The samples provided for geochemical studies are firstly, where necessary, carefully air dried. Then the samples are crushed to 1/8" chips using a van Gelder jaw crusher, and finally they are crushed to 0.1mm using an NV Tema grinder.

2. EXTRACTION OF SEDIMENT SAMPLES

Crushed sediment (maximum of 250g) and 320 mls of purified dichloromethane: methanol (10:1) were placed in a 500 ml conical flask. A double surface condenser was fitted to the flask, and the sample was then extracted under the influence of ultra-sonic vibration (60-70°C) using a Buehler Ultramet II sonic bath for 2 hours. The solvent was then separated from the sediment using a large Buchner filtration system. The extract was recovered by careful evaporation of the solvent on a steam bath and weighed. The weight of extract was used to calculate %SOM(UNC) using the following formula:

$$\%SOM(UNC) = \frac{\text{Wt. extract}}{\text{Wt. sediment extracted}} \times \frac{100}{1}$$

3. SEPARATION OF PETROLEUM INTO CONSTITUENT FRACTIONS

The extracts were separated into saturated, aromatic and NSO (asphaltenes plus resins) fractions by column chromatography on silicic acid. The crude extract was applied to the top of a silicic acid column (sample to adsorbent ratio 1:50) and the saturated compounds were eluted with n-pentane, aromatic compounds with a 50:50 mixture of ether and n-pentane, and finally the NSO fraction was eluted with a 20:1 mixture of methanol and dichloromethane. The neat fractions were recovered by careful removal of the solvent by fractional distillation and weighed.

The sum weight of the three fractions was used to calculate the %SOM using the following formula:

$$\%SOM = \frac{\text{Wt. AROM. + Wt. SAT. + Wt. NSO}}{\text{Wt. SEDIMENT EXTRACTED}} \times \frac{100}{1}$$

This parameter can be used to assess the suitability of the sediments as source rocks according to the classification shown (later in this section) in the table "Classification of Source Rock Richness".

The weight of saturated compounds was used to calculate the percentage of saturated compounds in the sediment according to the following formula:

$$\%SaOM = \frac{\text{Wt. Saturates}}{\text{Wt. Sediment Extracted}} \times \frac{100}{1}$$

This parameter can be used to assess the suitability of the sediments as oil source rocks according to the classification shown in the table "Classification of Source Rock Richness".

The weight of each fraction was used to calculate the % by weight of each fraction in the extract according to the following formula:

$$\%\ \text{Fraction} = \frac{\text{Wt. Fraction}}{\text{Wt. All Fractions}} \times \frac{100}{1}$$

The composition of the extracts can provide information about their levels of maturity and/or source type (LeTran et al., 1974; Philippi, 1974). Generally, marine extracts have relatively low concentrations of saturated and NSO compounds at low levels of maturity, but these concentrations increase with increased maturation. Terrestrially derived organic matter usually has a low level of saturates and large amount of aromatic and NSO compounds irrespective of the level of maturity.

4. GLC ANALYSIS OF SATURATED COMPOUNDS

Capillary GLC traces were recorded for each saturate fraction. The following information was obtained from these traces:

(a) n-Alkane Distribution - The C_{12}-C_{31} n-alkane distribution was determined from the area under peaks representing each of these n-alkanes. This distribution can yield information about both the level of maturity and the source type (LeTran et al., 1974).

(b) Carbon Preference Index - Two values were determined:

$$CPI(1) = \frac{(C_{23} + C_{25} + C_{27} + C_{29})Wt\% + (C_{25} + C_{27} + C_{29} + C_{31})Wt\%}{2 \times (C_{24} + C_{26} + C_{28} + C_{30})Wt\%}$$

$$CPI(2) = \frac{(C_{23} + C_{25} + C_{27})Wt\% + (C_{25} + C_{27} + C_{29})Wt\%}{2 \times (C_{24} + C_{26} + C_{28})Wt\%}$$

The CPI is believed to be a function of both the level of maturity (Cooper and Bray, 1963; Scalan and Smith, 1970) and the source type (Tissot and Welte, 1978). Marine extracts tend to have values close to 1 irrespective of maturity whereas values for terrestrial extracts decrease with maturity from values as high as 20 but don't usually reach a value of 1.

