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COUSLAND 5/W48

PETROLEUM ENGINEERING COMPLETION REPORT

JULY 1954

C O U S L A N D

COUSLAND AREA - CORRELATION REPORT

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C.M. ADCOCK

WELL 5 - FORMATION TESTING COMPLETION REPORT

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C O N T E N T S

APPENDICES

ILLUSTRATIONS

I. SUMMARY

During the drilling of well 5 the gas sands of well 1 were encountered 130' lower structurally, and were below the respective gas/water levels. In all, ten horizons were tested in well 5; and small gas productions were obtained from six thin sands. Reservoir water production was also obtained from five of these sands. Fig. 1 shows the results of the formation tests carried out in well 5 in graphic form.

II. COMPARISON OF PRODUCING HORIZONS IN WELLS 1 & 5

Fig. 2 is an oil and gas sands correlation diagram. The following is a short comparison of the main producing horizons in both wells:-

(a) Oil sand 1248' - 1279' in well 1

This is represented by an oil sand 1350' - 1376' in well 5. The results of core-analysis indicate an oil saturation of 41% of the pore space in the top of the sand. At the base of the sand there is a negligible oil saturation; and the water saturation is approximately 82% of the pore space. During the formation test, oil, gas, and reservoir water were produced.

When the 1248' sand in well 1 was tested, a little water was produced in addition to oil and gas; but the water produced is considered to have been derived from returning drilling mud. The oil/water level is tentatively put at the 9180' contour.

(b) Gas sand 1582' - 1632' in well 1

This gas sand is represented by three sands in well 5 from 1693' - 1760'. The core samples examined contained very little oil. The top thin sand gave a water saturation of about 50% of the pore space, so that an appreciable gas saturation was to be expected. In the lower sections of the sand group the water saturation was generally of the order of 80% of the pore space. Three formation tests were carried out, yielding a little gas production - a few hundred cubic feet per day - and some reservoir water. Two samples of gas were collected for analysis.

During the production tests of the 1582' sand in well 1, gas production rates of the order of 3 million cubic feet per day were obtained. No edge-water was produced during these tests. Basing on recorded reservoir pressures, the gas/water level is placed at the 8890' contour.

(c) Gas sand 1720' - 1806' in well 1

The group of sands from 1835' - 1890' in well 5 has been correlated with the 1720' gas sand in well 1. The core samples examined from well 5 indicated an oil saturation of less than 17% of the pore space. Water saturations varied from 35% to 73%. Two formation tests were carried out; the top sand group giving no production whatsoever, and the bottom sand giving some 340 cubic feet of gas per day, together with some reservoir water.

During the production tests of the 1720' sand in well 1, gas production rates of the order of 4 million cubic feet per day were obtained. Edge-water was also produced; but this may have been due in part to a water coning effect whilst the production tests were being carried out. From a reservoir pressure correlation between wells 1 & 2, the gas/water level was placed at the 8763' contour. Basing on the recorded pressures in wells 1 & 5, the gas/water level is placed at the 8720' contour, or some 40' lower structurally than indicated by the earlier calculation.

(d) Gas sand 2094' - 2122' in well 1

Well 5 stopped drilling at 1918', and was not drilled down to the counterpart of the 2094' - 2122' gas sand in well 1; but would have undoubtedly proved edge-water if drilling had continued to this depth. In well 1 the 2094' sand produced gas at a rate of 150,000 cubic feet per day. No evidence of edge-water was obtained.

III. NOTE ON TWO SANDS NOT FOUND IN WELL 1

(a) Gas sand 1511' - 1527' in well 5

The core samples from this horizon had an oil saturation of from 80% to 90% of the pore space, with water saturations from 8% to 20% of the pore space. No oil production was obtained in the formation test; but only gas at a rate of 224 cubic feet per day. No reservoir water production was obtained.

The oil in the core samples appeared to be particularly viscous and waxy; and this may have been the reason for not obtaining any oil production, particularly as the reservoir temperature was only around 66° F.

(b) Gas sand 1656' - 1665' in well 5

From this sand a gas production of 4000 cubic feet per day was obtained, which was the maximum production rate recorded in any of the tests in well 5. A gas sample was collected for analysis. Some reservoir water was also produced. The core samples examined contained very little oil, and water saturations occupied 33% to 43% of the pore space; so that an appreciable gas saturation was to be expected.

IV. COUSLAND RESERVOIR PRESSURES

A tabulation of recorded reservoir pressures in wells 1, 2, 4 & 5 is given in appendix A. This also includes the calculation of the reservoir pressure at the base of the 1582' - 1632' sand of well 1 from the closed-in pressure: also the calculation of gas/water levels in the 1582' and 1720' sands of well 1 from the reservoir pressures in wells 1 and 5. Finally, the graph (fig. 3) shows all the reservoir pressures obtained in the Cousland area.

The possible gas/water level between the 1582' - 1632' sand group of well 1, and the 1693' - 1760' sand group of well 5 is tentatively put at the 8890' contour. Similarly, the possible gas/water level between the 1720' - 1806' sand group of well 1, and the 1835' - 1890' sand group of well 5 is tentatively put at the 8720' contour. However, an earlier correlation between wells 1 and 2 placed the gas/water level at the 8763' contour. It would seem that there is a known gas column of around 100' in each sand.

The correlation diagram fig. 2 shows the indicated gas/water levels for the 1582' and 1720' gas sands of well 1. The relevant reservoir pressures in wells 1 and 5 have also been included on the diagram.

V. CRUDE OIL SAMPLES PRODUCED

Crude oil was produced in well 1 from the 1248' - 1279' sand; and in well 5 from the 1350' - 1376' sand. These two sands are considered to be part of the same oil horizon. In neither well was the oil produced in commercial quantities.

From a consideration of water analyses the oil/water level is tentatively placed at the 9180' contour; which has been indicated on the correlation diagram Fig. 2. Thus, the possible oil column is approximately 130'; but so far there has been no possibility of obtaining economic production.

The analysis of the oil sample obtained in well 5 is included with this report. The analysis of the oil sample collected from well 1 is given in the geological completion report U.K. 62. The analysis of the sample collected on 16.1.38 is considered to be the most representative of the unweathered crude oil.

The I.P: Distillation curves have been plotted on the graph Fig. 4. It will be noted that the crude oil sample from well 5 contains the larger proportion of heavier fractions. The density of the C5 sample is 0.880 as compared with 0.863 for the C1 sample.

VI. NATURAL GAS ANALYSES

Natural gas samples at Cousland have been collected from wells 1, 4, and 5. Analyses of all gas shows have been carried out by Sunbury Research Station. The samples collected from wells 1 and 4 were analysed by the Podbielniak method. The samples collected from well 5 were analysed by the mass spectrometer method.

All the gas samples collected consist of from 85% to 96% Methane. The analyses are illustrated by means of circle diagrams fig. 5, showing the proportions of the gas constituents. The following points are indicated:-

(1) Some nitrogen is probably present in all the gas samples collected; although no nitrogen is shown in the analyses of the first two gas samples collected from well 1. (Perhaps no specific examination was made for nitrogen in these two instances.) The maximum quantity of nitrogen was found in the sample from the 1730' - 1760' sand at well 5, which contained 11.75% nitrogen.

(2) Acid gases, in very small quantities, have only been recorded in three samples collected from well 4. This gas must be Carbon dioxide. Traces of hydrogen sulphide, if present in Cousland natural gas, would not have been detected. The gas samples were invariably either collected in steel cylinders, or over water in glass aspirators. The hydrogen sulphide would have been removed from the gas samples in both cases.

(3) Ethane is found in small quantities in all Cousland gas samples, ranging from 1% to nearly 4%. With one exception, propane and heavier constituents are also only found in small quantities, ranging from 0.2% to 1.8%. The exception is the gas show which was supposedly coming from the 1248' - 1279' oil sand. In this case the analysis shows over 6% propane and heavier. This oil sand was tested by setting 8¾" casing on a seat, and bailing the hole dry. By this means an oil sample was collected, and gas production was obtained. But the gas production, could have been largely derived from the 1188' - 1209' gas sand, as leakage past the casing was to be expected. The gas production from the upper gas sand would then pick up the heavier hydrocarbons by contact with the oil sand, which would account for the difference in the two analyses.

