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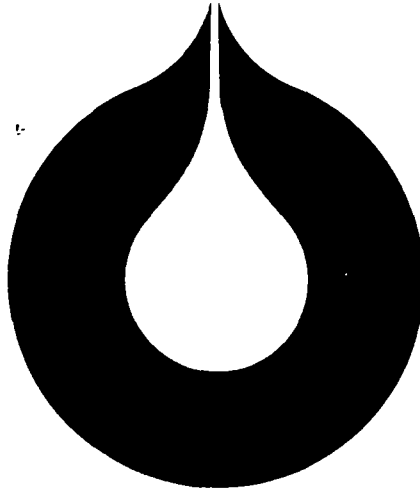
 **STATOIL**

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CHEMICAL ANALYSIS
OF
WATER, GAS AND OIL
FROM
WELL 1/9-3

STATOIL PRODUCTION LABORATORY

Den norske stats oljeselskap a.s

CHEMICAL ANALYSIS
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SUMMARY.

Analysis is done on gas, water and oil samples from the production testing of 1/9-3.

Samples were collected at bubble hose and separator at ambient conditions and subjected to different types of treatment both on rig and in the lab.

Results show that

- 1) the gas is getting richer in methane as one gets higher on the structure
- 2) formation water total dissolved solids or salinity is about 70.000 ppm.
- 3) Oil from different depths belongs to the same types, being paraffinic with a high wax content. Most probably the oil has originated from the same source rock.
- 4) Oil samples are correlatable even though they have been subjected to severe treatments and several months storage.

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1. INTRODUCTION.

During the testing of 1/9-3 in Sept. 78 samples of water, gas and oil were collected from tests at four different depths.

In November samples were selected for chemical analysis by Statoil Production Laboratory. The aim was to determine the properties of the formation water and to characterize the crude oil.

This should reveal if the different zones contained the same type of fluids and whether these could be correlated with fluids from other structures in the same block.

2. SAMPLE DESCRIPTION.

The samples were received in the lab. the 10th of November. Gas samples was collected in aluminized polyester film gas sampling bags with two valves and septum.

Water samples were collected in 25 l plastic containers.

The oil samples analysed by the lab. were collected and treated in many different ways before they arrived in the lab. Most of the oil samples had been in contact with water and vice versa for more than two months.

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Sample description

Lab. code	Sample no.	DST	Flow	Date	Hour	Sampling Point	Sample Cont.
G1	41	2	2	6.9.78.	21.50	Separator	Gas bag
G2	42	2	2	"	"	"	"
G3	43	2	2	"	20.07	"	"
G5	51	3	2	14.9.78	16.25	Bubble hose	"
G6	52	3	2	"	16.50	"	"
V10	16	1	2	2.9.78	17.40	"	25 L plastic
V11	17	1	2	"	17.35	"	"
V12	19	2	2	6.9.78	20.42	"	"
V13	20	2	2	"	21.40	"	"
V14	21	4	4	21.9.78	08.00	Separator	"
04	48/47	2	2	6.9.78	21.00	Bubble hose	2xl L glass note 1
06	20	2	2	"	21.40	"	25 L plastic note 2
05	46	3	2	14.9.78	10.26	"	1 L glass note 3
014	89	4	4	21.9.78	01.30/04.00	Bubble hose	" note 4
015	90	4	4	"	04.30/07.00	"	" "
03	8	4	4	"	08.00	Separator	20L jerry can

Note 1.

The samples (48/47) as received in the lab. have been heated, added demulsifier and centrifuged on the rig. In the lab. the contents of the two glasses were mixed. Centrifuging gave 13% water and 0,15% sediments.

Note 2.

Oil was collected by skimming the oil slick on the water sample V13 and centrifuged.

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Note 3.

Collected using a plastic container as a separator for oil, gas and water.

Note 4.

Sample has been centrifuged on rig.

3. METHODS.

3.1 Gas samples.

The gas was analyzed on a chromatograph with thermal conductivity detector. The instrument is calibrated and the accuracy range from 1% for C₁ to 5-7% for C₅ - C₇, giving 2% uncertainty of the calculated gas gravity. All samples contained a certain amount of air, due to insufficient flushing of gas bag. The amount of air is removed in the calculations by subtracting the concentration of O₂[O₂] and an amount N₂ equal to [O₂] x 3,78 where the factor is the ratio [N₂]/[O₂] in ordinary air. In most cases this left samples free of N₂.