(c) $C_{21}+C_{22}/C_{28}+C_{29}$ - This parameter provides information about the source of the organic matter (Philippi, 1974). Generally, a terrestrial source gives values <1.2 whereas a marine source results in values >1.5.

(d) Pristane/Phytane Ratio - This value was determined from the areas of peaks representing these compounds. The ratio renders information about the depositional environment according to the following scale (Powell and McKirdy, 1975):

<3.0 Marine depositional environment (i.e. reducing environment)

3.0-4.5 Mixed depositional environment (i.e. reducing/oxidising environment)

>4.5 Terrestrial depositional environment (i.e. oxidising environment)

(e) Pristane/$\underline{n}$-C_{17} Ratio - This ratio was determined from the areas of peaks representing these compounds. The value can provide information about both the source type and the level of maturation (Lijmbach, 1975). Very immature crude oil has a pristane/$\underline{n}$-C_{17} ratio >1.0, irrespective of the source type. However, the following classification can be applied to mature crude oil:

<0.5	Marine source
0.5-1.0	Mixed source
>1.0	Terrestrial source

In the case of sediment extracts these values are significantly higher and the following classification is used:

<1.0	Marine source
1.0-1.5	Mixed source
>1.5	Terrestrial source

(f) Phytane/$\underline{n}$-C_{18} Ratio - This ratio was determined from the areas of peaks representing these compounds. The value usually only provides information about the level of maturity of petroleum. The value decreases with increased maturation.

(g) Relative Amounts of $\underline{n}$-Alkanes and Naphthenes - Since $\underline{n}$-alkanes and naphthenes are the two dominant classes of compounds in the saturate fraction, a semi-quantitative estimate of the relative amounts of these compounds was made. This information can be used to assess the degree of maturation and/or the source type of the petroleum (Philippi, 1974; Tissot and Welte, 1978). Very immature petroleum has only small proportions of $\underline{n}$-alkanes, but as maturity increases the relative amount of $\underline{n}$-alkanes increases. In addition, terrestrial petroleum has a greater proportion of high molecular weight naphthenes than marine petroleum.

5. TOC DETERMINATIONS

The total organic carbon value (TOC) was determined on the unextracted sediment sample. The value was determined by treating a known weight of sediment with dilute HCl to remove carbonate minerals, and then heating the residue to 1700°C (Leco Induction Furnace) in a atmosphere of pure oxygen. The carbon dioxide produced was adsorbed on a "Carbosorb" tower. The weight of carbon dioxide produced was then used to calculate %TOC in the sediment.

6. SOLUBLE/TOTAL ORGANIC CARBON RATIOS

The ratios of SOM(mg)/TOC(g) and SAT(mg)/TOC(g) were determined from the appropriate data. The SOM(mg)/TOC(g) ratio can be used as a maturation indicator, especially if the parameter is plotted against depth for a given sedimentary sequence. In an absolute sense it is less reliable as a maturation indicator, although previous work (Tissot et. al., 1971; LeTran et. al., 1974) suggest that the following criteria can be used to determine maturity with this parameter:

<50	Low maturity
50- 100	Moderate maturity
>100	High maturity

The ratios of SOM(mg)/TOC(g) and SAT(mg)/TOC(g) can be used collectively to provide information about source type. For example, if SOM(mg)/TOC(g) is >100, suggesting a high level of maturity, but the SAT(mg)/

TOC(g) <20 it is very likely that the organic matter is terrestrial. Conversely, the same SOM(mg)/TOC(g) value with a SAT(mg)/TOC(g) value >40 suggests a marine source type.

7. ROCK-EVAL PYROLYSIS

Rock-Eval pyrolysis is carried out by placing approximately 100mg of the crushed sample into a crucible and then subjecting it to the following pyrolysis cycle:

Stage (i) - Sample purged with helium for 3.5 minutes outside of heated part of pyrolysis furnace;

Stage (ii) - Sample heated at 300°C for 3 minutes to liberate free petroleum (S_1 peak);

Stage (iii)- Sample heated from 300°C to 550°C at 25°C/minute to produce petroleum from kerogen (S_2 peak). The furnace is maintained at 550°C for one minute. Carbon dioxide produced during this pyrolysis up to 390°C (550°C in the case of the carbonate-free sediment) is absorbed on a special column;

Stage (iv) - During cool-down period the carbon dioxide produced during pyrolysis is measured (S_3 peak).