(4) The 1712' - 1720' sand, also the 1730' - 1760' sand of well 5 have been correlated with the 1582' - 1632' gas sand of well 1. The complete absence of propane and heavier hydrocarbons from the 1582' - 1632' gas sand is surprising. The 11.75% Nitrogen found in the gas sample from the 1730' - 1760' sand of well 5 is also unusual.

Appendix B lists the representative analyses of the gas shows in the Cousland area. The heavier than propane gas constituents, which are recorded in some of the analyses, have not been tabulated separately. The quantities present are so very small that they have been included under the heading "Propane and heavier". Similarly, no differentiation of the heavier hydrocarbons has been shown on the circle diagrams depicting the Cousland gas analyses.

VII. NOTE ON COUSLAND RESERVOIR WATERS

The Cousland reservoir waters consist mainly of sodium chloride brines. The brine concentration is characteristic of the edge-water. Varying amounts of calcium and magnesium chlorides are also present. Sulphates and carbonates are usually found in very small quantities.

In the Cousland completion report by N.L. Falcon (U.K.-62) a diagram is included showing the geological correlation of the sands in the Cousland wells which had then been drilled. The sand correlation chart fig. 6 is based on this information; and has been brought up to date to include the results from the drilling of wells 4 and 5.

The possibility of correlating edge-waters is dependent on the collection of truly representative samples. Since the edge-waters consist essentially of sodium chloride solutions (apart from the fresh water samples collected in the upper part of the hole in well 1), the ionic percentages are roughly similar for all samples collected. Thus no correlation is possible on this basis alone.

However, it has been found that in the U.K., water analyses are most readily compared in the form of the triangular pattern which has been adopted in the past, in which gram equivalents are plotted against ionic percentages. This method shows up the concentrations of the total solids in the reservoir waters, which often constitute the main distinguishing features; and also emphasizes the constituents present in smaller quantities.

In the water analyses diagrams, fig. 7, the reservoir waters obtained in wells 1, 2 and 5 are first of all compared. This is followed by a comparison with well 4 on the Fordel Mains anticline; and well 3 in the Falside area. The edge-waters which have not been correlated are tabulated for record purposes.

The detailed correlation of the Cousland edge-waters is given in Appendix C. A tabulation of all the analyses of Cousland reservoir waters so far collected is also given in Appendix C.

(Sgd.) C.M. Adcock.

Reference No. P.T. 233

VIII. WELL 5 - FORMATION TESTING COMPLETION REPORT

Cousland (Scotland) No. 5 Well

R.T. Elevation - 551'

Report on packer tests and routine core analysis carried out during drilling operations

This well which is situated some 1,000 feet south of No. 1 well was drilled for gas production.

In all, ten successful packer tests were carried out. In the initial tests, drill-collars were used in order to obtain sufficient weight in the drill-string to compress the Johnston wall-packer and thus effect a perfect shut-off.

In the first two tests carried out over intervals 887'-916' and 1053' - 1084' only gaseous reservoir water was produced. Core analyses results showed that the sandstones were almost fully water saturated.

Whilst drilling 7¾" at a depth of 1349' (U.G.C.9202') sandstone cuttings with a strong smell of oil were encountered, subsequently a 19' core showed the top 10' of the sandstone to be oil impregnated. After drilling through the sand which was some 27' thick a packer test was carried out over interval 1327' - 1370' and in a 2 hours 25 minutes production test, crude oil of Specific Gravity 0.88 was produced at a rate of some 40 gallons per day. There was also evidence of a little gas amounting to some 60 cubic feet per day, and the production of some reservoir water, although core analyses results showed this water to be somewhat contaminated with returned drilling-mud filtrate.

Another oil impregnated sandstone was encountered at a depth of 1511' (U.G.C.9040') and found to be some 16' thick. Examination of the oil in the core showed it to be of a very waxy nature and in all probability having a pour-point above the temperature of the reservoir (66°F) at this depth. This observation was borne-out in a packer test carried out over the interval 1509' - 1527', when only a small gas production, amounting to some 220 cubic feet per day, was obtained.

The next group of sands was encountered over the interval 1656' - 1752', each sand being tested individually. In the first test carried out over the interval 1646' - 1694' gas was produced at a rate of 3,850 cubic feet per day. The drill-stem fluid indicated that reservoir water was also produced in the test. In the second test carried out over the interval 1686' - 1702' a small gas show accompanied by reservoir water production was obtained. In the remaining two tests carried out over the intervals 1706' - 1722' and 1724' - 1755', the production consisted mainly of reservoir water with a little gas.

In the final group of sands penetrated, two packer tests were carried out. The first test carried out over interval 1830' - 1861' gave no evidence of production from the reservoir, and in the second test over the interval 1868' - 1903' the production consisted of reservoir water at an overall rate of 2970 gallons per day and gas at a rate of some 340 cubic feet per day.

Drilling continued to a depth of 1918' without encountering any further sandstones. After carrying out a normal Schlumberger electrical logging survey the hole was plugged with cement to surface.

(Sgd.) K. Kirby.

C O N T E N T S

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TABLE I - Summary of Core Analysis Results

TABLE C.A.1 - Crushed Core Samples

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TABLE C.A.3 - Fluid Saturations & Salinities

SECTION 1

DETAILS OF FORMATION TESTS

Well Data Water Sands	Below R.T.	U.G.C.
Sandstone	885' - 910'	9666' - 9641'
Sandstone	1050' - 1065'	9501' - 9486'
Oil Sands		
Sandstone	1350' - 1376'	9201' - 9175'
Sandstone	1511' - 1527'	9040' - 9024'
Gas Sand		
Sandstone	1656' - 1665'	8895' - 8886'
Sands correlating with the 1582' - 1632' gas sand group of well 1		
Sandstone	1693' - 1700'	8858' - 8851'
Sandstone	1712' - 1720'	8839' - 8831'
Sandstone	1730' - 1760'	8821' - 8791'
Sands correlating with the 1720' - 1806' gas sand group of well 1		
Sandstone	1835' - 1844'	8716' - 8707'
Sandstone	1853' - 1857'	8698' - 8694'
Sandstone	1874' - 1890'	8677' - 8661'
8.5/8" casing shoe	775'	9776'
7.3/4" hole to	1773'	8778'
Bottom of 5.3/8" pilot hole	1918'	8633'

2. Packer Test on 8th & 9th March

(a) Summary

An attempt to test the formation on the 8th March was unsuccessful owing to the go-devil failing to burst the Johnston trip-valve disc. After coring 4' a repeat test was carried out, and during a 1 hour 15 minutes production test reservoir water of 1.004 S.G. was produced at an initial rate of 6,630 gallons per day. The fluid above the trip-valve was slightly gaseous.

(b) Diary of Test (Interval 887' - 916')

10.00 a.m.	Wound up clock (R.P.G.3 Amerada, element No. 6278-B)
10.15 a.m.	Making up anchor string
10.30 a.m.	Making up packer ($4\frac{1}{2}$" Johnston Tester with $7\frac{1}{2}$" wall packer)
10.50 a.m.	Making up drill-collars (4)
11.15 a.m.	Running in drill pipe ($4\frac{1}{2}$")
11.40 a.m.	Sitting 2' off bottom for mud pressure, put on wellhead fittings
11.52 a.m.	Lowered to bottom, sheared pin and opened retaining valve for production
1.06 p.m.	Took off wellhead fittings
1.10 p.m.	Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial rate - 45 cub.ft. per hr. or 6730 g.p.d.
Final rate - 11 cub.ft. per hr. or 1645 g.p.d.
Overall rate - 24 cub.ft. in 1 hr. 15 mins.or 2870 g.p.d.
(24 cubic feet are equivalent to 3.5 sump volumes)
Average back pressure = 112.6 p.s.i.g.

(ii) From drill-pipe

Fluid in drill pipe - 312' or 152 gallons
Time retaining valve open = 75 minutes
Hence overall production rate - 2920 g.p.d.

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 6278-B (0-1100 p.s.i.)
Calibration Temperature - 48°F.
Reservoir Temperature - 55°F.
Corrected mud pressure at 908' below R.T. - 450.0 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections)1.1
Mud Pressure at 908' calculated from mud gravity 449.2 p.s.i.
Rising Reservoir Pressure at 910' below R.T. - 354.2 p.s.i.g.