3.2 Water samples.

Prior to analysis all samples was filtered through 0,45 micron filter paper. Most of the analysis were carried out according to API Recommended Practice. Exceptions are determination of iron using atomic absorption and lithium using flame emission spectroscopy.

The amount of Na⁺ is calculated by balancing equivalent weights. The analysis is "controlled" by using correlations (assuming pure NaCl solution) to estimate total dissolved solids from the measurements of specific gravity and resistivity. The concentration of Cl⁻ is multiplied by 1,65 (= $\frac{\text{Mol. weight NaCl}}{\text{atomic weight Cl}}$) to give the total dissolved solids, again assuming a pure NaCl solution.

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An equivalent NaCl concentration is calculated from the analysis using Schlumberger Log Interpretation Chart: Gen-8 (1972).

3.3 Oil analysis.

Most of the analysis was carried out according to well known ASTM and IP standards. An exception is the determination of wax content. This is done by measuring the amount of wax-like material which precipitates in two different processes:

- a) centrifuging the oil (2000 rpm in 10 min.) at several temperatures.
- b) when cooling a solution of oil in methylene chloride to -32°C .

The chromatographic analysis was designed to characterize the crude so that comparisons could be made. Therefore both the oil and the gas in equilibrium with it (head space gas) was analysed using high resolution capillary column and flame ionization detector. The amount of oil eluted from the column (recovery) is typical in the order of 50%.

Compositions are compared by plotting normalized values of some naphthenic and iso prenyl molecules, since these normally will be least affected by extraction by water and bacterial action. The ratio between the amount of certain molecules in the C_2 - C_7 range is calculated following a suggestion by Erdman (1). The same is done for the iso prenyls pristane and phytane and the neighbouring normal paraffins. This is normal practice in organic geochemistry.

- (1) Erdman, J.G : "Geochemical correlation of Petroleum".
Bull. Am. Ass. Petr. Geologist. 58 pp2326 (1974)

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4. RESULTS.4.1 Gas analysis.

Concentration of gas components are given as mol %.

Lab. code Sample no.	G1 41	G2 42	G3 53	G5 51	G6 52
N ₂	-	-	-	0.6	-
CO ₂	3.0	3.1	2.7	—	-
C ₁	78.0	77.7	80.8	85.4	90.3
C ₂	10.3	11.1	10.0	9.2	6.7
C ₃	5.5	5.0	4.2	3.1	2.0
iC ₄	0.70	0.85	0.65	0.36	0.25
nC ₄	1.56	1.47	1.14	0.84	0.52
iC ₅	0.38	0.37	0.28	0.19	0.1
nC ₅	0.38	0.33	0.20	0.20	0.1
C ₆	0.18	0.08	0.03	0.11	0.03
Mol.% air in sample	10	36	15	6	5
Calculated gas gravity	0.740	0.738	0.707	0.660	0.623
Calculated mol. weight	21.4	21.3	20.4	19.1	18.0

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4.2 Water analysis

Concentration of ions are given as mg/l.

Lab code	V 10	V 11	V 12	V 13	V 14
Sample no.	16	17	19	20	21
Chloride, Cl^-	41800	42400	40800	32800	54500
Sulfate, SO_4^{--}	970	815	730	480	1200
Carbonate, CO_3^{--}	0	0	0	0	0
Bicarbonate, HCO_3^-	610	480	670	490	390
Hydrooxyd, OH^-	0	0	0	0	0
Calcium, Ca^{++}	4550	4670	3900	3125	25640
Magnesium, Mg^{++}	212	207	1530	390	2190
Iron, Fe (total)	1.85	1.75	4.2	6.8	390
Lithium, Li^+	11.2	11.3	11.2	9.1	4.4
pH	7.4	7.2	7.4	7.3	4.65
Specific grav. (15°C)	1.0508	1.0509	1.0500	1.0404	1.083
Resistivity (Ωm) at 23°C	0.107	0.108	0.110	0.132	0.091
Calculated values:					
Sodium, Na^+	22135	22089	19624	17330	2267
Equivalent NaCl (g/l)	67.94	68.51	64.94	53.24	-
Total dissolved solids (g/l) by					
1) adding	70.28	70.66	67.27	54.62	86.52
2) gravity corr.	68.0	68.0	67.0	54.0	112.0
3) resist. corr.	69.3	69.3	67.5	54.3	89.9
4) Cl^- concentr.	68.9	70.0	67.3	54.1	83.6