The units used for Rock-Eval data are as follows:

S_1, S_2, S_3 = kg/tonne of rock
T_{max} = °C
Hydrogen Index = mg HC/g TOC
Oxygen Index = mg CO_2/g TOC

Rock-Eval data is most commonly used in the following manner:

(i) S_1 - indicates the level of oil and/or gas already generated by the sample.

(ii) S_1+S_2 - referred to as the genetic potential this parameter is used for source rock evaluation according to the following criteria:

<2	kg/tonne	Poor
2-6	kg/tonne	Moderate
>6	kg/tonne	Good

(iii) $S_1/(S_1+S_2)$ - this parameter is the production index which is a measure of the level of maturity of the sample.

(iv) T_{max} - the temperature corresponding to the S_2 maxima. This temperature increases with increasingly mature sediments.

(v) HI, OI - the hydrogen ($[S_2 x100]/TOC$) and oxygen ($[S_3 x100]/TOC$) indices when plotted against one another provide information about the type of kerogen contained in the sample and the maturity of the sample.

8. WHOLE OIL GAS CHROMATOGRAPHIC ANALYSIS

This analysis was carried out under the following conditions: Instrument = Varain Aerograph 2740; coloumn = 25m x 0.2mm I.D. WCOT capillary column with SP2100 stationary phase; temperature program = 2 mins at -20°C then programmed to 280°C at 4°C/min; detector temperature = 310°C; injector temperature = 300°C; injection mode 80:1 split; carrier gas = hydrogen at 35 cm/sec.

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FIGURE 1

APRIL, 1983

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

SHELL

VOLADOR #1

LIME
DOLOMITE
CLAY
SILT
SAND
COAL
IGNEOUS
META
EVAPORITE

IN METRES ■ IN FEET □

SAMPLE TYPE
□ CUTTINGS
□ CONV. CORE
■ SWC

SAMPLE QUALITY
□ POOR
□ FAIR
■ GOOD

S_1 = VOLATILE HYDROCARBONS (HC) ×

S_2 = HC GENERATION POTENTIAL

$S_1 + S_2$ = TOTAL HYDROCARBON

S_3 = ORGANIC CO_2

PI = PRODUCTION INDEX

$$PI = \frac{S_1}{S_1 + S_2}$$

HI = HYDROGEN INDEX

$$HI = \frac{S_2}{TOC} \times 100$$

OI = OXYGEN INDEX

$$OI = \frac{S_3}{TOC} \times 100$$

T_{max} [Max. Temp. S_2]

PRE OIL WINDOW
OIL WINDOW
WET GAS/COND
THERMAL C_1

INDIGENOUS KEROGEN
□ ALGINITE
▦ EXINITE
▨ VITRINITE
■ INERTINITE
OIL / GAS

LITHOLOGY (Percent) 20 40 60 80	DEPTH	ORGANIC CARBON (Percent of Rock) 5 10 20 40	PYROLYSIS YIELD (mg/g Rock) S_1; S_1+S_2 10 20 40 60 100	S_3 1 2 3 4	PI .2 .4	■ HI ▲ OI 100 200 300	T_{max} °C 440 480	▲ VITRINITE REFLECTANCE .6 1.2 1.8	INDIGENOUS KEROGEN 25 50 75	% IND
	3400								No data	
	3500									
	3600								No data	
	3700								No data	
	3800								No data	
	3900								No data	
	4000								No data	
	4100								No data	
	4200								No data	
	4300								No data	
	4400								No data	
	4500								No data	
	4600								No data	
	4700									

ANALABS OIL AND GAS DIVISION. 52 Murray Road, Welshpool, W.A. 6106.
TEL: (08) 458 7888 Telex : Analab AA82560.

FIGURE 2

APRIL, 1983

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

SHELL

VOLADOR #1

LIME
DOLOMITE
CLAY
SILT
SAND
COAL
IGNEOUS
META
EVAPORITE

IN METRES ■ IN FEET □

SAMPLE TYPE
□ CUTTINGS
□ CONV. CORE
■ SWC

SAMPLE QUALITY
□ POOR
□ FAIR
■ GOOD

EXTRACTABLE ORGANIC MATTER (E.O.M.)