(e) Drill-stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10⁵ parts	Fluoresceine Parts/10⁶	% water separation by settling
Above trip valve	1.0035	202	2	85
2nd Stand above T.V.	1.0035	200	4	90
4th Stand above T.V.	1.0030	184	16	50
Top of column	1.0025	64	48	Nil
Circulating Mud	1.0021	12	48	Nil

Packer Test on 14th March 1954

(a) Summary

During a 2 hours 17 minutes production test a throughput of 12 cubic feet was recorded on the gas meter. This amounts to an overall fluid production rate of some 800 gallons per day. The fluid above the trip valve had a somewhat watery appearance.

Owing to the retaining valve opening before the rubber had effected a shut-off, only a Falling Reservoir Pressure of 479.6 p.s.i.g. wa recorded at a depth of 1082' below R.T. during the test. This pressure appears to have been affected by hysteresis, and is somewhat higher than a normal pressure at a depth of 1082'.

(b) Diary of Test (Interval 1053' - 1084')

9.45 a.m. Wound up clock (R.P.G.3 Amerada, element No. 6278-B)
9.55 a.m. Making up anchor string
10.15 a.m. Making up packer (4½" Johnston tester with 7¼" wall packer)
10.45 a.m. Making up 4½" drill collars (4)
11.00 a.m. Running in drill pipe
11.35 a.m. Sitting 9' off bottom for mud pressure

11.55 a.m. Lowered to bottom, sheared pin and set rubber
Annular-space fell approx. 10'
Sitting for Rising Reservoir?
12.57 p.m. Dropped go-devil and commenced production test
3.15 p.m. Closed retaining valve and pulled free

(c) Production Measurements

(i) From gas meter

Initial Rate - 1 cub.ft. in 4½ mins. or 1990 g.p.d.
Final Rate - 1 cub.ft. in 19 mins. or 470 g.p.d.
Overall Rate - 12 cub.ft. in 137 mins. or 790 g.p.d.
(12 cub.ft. are equivalent to 1.6 sump volumes)
Average back pressure = 63.6 p.s.i.g.

(ii) From drill pipe

Fluid in drill pipe = 160' or 78 gallons
Time tester valve open = 137 minutes
Hence overall production rate = 820 g.p.d.

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 6278-B (0-1100 p.s.i.)
Calibration Temperature - 46°F.
Reservoir Temperature - 59°F.
Corrected mud pressure at 1073' below R.T. = 578.0 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.20 p.s.i.g.
Mud Pressure at 1073' calculated from mud gravity = 558.8 psig
Falling Reservoir Pressure at 1082' below R.T. = 479.6 p.s.i.g

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10^5 parts	Fluoresceine parts/10^6
Above trip valve	1.0044	247	24
Middle of column	1.0045	256	32
Top of column	1.0030	151	32
Circulating Fluid	-	8	48

4. Packer Test on 23rd March

(a) Summary

After an unsuccessful attempt to test the formation with the packer set at 1333', a repeat test was carried with the packer set at 1327'. At this depth a shut-off was obtained, and during a 2 hours 25 minutes production test, crude oil of S.G. 0.88 was produced at a rate of some 40 gallons per day, and gas at a rate of some 60 cubic feet per day. This gives a gas oil ratio of 9.4. The remainder of the fluid above the trip valve had a slightly watery appearance.

(b) Diary of Test (Interval 1327' - 1370')

2.00 p.m.	Wound up clock (R.P.G.3 Amerada, element No. 6278-B)
2.15 p.m.	Making up anchor string
2.35 p.m.	Making up packer (4½" Johnston tester with 7¼" wall packer)
2.45 p.m.	Running in drill pipe (4½")
3.45 p.m.	Sitting 2' off bottom for mud pressure
4.00 p.m.	Lowered to bottom, sheared pin and set rubber. Sitting for Rising Reservoir Pressure
4.56 p.m.	Dropped Go-devil and commenced production
7.22 p.m.	Took off wellhead fittings and closed retaining valve
7.25 p.m.	Pulled packer free.

(c) Production Measurements

(i) From gas meter

Initial Rate = 1 cub.ft. in 1 min. 30 secs. or 5,980 g.p.d.
Final Rate = 1 cub.ft. in 10 min.30 secs. or 850 g.p.d.
Overall Rate = 18 cub.ft. in 2 hrs. 25 mins. or 1100 g.p.d.
Average back pressure = 46.8 p.s.i.g.

(ii) From drill pipe

Fluid in drill pipe = 146' or 71 gallons
Total time tester valve open = 145 mins.
Hence overall production rate = 705 g.p.d.
(146' are equal to 1.2 sump volumes)

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 6278-B (0-1100 p.s.i.g.)
Calibration Temperature = 53°F.
Reservoir Temperature = 63°F.
Corrected Mud Gravity at 1366' below R.T. = 654.2 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections)1.1(
Mud Pressure at 1366' calculated from mud gravity = 652 p.s.i.
Reservoir Pressure at 1368' below R.T. (a) at end of test - 521.5 p.s.i.g.
(b) extrapolated - 538.4 p.s.i.g.

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10⁵ parts	Fluoresceine parts/10⁶	% water separation by settling
Above Trip Valve	1.0074	538	24	20
Middle of Column	1.0039	222	32	Nil
Top of Column	-	80	48	Nil
Circulating Fluid	1.0020	16	64	Nil

5. Packer Test on 27th March

(a) Summary

During a 3 hours production test gas was produced at a rate of some 224 cubic feet per day. No reservoir pressure was recorded owing to the fact that on compressing the rubber, the sump pressure was squeezed up to 930 p.s.i.g. and stayed at this pressure during the 1 hour 'Rising Reservoir Pressure' test. This indicates that the formation was tight and scarcely productive.

(b) Diary of Test (Interval 1509' - 1527')

10.20 a.m.	Wound up clock (R.P.G.3 Amerada, element No. 6278-B)
10.40 a.m.	Making up anchor string
10.55 a.m.	Making up tester ($4\frac{1}{2}$" Johnston Test with $7\frac{1}{4}$" wall packer)
11.15 a.m.	Running in drill pipe ($4\frac{1}{2}$")
12.12 p.m.	Sitting 8' off bottom for mud pressure
12.30 p.m.	Lowered to bottom, sheared pin and set packer
2.26 p.m.	Dropped Go-devil and commenced production test
5.26 p.m.	Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial Rate = 1 cub.ft. in 1 min. 30 secs. or 960 ft^3 per day
Final Rate = 1 cub.ft. in 8 min. or 180 ft^3 per day
Overall Rate = 28 cu.ft. in 180 min. or 224 ft^3 per day
(Average back pressure = 47.6 p.s.i.g.)

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 6278-B (0-1100 p.s.i.)
Calibration Temperature - 48°F.
Reservoir Temperature - 66°F.
Corrected mud pressure at 1519' below R.T. - 776.5 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.17
Mud Pressure at 1519' calculated from mud gravity - 771.3 p.s.i.
No reservoir pressure was recorded during the test.

6. Packer Test on 8th & 9th April

(a) Summary

After three unsuccessful attempts had been made to test the formation, a successful test was carried out over interval 1646' - 1694'. During a $2\frac{1}{2}$ hours flow test an initial production rate of some 1150 cubic feet per day was recorded through the gas meter. After 2 hours the rate had increased to some 2900 cubic feet per day.

On closing-in the drill pipe for $16\frac{1}{2}$ hours a pressure of 300 p.s.i.g. was recorded on the wellhead. After blowing-down the pressure a gas productionnrate of 3850 cubic feet per day was recorded through the gas meter.

On breaking-down the drill pipe some 350' of water of S.G. 1.020 were found above the trip-valve. This amounts to a production rate of some 220 gallons per day.