Add. measurements made on V14: Na: 10.500 mg/l. Solids: 108.250 mg/l.

4.3 OIL ANALYSIS.

A summary of the properties of the 6 oil samples is presented below. The chromatographic data are given as weight %. For the liquid phase the composition is normalized to 100% for the fraction eluting up to and including nC₂₂.

Lab. code	0 4		0 6		0 5		0 14		0 15		0 3	
Sample no.	48 & 47		20		46		89		90		8	
Density, 15°C	0.8525		0.8499		0.8516		0.8039		0.7962		0.7702	
Approx.°API	34.3		34.8		34.5		44.5		46.2		52.0	
kin. viscosity at 40°C (cst)	8.3		8.1		7.0		1.98		1.65		1.13	
K (OUP)	12.1		12.1		12.05		12.10		12.05		12.1	
- 10°C } centri- + 5°C } fusing + 10°C } % WAX	not visible		not visible		not visible		50		50		25	
ambient Methylene chloride methode	10.5		7.0		8.5		10		2		2	
Cloudpoint (°C)	NOT MEASURABLE		MEASURABLE		MEASURABLE		+22		+22		+6	
Pourpoint (°C)	+7		+6		-5		-15		-15		-24	
Asphalt %	0.46		0.19		0.81		0.052		0.065		0.052	
Salt mg/l	—		—		12		130		110		35	
Chromatography	gas	liq.	gas	liq.	gas	liq.	gas	liq.	gas	liq.	gas	liq.
C ₁	0.148	-	0.294	-	0.047	-	0.296	-	2.94	0.002	-	-
C ₂	2.30	-	2.91	0.003	0.036	-	1.88	0.009	8.41	0.014	5.02	0.036
C ₃	12.8	0.057	16.2	0.08	16.4	0.24	7.84	0.057	15.1	0.078	30.6	0.805
iC ₄	7.70	0.071	8.69	0.101	13.4	0.33	15.1	0.063	6.26	0.078	11.2	0.70
nC ₄	17.7	0.26	20.6	0.35	28.3	0.842	15.5	0.246	15.7	0.291	23.3	2.24
iC ₅	9	0.380	9.83	0.449	10.6	0.612	11.2	0.413	8.94	0.447	8.01	1.96
nC ₅	16.9	0.935	11.5	0.694	11.8	0.838	15.1	0.735	11.4	0.770	8.58	2.90
2MC ₅	4.90	0.653	3.45	0.502	2.87	0.431	5.69	0.682	4.02	0.724	1.94	1.57
3 MC ₅	2.28	0.357	1.89	0.335	1.50	0.268	3.20	0.451	2.24	0.478	1.02	0.958
nC ₆	5.39	1.08	5.46	1.20	4.21	0.916	9.29	1.76	6.53	1.80	2.77	3.32
MCC ₅	1.57	0.422	1.59	0.466	1.03	0.294	2.39	0.589	1.67	0.597	0.68	0.99
nC ₇	2.32	1.63	2.25	1.81	1.44	1.05	2.93	2.83	2.19	2.92	0.795	3.42
MCC ₆	1.93	1.61	1.88	1.74	1.09	0.917	2.21	2.30	1.59	2.33	0.602	2.61
ECC ₆		0.779		0.819		0.440		1.068		1.103		1.016
Farnesane		1.01		1.05		1.29		0.948		0.925		0.700
nC ₁₇		1.52		1.48		1.75		1.18		1.05		0.806
Pristane		1.24		1.64		2.07		1.06		0.964		0.749
nC ₁₈		1.45		1.62		1.63		1.14		1.02		0.728
Phytane		1.24		1.25		1.61		0.807		0.745		0.568

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Results calculated from the chromatographic data for the crude oil (liq.).