▨ TOTAL EXTRACTABLE ORGANIC MATTER

■ SATURATE (SAT.) HYDROCARBON (H.C.)
□ AROMATIC (AROM.) H.C.
→ TOTAL H.C.

⁝⁝ NITROGEN-SULPHUR-OXYGEN (N.S.O)
▤ ASPHALTENE (ASPH)
→ NON H.C.

PRE OIL WINDOW
OIL WINDOW
WET GAS/COND
THERMAL C_1

INDIGENOUS KEROGEN
□ ALGINITE
⁝⁝ EXINITE
▨ VITRINITE
■ INERTINITE
→ OIL / GAS

LITHOLOGY (Percent) 20 40 60 80	DEPTH	ORGANIC CARBON (Percent of Rock) 2.5 5 10 20 40	E.O.M. RICHNESS (ppm) 2000 4000 6000 8000 10000	SAT/AROM ■ ▲ ASPH/NSO 1 2	H.C. / Non H.C. 2 4	SAT/TOC ■ XXX EOM/TOC 50 100	▲ VITRINITE REFLECTANCE .6 1.2 1.8	INDIGENOUS KEROGEN 25 50 75 % IND
	3400							No data
	3500					XX		No data
	3600					XX		No data
						X		No data
	3691.5					XX		No data
	3800					XX		No data
	3900					XXXXX		No data
	4000					X		No data
	4100					XXXXXXXX		No data
						XXXXXXXXXX		No data
	4200					XXXXXXXXXXXXXXXX		No data
	4300					XXXXXXXXXXXX		No data
	4400					XXXXXXXXXXXXXXX		No data
	4526.0					XXXXXXXXX		No data
	4536.0					XXXXXXXX		No data
	4554.0					XXXXXXX		No data
	4700							

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FIGURE 3

APRIL, 1983

ANA-LOG

HYDROCARBON SOURCE ROCK EVALUATION

SHELL

VOLADOR #1

LIME
DOLOMITE
CLAY
SILT
SAND
COAL
IGNEOUS
META
EVAPORITE

IN METRES ■ IN FEET □

SAMPLE TYPE
□ CUTTINGS
□ CONV. CORE
■ SWC

SAMPLE QUALITY
□ POOR
□ FAIR
■ GOOD

C_{12+} SATURATE GAS CHROMATOGRAPHY

Prist/Phyt	Environment	Prist/NC17 Rock	Prist/NC17 Oil	Environment	C21+C22 / C28+C29	Environment	CPI	Environment
< 3.0	Reducing	< 1.0	< 0.5	Open Water	> 1.5	Marine and/or Mature	<= 1.1	Marine and/or Mature
3.0 - 4.5	Mixed	1.0 - 1.5	0.5 - 1.0	Restricted	1.2 - 1.5	Mixed	> 1.1	Terrestrial and/or Immature
> 4.5	Oxidising	> 1.5	> 1.0	Coal Swamp	< 1.2	Terrestrial and/or Immature	CPI Carbon Preference Index	

PRE OIL WINDOW
OIL WINDOW
WET GAS/COND
THERMAL C_1

INDIGENOUS KEROGEN
ALGINITE
EXINITE
VITRINITE
INERTINITE
OIL
GAS

LITHOLOGY (Percent) 20 40 60 80
DEPTH
ORGANIC CARBON (Percent of Rock) 2.5 5 10 20 40
ALKANE % DISTRIBUTION
PRIST/PHYT 2 4 6 8 10 12
PRIST/NC17 2 4 6
21+22/28+29 1 2 3 4 5
CPI 1 1.5
▲ VITRINITE REFLECTANCE .6 1.2 1.8
INDIGENOUS KEROGEN 25 50 75 % IND

3549.9
3645.0
3673.5
3691.5
3800
3900
4000
4100
4200
4300
4360.0
4383.0
4526.0
4536.0
4554.0

No data

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ANALABS
A Division of Macdonald Hamilton & Co. Pty. Ltd.

OIL AND GAS DIVISION

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Samples can be forwarded to Perth from any of the following Analabs Centres:

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Telex KALAB AA 91784

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Telex QLDLAB AA 44030

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Cairns, Queensland, 4870
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Tofua Street, Walu Bay
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