(b) Diary of Test (Interval 1646' - 1694')

8th April

2.30 p.m.	Making up anchor string (3½" F.J. pipe)
2.45 p.m.	Making up tester (3½" Johnston tester with 5" wall packer)
3.00 p.m.	Running in drill pipe (4½")
3.40 p.m.	Sitting 2' off bottom for mud pressure
3.55 p.m.	Lowered to bottom, sheared pin and set packer. Sitting for Rising Reservoir Pressure
4.20 p.m.	Dropped Go-devil and started production test.
6.56 p.m.	Meter throughput 170 cubic feet Shut in drill pipe to record closed-in pressure (gas Recording pressure build-up during night

9th April

10.30 a.m.	C.I.P. 300 p.s.i.g.
10.45 a.m.	Collected gas samples
11.35 a.m.	Blowing-down gas pressure
11.55 a.m.	Re-connected gas meter to record gas production rate
12.15 p.m.	Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial Rate = 48 cub.ft. per hr. or 1150 cub.ft. per day
Final Rate = 96 cub.ft. per hr. or 2300 cub.ft. per day
Overall Rate = 170 cub.ft. in 2½ hrs. or 1630 cu.ft. per day

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.)
Calibration Temperature = 50°F.
Reservoir Temperature = 70°F.
Corrected Mud Pressure at 1690' below R.T. = 845.6 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.17
Mud Pressure at 1690' calculated from mud gravity 858.3 p.s.i.g.
Reservoir Pressure:- A Falling pressure of 920.2 p.s.i.g. was recorded at the end of a 30 minutes 'Reservoir Pressure Test' period, but had not reached equilibrium. The curve was not an exponential and no equilibrium reservoir pressure could be extrapolated.

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10⁵ parts	Fluoresceine Parts/10⁶	% Water separation by settling
Above tester valve	1.0200	1640	2	80
1st Stand above T.V.	1.0195	1580	3	70
Middle of column	1.0123	904	8	5
Top of column	1.0058	424	16	-
Circulating Fluid	1.0015	28	32	-

7. Packer Test on 13th April

(a) Summary

In a 1 hour 12 minutes production test, gas and reservoir water were produced at rates of 80 cubic feet and 200 gallons per day respectively. A reservoir pressure of 650.3 p.s.i.g. was recorded at a depth of 1700' below R.T. and reached equilibrium during the test.

(b) Diary of Test (Interval 1686' - 1702')

6.55 p.m. Wound up clock (R.P.G.3 Amerada, element No. 3836)
7.25 p.m. Making up tester (3½" Johnston Tester with 5" wall packer)
7.35 p.m. Running in drill pipe (4½")
8.25 p.m. Sitting 10' off bottom for mud pressure
9.10 p.m. Lowered to bottom, sheared pin and set packer. Sitting for Rising Reservoir Pressure.
10.20 p.m. Dropped Go-devil and started production test
11.32 p.m. Disconnected gas meter
11.34 p.m. Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial Rate = 1 cub.ft. in 7 mins. or 1280 g.p.d.
Final Rate = 1 cub.ft. in 21 min. or 430 g.p.d.
Overall Rate = 5½ cub.ft. in 72 mins. or 685 g.p.d.

(ii) From drill pipe

Fluid in drill pipe = 20' or 10 gallons
Time tester valve open = 72 minutes
Hence overall production rate = 200 g.p.d.

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.g.)
Calibration Temperature = 55°F.
Reservoir Temperature = 75°F.
Corrected Mud Pressure @ 1690' below R.T. = 856.6 p.s.i.g.
Mud Gravity (excluding temperature & pressure corrections) 1.16
Mud Pressure @ 1690' below R.T. calculated from mud gravity = 852.5 p.s.i.g.
Reservoir Pressure @ 1700' below R.T. = 650.3 p.s.i.g.

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10^5 parts	Fluoresceine Parts/10^6	% Water Separation by settling
Above Retaining valve	1.0041	300	4	40
Above trip valve	1.0028	148	8	Nil
Circulating Fluid	1.0020	36	24	Nil

8. Packer Test on 21st & 22nd April

(a) Summary

During a 3 hours 53 minutes flowing test a throughput of 146 cubic feet was recorded on the gas meter.

After leaving the drill pipe closed-in over night a pressure of 11½ p.s.i.g. was recorded at the wellhead.

On breaking down the drill stem some 1400 feet of 1.0106 S.G. reservoir water were found above the trip-valve. Thus the production consisted of reservoir water and a small quantity of gas.

(b) Diary of Test (Interval 1706' - 1722')

21st April

2.12 p.m.	Wound up clock (R.P.G.3 Amerada)
2.20 p.m.	Making up anchor string
2.35 p.m.	Making up tester (3½" Johnston Tester with 5" wall packer)
3.05 p.m.	Running in drill pipe (4½")
4.02 p.m.	Sitting 2' off bottom for mud pressure
4.18 p.m.	Lowered to bottom, sheared pin and set packer. Sitting for Rising R.P.
5.22 p.m.	Dropped Go-devil and commenced production test
9.15 p.m.	Meter throughput 146 cubic feet. Closed in drill pipe to record pressure build-up

22nd April

9.00 a.m.	Closed-in pressure 11½ p.s.i.g.
10.05 p.m.	Collected gas sample
10.15 a.m.	Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial Rate = 80 cub.ft. per hr. or 12,000 g.p.d.
Final Rate = 11 cub.ft. per hr. or 1,650 g.p.d.
Overall Rate = 146 cu.ft. in 3 hrs.53 mins. or 5,620 g.p.d.
Average back pressure = 407.3 p.s.i.g.

(ii) From drill pipe

Fluid in drill pipe = 1400' or 683 gallons
Time tester valve open = 17 hrs. 48 minutes
Hence overall production rate = 920 g.p.d.

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.g.)
Calibration Temperature = 52°F.
Reservoir Temperature = 73°F.
Mud Pressure at 1718' below R.T. = 845.9 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.14
Mud Pressure at 1718' calculated from mud gravity = 850.4 p.s.i.g.
Reservoir Pressure at 1720' below R.T. = 664.1 p.s.i.g.

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10⁵ parts	Fluoresceine Parts/10⁶	% water separation by settling
Above trip valve	1.0106	688	-	100
60' above trip valve	1.0100	730	-	100
700' above trip valve	1.0095	660	-	100
Top of column (1400')	1.0031	144	4	Nil
Circulating Fluid	-	32	8	Nil

9. Packer Test on 24th April

(a) Summary

During a 3 hours 28 minutes flow test a throughput of 144 cubic feet was recorded on the gas meter. This amounts to an overall production rate of some 1,000 cubic feet per day.

After closing-in the drill-pipe for 1 hour a pressure of 7 p.s.i.g. was recorded on the wellhead. This pressure appeared to have reached equilibrium and so the retaining valve was closed and the packer pulled free.

On breaking down the drill stem some 1100' of reservoir water of S.G. 1.008 were found above the retaining valve. Thus the production consisted of reservoir water at an overall rate of 2410 gallons per day, and gas at an overall rate of 350 cubic feet per day.

(b) Diary of Test (Interval 1724' - 1755')

9.40 a.m.	Wound up clock (R.P.G.3 Amerada)
9.50 a.m.	Making up anchor string ($3\frac{1}{2}$" F.J.)
10.10 a.m.	Testing packer ($3\frac{1}{2}$" Johnston tester with 5" wall packer)
10.20 a.m.	Set $4\frac{1}{2}$" Johnston bursting-disc 60' above retaining valve
10.25 a.m.	Running in drill pipe ($4\frac{1}{2}$")
11.10 a.m.	Sitting 2' off bottom for mud pressure
11.25 a.m.	Lowered to bottom, sheared pin and set packer. Sitting for Rising Reservoir Pressure.
12.32 p.m.	Dropped Go-devil and started production
4.00 p.m.	Meter throughput 144 cubic feet. Closed-in drill for pressure build-up
5.00 p.m.	Closed in pressure .7 p.s.i.g.
5.30 p.m.	" " " 7 p.s.i.g.
5.45 p.m.	Collected gas sample
5.55 p.m.	Pulled packer free

(c) Production Measurements

(i) From gas meter

Initial Rate - 65 cubic feet per hr. or 9,700 g.p.d.
Final Rate - 20 cubic feet per hr. or 2,990 g.p.d.
Overall Rate - 144 cubic feet in 3 hrs. 28 mins. or 6,200 g.p.d.
(144 cubic feet are equal to 36 sump volumes)
Average back pressure = 301.0 p.s.i.g.

(ii) From drill pipe

Fluid in drill pipe = 1100' or 535 gallons
Total time tester valve open = 5 hrs. 23 mins.
Hence overall production rate = 2380 g.p.d.