Lab. code Sample no.	0 4 48&47	0 6 20	0 5 46	0 14 89	0 15 90	0 3 8
Ratio between selected molecules:						
C ₂ /C ₃	-	0.038	-	0.16	0.18	0.045
iC ₄ /nC ₄	0.27	0.28	0.39	0.26	0.27	0.31
iC ₅ /nC ₅	0.41	0.65	0.73	0.56	0.58	0.67
2MC ₅ /3MC ₅	1.83	1.50	1.61	1.51	1.52	1.64
nC ₆ /MC ₅	2.56	2.58	3.11	2.98	3.02	3.36
nC ₇ /MC ₆	1.01	1.04	1.15	1.23	1.25	1.31
nC ₁₇ /Pristan	1.23	0.91	0.84	1.12	1.09	1.08
nC ₁₈ /Phytan	1.18	1.30	1.02	1.42	1.38	1.28
Pristan/Phytan	1.00	1.31	1.29	1.31	1.30	1.32
Compositional data for some naphthenic & isoprenoid molecules:						
MCC ₅	0.26	0.27	0.32	0.26	0.26	0.38
MCC ₆	1	1	1	1	1	1
ECC ₆	0.48	0.47	0.48	0.46	0.47	0.39
Farnesane	0.63	0.60	1.40	0.41	0.40	0.27
Pristan	0.77	0.94	2.26	0.46	0.41	0.29
Phytan	0.77	0.72	1.76	0.35	0.32	0.22

The data is plotted in appendix 1 and 2.

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5. DISCUSSION.

5.1 Gas analysis.

Samples G1 and 2 are parallel samples and the differences found are due to the sampling, leaving 36% air in the gas bag in sample no. G2. Samples G5 and G6 have no CO₂ content and shows an increasing amount of methan and decreasing specific gravity with time.

5.2 Water analysis.

5.2.1 Technical comments.

For samples V 10 - 13, calculated total dissolved solids showed good agreement with solid content inferred from correlations with resistivity and specific gravity. This means that the major ions are identified and that the calculated amount of Na⁺ probably is "correct". Na⁺ and total dissolved solids should have been determined by direct measurements to give a control of the analysis.

Lithium is determined to get an idea of the order of magnitude present. This should also have been done for K⁺ and Ba²⁺.

It is seen that the "equivalent NaCl" concept tends to give higher resistivities than actually measured.

The calculated Na⁺ concentration in V 14 was much too low to be believed and the total dissolved solids did not correlate with the specific gravity. Therefore Na⁺ and the solid was determined independently. This shows that an anion is missing.

5.2.2 Interpretation of results.

V 10 and V 11 are almost parallel samples and the results

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are very similar. V 13 is sampled one hour later than V 12 and shows a much lower Cl^- content. The Cl^- concentration in the samples V 10 - V 12 is significantly higher than in the mud (Cl^- in mud is approx. 15.000 ppm), the pH is close to neutral, and the well was flowed for several hours after clean up. Therefore one can assume that these samples are representative for the formation water.

No explanation can be given for the low Cl^- concentration in sample V 13.

V 14 is collected after acidizing and shows a high Cl^- and Ca^{++} and a low pH as expected. The missing anion could be due to other acids in the stimulation fluid. This hypothesis can not be tested since the sample is discarded.

5.3 Oil analysis.

Density and viscosity varies considerably but the UOP characterization factor is the same for all samples indicating same type of oil (paraffinic).