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.g.)
Calibration Temperature = 54°F.
Reservoir Temperature = 71°F.
Corrected Mud Pressure at 1751' below R.T. = 870.4 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.14
Calculated Mud Pressure at 1751' below R.T. = 866.3 p.s.i.g.
Reservoir Pressure at 1753' below R.T. = 680.7 p.s.i.g.

(e) Drill stem samples

	Sp.Gr. @ 60° F.	Salinity Cl/10⁵ parts	Fluoresceine Parts/10⁶	% water separation by settling
Above trip valve	1.0077	608	1	95
1st stand above T.V.	1.0074	616	1	95
Middle of column	1.0073	572	3	90
Top of column	1.0025	152	32	Nil
Circulating Fluid	-	52	48	Nil

10. Packer Test on 3rd May

(a) Summary

In a 37 minutes production test there was no evidence of production on the gas meter. The Amerada chart showed that the test had been mechanically satisfactory.

(b) Diary of Test

9.45 a.m.	Wound up clock (R.P.G.3 Amerada)
10.00 a.m.	Making up anchor string (3½" F.J. pipe)
10.20 a.m.	Tested packer (3½" Johnston tester with 5" wall packer)
10.25 a.m.	Put 4½" Trip Valve 60' above retaining valve
10.30 a.m.	Running in drill pipe (4½")
11.25 a.m.	Sitting 2' off bottom for mud pressure
11.40 a.m.	Lowered to bottom, sheared pin and set packer
12.38 p.m.	Dropped Go-devil and commenced production test
1.15 p m.	Pulled packer free.

(c) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.)
Calibration Temperature = 54°F.
Reservoir Temperature = 70°F.
Corrected Mud Pressure at 1857' below R.T. = 923.2 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.14
Mud Pressure at 1857' below R.T. calculated from mud gravity = 918.8 p.s.i.g.
During a 1 hour "Reservoir Pressure" period there was no sign of any pressure increase on the Amerada chart, thus confirming that the formation was non-productive.

11. Packer Test on 5th May

(a) Summary

In a 1 hour 56 minutes production test reservoir water of 1.005 S.G. was produced at an overall rate of 2,970 gallons per day and gas at a rate of 340 cubic feet per day.

(b) Diary of Test (Interval 1868' - 1903')

10.30 a.m.	Wound up clock (R.P.G.3 Amerada)
10.50 a.m.	Making up anchor string (3½" F.J.)
11.05 a.m.	Tested packer (3½" Johnston tester with 5" wall packer). 4½" Trip valve set 120' above retaining valve.
11.15 a.m.	Running in drill pipe (4½")
12.18 p.m.	Sitting 2' off bottom for mud pressure
12.33 p.m.	Lowered to bottom, sheared pin and set packer Sitting for Rising Reservoir Pressure
2.04 p.m.	Dropped Go-devil and commenced production test
4.00 p.m.	Pulled packer free.

(c) Production Measurements

(i) From drill pipe

Initial Rate = 48 cubic feet per hr.or 7,180 g.p.d.
Final Rate = 23 cubic feet per hr. or 3,440 g.p.d.
Overall Rate = 61 cubic feet in 1 hr. 56 mins. or 4,720 g.p.d.
Average back pressure = 141.5 p.s.i.g.

(ii) From drill pipe

Fluid in drill pipe = 550' or 240 gallons
Total time tester valve open = 116 mins.
Hence overall production rate = 2970 galls.
(550' fluid are equal to 7.8 sump volumes)

(d) Reservoir Pressure Calculations

R.P.G.3 Amerada, element No. 3836 (0-2140 p.s.i.)
Calibration Temperature = 55°F.
Reservoir Temperature = 72°F.
Corrected Mud Pressure at 1899' below R.T. = 936.8 p.s.i.g.
Mud Gravity (excluding pressure & temperature corrections) 1.15
Mud Pressure at 1899' calculated from mud = 947.8 p.s.i.g.
Reservoir Pressure at 1901' below R.T. = 717.8 p.s.i.g.

(e) Drill stem samples

	Sp.Gr. @ 60°F.	Salinity Cl/10⁵ parts	Fluoresceine Parts/10⁶	% water separati by settlin
Above Retaining Valve	1.0051	332	1	95
Above Trip Valve	1.0050	332	1	90
Middle of column	1.0050	308	2	90
Top of column	1.0030	92	32	Nil
Circulating Fluid	-	36	32	Nil

TABLE I

GAS ANALYSES

(Analysed by A.I.O.C., Research Station, Sunbury)

Date collected	9th April	22nd April	24th April
Horizons Exposed	Sandstone (1656'-1665')	Sandstone (1712'-1720')	Sandstone (1730'-1752')
Constituent-Nol. %			
Nitrogen	6.00	3.80	11.75
Carbon Dioxide	Nil	Nil	Nil
Hydrogen Sulphide	Nil	Nil	Nil
Methane	89.90	93.25	85.15
Ethane	2.85	2.50	2.95
Propane	0.95	0.35	0.15
Butane	0.25	0.10	Nil

TABLE II

INSPECTION DATA ON SAMPLE OF CRUDE COLLECTED DURING PACKER TEST ON 23rd MARCH (Sandstone 1349-1376')

TEST		RESULT
Water content % vol.		0.2
On dried sample		
Specific Gravity at 60°F./60°F.		0.8803
Distillation I.P. 24	°C	84
I.B.P.		-
Volume Recovered at 50°C.	%	-
75°C.	%	>1
100°C.	%	>1
125°C.	%	1.5
150°C.	%	3.0
175°C.	%	4.5
200°C.	%	6.5
225°C.	%	9.0
250°C.	%	12.5
275°C.	%	17.5
300°C.	%	18.4
Total Distillate	%	81.5
Residue	%	0.1
Loss		0.8080
Specific Gravity at 60°F. of distillate		0.8994
" " " " " residue		24.6
Wax Content	%wt	92
Melting Point of Wax	°F.	51.62
Kinematic Viscosity at 100°F.	cs.	>0.05
Asphaltenes	%wt	0.16
Sulpher content	%wt	Nil
Saponification Value		
Residue from Distillation		
Specific Gravity at 60°F/60°F.		0.8994
Kinematic Viscosity	cs	145.5
Sulphur Content	%wt	0.17
Pour Point (Upper)	°F.	30
Fraction I.B.P. - 300°C.		
Bromine Number		4
Unsaturateds	%vol.	5

TABLE III.

ANALYSIS OF RESERVOIR WATERS

(Analysed by W.W. Taylor, B.Sc., F.R.I.C., Public Analyst, Nottingham)

DATE COLLECTED	9th March	23rd March	9th April	13th April	21st April	24th April	5th May
HOW COLLECTED	From drill-stem during packer test	From drill-stem during packer test	From drill-stem during packer test	From drill-stem during packer test	From drill-stem during packer test	From drill-stem during packer test	From drill-stem during packer test
HORIZONS EXPOSED	Sandstone (885'-910')	Sandstone (1349'-1376')	Sandstone (1656'-1665')	Sandstone (1693'-1700')	Sandstone (1712'-1720')	Sandstone (1730'-1752')	Sandstone (1873'-1890')
SP.GR. AT 60°F.	1.0040	1.0074	1.0200	1.0041	1.0106	1.0077	1.0051
pH VALUE	7.9	8.5	7.3	8.0	7.6	7.7	7.9
TOTAL SOLIDS	363.9	1134.4	3002.4	565.0	1169.4	1126.6	617.2
PARTS PER 100,000							
NA	126.3	402.8	918.9	202.2	397.8	387.0	223.2
K	2.9	2.1	2.5	1.4	3.4	4.3	1.4
CA	9.6	22.4	176.0	12.2	39.6	38.4	15.4
MG	3.5	12.2	44.5	4.1	12.5	9.3	2.8
CL	201.6	639.0	1846.0	284.0	674.5	639.0	333.7
SO_4	0.6	14.8	1.6	20.9	0.5	0.6	1.1
CO_3	19.4	41.1	12.9	40.2	41.1	48.0	39.6
REACTION EQUIVALENTS %							
NA	43.3	44.5	38.1	45.0	42.4	42.9	45.2
K	0.6	0.1	-	0.2	0.2	0.3	0.1
CA	3.8	2.8	8.4	3.1	4.9	4.9	3.6
MG	2.3	2.6	3.5	1.7	2.5	1.9	1.1
CL	44.8	45.7	49.6	40.9	46.6	45.9	43.8
SO_4	0.1	0.8	-	2.2	-	-	0.1
CO_3	5.1	3.5	0.4	6.9	3.4	4.1	6.1
REMARKS	The sample was collected from above the trip valve & should be reliable as 3.5 sump volumes were produced during the test.	The sample was collected from above the trip valve & should be reliable as 1.2 sump volumes were produced during the test	The sample was collected from above the trip valve & should be reliable as 4 sump volumes were produced during the test	The sample was collected from above the retaining valve & should be reliable as a salinity greater than the mud filtrate indicated the presence of reservoir water	The sample was collected from above the trip valve & should be reliable as 48 sump volumes were produced during the test	The sample was collected from above the trip valve & should be reliable as 36 sump volumes were produced during the test.	The sample was collected from above the retaining valve & should be reliable as 8 sump volumes were produced during the test

SECTION 2

DETAILS OF CORE ANALYSIS WORK

(a) Summary

The results of detailed core analysis measurements made on twenty-four samples taken from some twenty-one cores are presented.

These samples embrace the oil sand and gas successions encountered during drilling operations.

In the main, porosities were between 10 & 15% except at the base of the 1730' - 1760' sand and the top of the 1835'-1857' sands, where the average was 7%. Apart from three zones - 901', 1352'-56' and 1519'-1663' - permeabilities were low - mostly less than 10 millidarcies.

Nearly all the sandstones encountered gave a measurable oil and gas saturation although the majority of the rocks were fully water saturated.

(b) Experimental

The routine methods used are reported briefly with general comments.

(i) Oil & water saturations

Approximately 100 grms of the crushed samples were refluxed in toluene for 8 hours and any water collected in a Dean & stark side-arm attachment. This extraction was carried out as soon as the core came out of the hole so that losses due to gas expansion and evaporation were at a minimum.

(ii) Salinities

The salt content was measured by boiling the extracted dried crushed sample with 250 ccs. distilled water for three hours and then carrying out a Mohr titration using silver nitrate.

The salinity of the water in the core was estimated, using the salt content of the crushed sample and the water saturation measurement. The salinity of the mud filtrate and also the connate water, where possible, were measured by a Mohr titration. From these salinities it is obvious that considerable mud invasion of the sandstones had taken place during the short time that the cores were exposed to the circulating fluid.

(iii) Porosities

Porosities were measured on small cylindrical plugs - 1" diameter and 1" long - by measuring the increase in weight of the plug on saturating in vaccuo with a brine solution of salinity approximately equal to that of the connate water. It is assumed that 100% of the effective pore space is filled with brine and that no clayey inter-granular cementation material, which would swell in the brine solution, is present in the small cylindrical core.

(iv) Permeabilities

Air permeabilities were determined by measuring the rate of flow of air through the small plugs at a given differential pressure or conversely measuring the pressure differential at a given rate of flow.

TABLE I.

SUMMARY OF CORE ANALYSIS RESULTS

Sample Ref. No.	Depth Ft. below R.T.	Salinities - P.P.M. NaCl			Saturations - % Pore Space				K_A Mds.	Ø B.
		Water in Core	Connate Water	Mud Filtrate	Measured Sw	Measured So	Deduced SG(Min)	Deduced SG(Max)		
1	892' 6"	1,494	3,337	198	88.5	-	11.5	63.4	-	10.2
2	897'	473	3,337	198	96.3	-	3.7	91.5	8,60	14.6
3	901' 6"	260	3,337	198	71.9	-	28.1	98.6	439.80	15.5
4	928'	13,767	-	198	100.0	-	-	-	-	0.7
5	1065'	6,314	-	132	71.8	16.7	11.5	-	7.80	13.0
6	1074'	3,303	4,080	132	93.3	6.7	-	18.5	0.77	10.7
7	1083'	4,806	-	132	86.7	2.6	10.7	-	7.88	14.1
8	1352'	15,517	-	264	42.3	40.7	17.0	-	265.10	16.4
9	1356'	19,977	-	264	59.6	14.6	25.8	-	213.90	15.3
10	1359'	24,783	-	264	74.8	5.5	19.7	-	10.03	12.0
11	1365'	24,523	-	264	81.7	-	18.3	-	0.39	7.9
12	1519'	85,243	-	462	7.7	89.4	2.9	-	67.90	14.2
13	1523'	36,526	-	462	19.6	80.4	-	-	57.28	14.3
14	1661'	2,771	27,089	462	43.0	2.4	54.6	93.5	161.10	15.5
15	1663'	3,047	27,089	462	32.8	2.8	64.4	93.7	40.80	13.8
16	1694' 6"	10,136		595	49.2	3.4	47.4	-	1.93	10.8
17	1695' 6"	1,500	4,955	595	94.4	5.6	-	74.8	3.66	9.1
18	1715'	1,518	11,364	529	81.8	-	18.2	92.6	123.90	13.3
19	1718' 6"	1,915	11,364	529	71.3	2.5	26.2	88.4	96.3	12.3
20	1735'	3,411'	10,043	859	90.0	10.0	-	65.0	1.00	7.7
22	1739'	10,595	-	859	63.3	12.2	24.5	-	0.59	9.5
23	1858'	18,920	-	859	34.6	11.9	53.5	-	1.40	7.8
24	1887'	12,207	-	595	73.1	16.8	10.1	-	0.08	5.0
25	1890'	8,793	-	595	59.5	2.3	38.2	-	0.24	6.2

SYMBOLS

1. Sw = water saturation
2. So = Oil Saturation
3. Sg = Gas Saturation
4. Ka = Air Permeability in millidarcies
5. Øb = Effective Porosity to Brine

C.A.I. AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

CRUSHED CORE SAMPLES

Sample Ref. No.	Depth in feet	OIL AND WATER CONTENTS: Weighing Data: Thimble grams w_1	Thimble Plus Sample: Saturated grams w_2	Thimble Plus Sample: Extracted grams w_3	Weight of extracted sample grams $(w_3 - w_1)$ W_1	Loss in weight grams $(w_2 - w_3)$ a	Water in D & S Receiver: Initial mls. b_1	Water in D & S Receiver: Final mls. b_2	Water in D & S Receiver: Produced mls. $(b_2 - b_1)$ c	Oil (including bitumen) grams $(a - c)$ d	Volume of Toluene mls. e	SALT CONTENTS: Volume distilled water added to W_1 mls. f_1	Volume of solution titrated mls. f_2	Volume of Sulphuric acid to neutralise mls. f_3	N/20 Silver Nitrate used for f_2 titration: 1 mls. f_4	N/20 Silver Nitrate used for f_2 titration: 2 mls. f_5	Mean quantity mls. $\frac{f_4+f_5}{2}$ g	Weight of Sodium Chloride: In f2 $0.3441 \times 8.5 \times g \times 10^{-3}$ grams w_4	Weight of Sodium Chloride: Total Extracted $\frac{w_4 \times f_1}{f_2}$ grams W_2
C5/1	892½	61.171	194.723	189.899	128.728	4.824	1.9	6.8	4.9	-	178	250	50	-	0.5	0.5	0.5	.001463	.00732
2	897	57.617	162.427	156.153	98.536	6.274	1.5	7.7	6.2	-	189			-	0.2	0.2	0.2	.000585	.00293
3	901½	57.135	175.020	169.423	112.288	5.597	1.3	6.95	5.65	-	193			0.3	0.1	0.1	0.1	.000293	.00147
4	928	58.702	160.770	160.164	101.462	0.606	1.5	2.2	0.7	-	203			0.3	0.3	0.2	0.25	.000732	.00366
5	1065	55.078	168.151	162.932	107.854	5.219	1.2	5.6	4.4	0.819	223			-	1.9	1.9	1.9	.00556	.02780
6	1074	57.804	178.994	173.708	115.904	5.286	0.9	5.9	5.0	0.286	251			-	1.3	1.3	1.3	.003306	.01653
7	1083	59.139	183.861	177.305	118.166	6.556	3.1	9.5	6.4	0.156	300			-	2.1	2.1	2.1	.00615	.03075
8	1352	58.637	168.273	162.182	103.545	6.091	0.5	3.8	3.3	2.791	235			-	3.5	3.5	3.5	.01024	.05120
9	1356	58.635	161.393	156.409	97.774	4.984	0.7	4.8	4.1	0.884	230			-	5.6	5.6	5.6	.01638	.08190
10	1359	61.678	190.313	185.203	123.525	5.110	0.8	5.6	4.8	0.310	200			-	8.1	8.25	8.17	.0238	.1190
11	1365	61.149	190.079	186.743	125.594	3.336	1.6	5.0	3.4	-	220			0.2	5.6	5.8	5.7	.01668	.08340
12	1519	58.690	185.283	178.983	120.293	6.300	2.2	2.8	0.6	5.700	272	250	50	-	3.5	3.5	3.5	.01024	.05120
13	1523	55.072	169.944	163.369	108.297	6.575	5.2	6.6	1.4	5.175	240			-	3.5	3.5	3.5	.01024	.05120