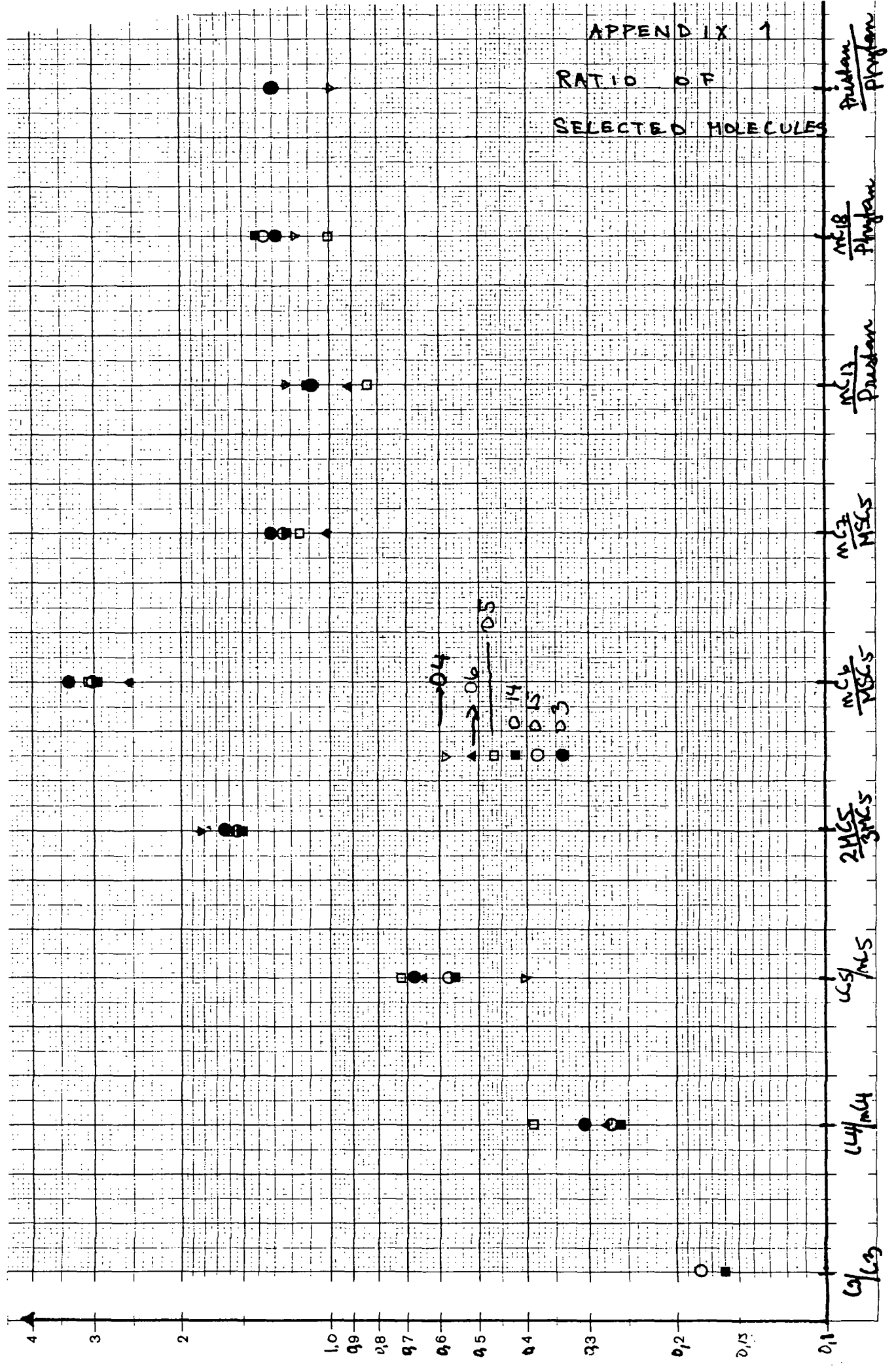
This correlation is, however, not very sensitive.

The chromatographic analysis, as seen in appendix 1 and 2, shows that most probably the oils stems from the same source rock. The agreement is closer than what could be expected when considering the rough treatment given to several of the samples.

The wax content, however, varies quite a lot. This is also seen from the pour and cloud point. The variation seems to follow the variation in density and molecular weight. The wax content is high and the asphaltene is low, which again indicates paraffinic oil.

APPENDIX 1

RATIO OF
SELECTED MOLECULES



APPENDIX 2

LEGEND

- ▽ 0.4
- ▲ 0.6
- 0.5
- 0.14
- 0.15
- 0.3

DISTRIBUTION OF
SELECTED MOLECULES
NORMALIZED ON MCC₆