C.A.I. AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

CRUSHED CORE SAMPLES

Sample Ref. No.	Depth in feet	OIL AND WATER CONTENTS: Weighing Data — Thimble grams w_1	Thimble Plus Sample — Saturated grams w_2	Thimble Plus Sample — Extracted grams w_3	Weight of extracted sample grams $(w_3 - w_1)$ W_1	Loss in weight grams $(w_2 - w_3)$ a	Water in D & S Receiver — Initial mls. b_1	Final mls. b_2	Produced mls. $(b_2 - b_1)$ c	Oil (including bitumen) grams $(a - c)$ d	Volume of Toluene mls. e	SALT CONTENTS: Volume distilled water added to W_1 mls. f_1	Volume of solution titrated mls. f_2	Volume of Sulphuric acid to neutralise mls. f_3	N/20 Silver Nitrate used for f_2 titration — 1 mls. f_4	2 mls. f_5	Mean quantity mls. $\frac{f_4+f_5}{2}$ g	Weight of Sodium Chloride — In f2 $0.3441 \times 8.5 \times g \times 10^{-3}$ grams w_4	Total Extracted $\frac{w_4 \times f_1}{f_2}$ grams W_2
14	1661	58.763	175.986	172.517	113.754	3.469	2.4	5.7	3.3	0.169	240			0.3	0.6	0.65	0.625	.00183	.00915
15	1663	59.909	182.506	179.924	120.015	2.582	0.9	3.3	2.4	0.182	240			–	0.5	0.5	0.5	.00146	.00730
16	1694½	57.798	174.277	171.516	113.718	2.761	1.6	4.2	2.6	0.161	247			0.1	1.8	1.8	1.8	.00527	.02635
17	1695½	58.638	180.015	175.377	116.739	4.638	1.7	6.1	4.4	0.238	–			0.3	0.4	0.5	0.45	.00132	.00660
18	1715	58.636	186.075	180.274	121.638	5.801	2.5	8.3	5.8	–	226			2.0	0.6	0.6	0.6	.00176	.00880
19	1718½	57.799	184.222	179.477	121.678	4.745	1.2	5.8	4.6	0.145	–			1.2	0.6	0.6	0.6	.00176	.00880
20	1735	55.078	186.422	182.408	127.330	4.014	1.0	4.65	3.65	0.364	–			–	0.8	0.9	0.85	.00249	.01245
22	1739	59.124	176.367	172.964	113.840	3.403	0.9	3.8	2.9	0.503	–			–	2.1	2.1	2.1	.00614	.03070
23	1858	57.616	135.125	133.188	75.572	1.937	4.8	6.3	1.5	0.437	–			0.7	1.1	1.1	1.1	.00322	.0161
24	1887	57.616	166.729	163.713	106.097	3.016	1.05	3.55	2.5	0.516					1.35	1.35	1.35	.00395	.01975
25	1890	57.795	183.861	181.014	123.219	2.847	2.7	5.45	2.75	0.097					1.15	1.10	1.125	.00329	.01645

C.A.2 AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

CORE PLUG SAMPLES

Plug Reference No.	Length of plug cms. L	PERMEABILITY TO AIR: Manometer reading cms. h_1	Manometer reading p.s.i. $h_1 \times 0.0142$ p_1	Gauge Pressure p.s.i. p_1	Flow Rate ccs/sec. Q_0	Atmospheric Pressure Hg cms h_2	Atmospheric Pressure p.s.i. $h_2 \times 0.194$ p_0	$p_1\left(1+\frac{p_1}{2p_0}\right)$ i	$53.5LQ_0$ j	Air Permeability mds. $\frac{j}{i}$ k_A	BULK VOLUMES: Weighing Data Beaker grams w_5	Beaker plus mercury grams w_6	Weight of Hg. grams (w_6-w_5) l	Temp. of Hg t^{oo}	Specific Volume of Hg. ccs/gram m	Bulk Volume of plug ccs. $1 \times m$ V	PORE VOLUMES: Weighing Data Dry plug grams W_3	Weighing bottle grams w_7	Bottle plus satd:plug grams w_8	Weight of sat: plug grams (w_8-w_7) n	Wt. of brine grams $(n-W_3)$ o	Brine measured density grams per cc ρ	Brine plug pore vol. ccs. $\frac{o}{\rho}$ v	% Porosity to brine v/V $\times 100$ ϕB
C5/1	2.47	-	-	36.75	-	74.3	14.41	83.59	-	-	36.258	201.566	165.308	19.8	.07382	12.19	29.024	24.486	54.766	30.280	1.254	1.0053	1.248	10.2
2	2.45	-	-	16.76	2.5	"	"	38.16	327.7	8.6		201.314	165.056	21.8	.07385	12.18	27.155	"	53.424	28.938	1.783	"	1.774	14.6
3	2.53	52.9	0.751	-	2.5	"	"	0.77	338.5	439.8		204.997	168.739	22.7	.07386	12.45	27.587	"	54.013	29.527	1.940	"	1.930	15.5
4	2.50	-	-	36.75	-	"	"	83.59	-	-		206.304	170.046	23.4	.07387	12.55	33.364	"	57.938	33.452	.088	"	.0875	0.7
5	2.46	-	-	18.44	2.5	"	"	42.00	329.0	7.8		200.948	164.690	23.5	.07387	12.15	27.700	"	53.769	29.283	1.583	"	1.575	13.0
6	2.49	-	-	36.75	0.48	"	"	83.59	64.0	0.77		202.409	166.151	23.9	.07387	12.26	28.857	"	54.663	30.177	1.320	"	1.313	10.7
7	2.40	-	-	17.93	2.5	"	"	40.80	321.1	7.88		195.631	159.373	23.2	.07386	11.77	26.646	"	52.805	28.319	1.673	"	1.664	14.1
8	2.51	85.6	1.215	-	2.5	74.0	14.36	1.267	335.9	265.10		200.581	164.323	22.7	.07386	12.13	26.427	"	52.914	28.428	2.001	"	1.991	16.4
9	2.47	-	-	1.47	2.5	"	"	1.545	330.5	213.90		196.000	159.742	23.3	.07386	11.78	25.655	"	51.956	27.470	1.815	"	1.805	15.3
10	2.55	-	-	14.92	2.5	"	"	34.00	341.2	10.03		204.837	168.579	23.7	.07387	12.45	28.730	"	54.717	30.231	1.501	"	1.493	12.0
11	2.54	-	-	36.75	0.24	"	"	83.70	32.6	0.39		203.286	167.028	23.6	.07387	12.33	29.507	"	54.976	30.490	.983	"	.978	7.9
12	2.52	-	-	4.32	2.5	75.0	14.55	4.960	337.0	67.90	35.958	204.459	168.501	22.0	.07385	12.45	27.271	24.065	53.131	29.066	1.795	1.0150	1.768	14.2
13	2.51	-	-	5.00	2.5	"	"	5.860	335.5	57.28		203.012	167.054	20.7	.07383	12.33	26.924	"	52.776	28.711	1.787	"	1.760	14.3

C.A.2 AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

CORE PLUG SAMPLES

Plug Reference No.	Length of plug cms. L	PERMEABILITY TO AIR: Manometer reading cms. h_1	Manometer reading p.s.i. $h_1 \times 0.0142$ p_1	Gauge Pressure p.s.i. p_1	Flow Rate ccs/sec. Q_0	Atmospheric Pressure Hg cms h_2	Atmospheric Pressure p.s.i. $h_2 \times 0.194$ p_0	$p_1\left(1+\frac{p_1}{2p_0}\right)$ i	$53.5LQ_0$ j	Air Permeability mds. $\frac{j}{i}$ k_A	BULK VOLUMES: Weighing Data Beaker grams w_5	Weighing Data Beaker plus mercury grams w_6	Weight of Hg. grams (w_6-w_5) l	Temp. of Hg t^{oo}	Specific Volume of Hg. ccs/gram m	Bulk Volume of plug ccs. $l \times m$ V	PORE VOLUMES: Weighing Data Dry plug grams W_3	Weighing bottle grams w_7	Bottle plus satd:plug grams w_8	Weight of sat: plug grams (w_8-w_7) n	Wt. of brine grams $(n - W_3)$ o	Brine measured density grams per cc ρ	Brine plug pore vol. ccs. $\frac{o}{\rho}$ v	% Porosity to brine v/V ×100 ϕB
14	2.55	-	-	1.985	2.5	75.7	14.67	2.118	341.1	161.1	35.961	208.436	172.475	23.0	.07386	12.34	28.402	24.487	54.835	30.348	1.946	1.0150	1.917	15.5
15	2.47	-	-	6.61	2.5	"	14.67	8.1	330.5	40.8	35.961	203.623	167.662	22.8	.07386	12.38	28.019	24.487	54.239	29.752	1.733	1.0150	1.707	13.8
16	2.39	-	-	36.75	1.25	"	"	82.8	159.8	1.93	"	197.567	161.606	24.2	.07388	11.94	27.677	"	53.469	28.982	1.305	1.0146	1.286	10.8
17	2.41	-	-	36.75	2.35	"	"	82.8	303.0	3.66	"	200.300	164.339	13.1	.07373	12.12	28.709	"	54.308	29.821	1.112	"	1.096	9.05
18	2.55	-	-	2.535	2.5	75.8	14.7	2.753	341.1	123.9	"	210.302	174.34	16.4	.07377	12.86	29.291	24.486	55.510	31.024	1.733	1.0150	1.707	13.3
19	2.52	-	-	3.16	2.5	"	"	3.5	337.0	96.3	"	207.162	171.201	17.9	.07379	12.63	29.281	"	55.341	30.855	1.574	"	1.551	12.3
20	2.57	-	-	36.75	0.6	75.68	14.67	82.77	82.6	0.998	"	210.924	174.963	19.0	.07381	12.91	31.733	"	57.226	32.740	1.007	"	0.992	7.7
22	2.54	-	-	36.75	0.36	"	"	82.77	48.9	0.591	"	208.424	172.463	20.0	.07382	12.73	30.166	"	55.883	31.397	1.231	"	1.213	9.5
23	2.42	-	-	36.75	0.9	74.60	14.46	83.47	116.5	1.395	35.960	198.933	162.973	21.4	.07384	12.03	28.944	24.487	54.387	29.900	0.956	1.0150	0.942	7.84
24	2.51	-	-	36.75	0.05	74.9	14.53	83.26	6.72	0.081	"	207.494	171.534	16.9	.07378	12.66	30.583	24.486	55.714	31.228	0.645	1.0113	0.638	5.04
25	2.64	-	-	36.75	0.14	"	"	83.26	19.77	0.238	"	215.455	179.495	18.2	.07380	13.25	32.215	"	57.532	33.046	0.831	"	0.822	6.2

C.A.3. AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

FLUID SATURATIONS AND SALINITIES

ROCK SAMPLES			FLUID SATURATIONS (not corrected for mud invasion)						SALINITIES				SATURATIONS (adjusted for mud invasion)	
						Saturation—% Pore Space			Salinities—ppm. Sodium Chloride				Saturation—% Pore Space	
Geological Horizon	Rock Formation	Depth in feet	Sample Reference No.	Pore Space (in crushed sample) $v \times \frac{W_1}{W_3}$ q	Oil Specific gravity r	Water (maximum) $\frac{c}{q} \times 100$ s_1	Oil $\frac{d}{q \times r} \times 100$ t_1	Difference ? Gas (minimum) $100-(s_1+t_1)$ u_1	Water in core $\frac{W_3 \times W_2 \times 10^8}{W_1 \times v \times s_1}$ x_1	Measured connate Water y	Measured Mud Filtrate z	Water in core corrected for mud invasion $100\frac{(x_1-z)}{(y-z)}$ x_2	Water (minimum) $\frac{x_2}{100} \times s_1$ s_2	Difference ? Gas (maximum) $100-(s_2+t_1)$ u_2
	Sandstone	892½	C5/1	5.535	-	88.5	-	11.5	1,494	3,337	198	41.3	36.6	63.4
	"	897	2	6.44	-	96.3	-	3.7	473	3,337	198	8.8	8.5	91.5
	"	901½	3	7.86	-	71.9	-	28.1	260	3,337	198	2.0	1.4	98.6
	Limestone	928	4	0.266	-	100	-	-	13,767	-	198			
	Sandstone	1065	5	6.13	0.8	71.8	16.7	11.5	6,314	-	132			
	"	1074	6	5.27	"	93.3	6.7	-	3,303	4,080	132	80.3	74.9	18.5
	"	1083	7	7.38	"	86.7	2.6	10.7	4,806	4,080	132			
	"	1352	8	7.80	0.88	42.3	40.7	17.0	15,517		264			
	"	1356	9	6.88	"	59.6	14.6	25.8	19,977		264			
	"	1359	10	6.42	"	74.8	5.5	19.7	24,783		264			
	"	1365	11	4.16	"	81.7	-	18.3	24,523		264			
	"	1519	12	7.86	0.9	7.7	89.4	2.9	85,243	-	264			
	"	1523	13	7.08	0.9	19.6	80.4	-	36,526	-	264			

C.A.3. AREA: COUSLAND (SCOTLAND) WELL No. 5 DATE

FLUID SATURATIONS AND SALINITIES

ROCK SAMPLES			FLUID SATURATIONS (not corrected for mud invasion)						SALINITIES				SATURATIONS (adjusted for mud invasion)	
						Saturation—% Pore Space			Salinities—ppm. Sodium Chloride				Saturation—% Pore Space	
Geological Horizon	Rock Formation	Depth in feet	Sample Reference No.	Pore Space (in crushed sample) $v \times \frac{W_1}{W_3} \times \frac{c}{q} \times 100$ q	Oil Specific gravity r	Water (maximum) $\frac{c}{q} \times 100$ s_1	Oil $\frac{d}{q \times r} \times 100$ t_1	Difference ? Gas (minimum) $100-(s_1+t_1)$ u_1	Water in core $\frac{W_3 \times W_2 \times 10^8}{W_1 \times v \times s_1}$ x_1	Measured connate Water y	Measured Mud Filtrate z	Water in core corrected for mud invasion $\frac{100(x_1-z)}{(y-z)}$ x_2	Water (minimum) $\frac{x_2 \times s_1}{100}$ s_2	Difference ? Gas (maximum) $100-(s_2+t_1)$ u_2
	Sandstone	1661	14	7.68	0.9	43.0	2.4	54.6	2,771	27,089	462	8.7	3.7	93.5
	"	1663	15	7.320	0.9	32.8	2.8	64.4	3,047	27,089	462	9.7	3.2	93.7
	"	1694½	16	5.285	0.9	49.2	3.4	47.4	10,136		595			
	"	1695½	17	4.459	0.9	94.4	5.6	-	1,500	4,955	595	20.8	19.6	74.8
	"	1715	18	7.090		81.8	-	18.2	1,518	11,364	529	9.1	7.4	92.6
	"	1718½	19	6.448	0.9	71.3	2.5	26.2	1,915	11,364	529	12.8	9.1	88.4
	"	1735	20	3.980	0.9	90.0	10.0	-	3,411	10,043	859	27.8	25.0	65.0
	"	1739	22	4.579	0.9	63.3	12.2	4.5	10,595		859			
	"	1858	23	4.33	0.9	34.6	11.9	3.5	18,920		859			
	"	1887	24	3.42	0.9	73.1	16.8	10.1	12,207		595			
	"	1890	25	4.62	0.9	59.5	2.3	38.2	8,793		595			

APPENDIX A.

Cousland Reservoir Pressures

10,000
8933
1067

1. Tabulation of recorded pressures

Well	Depth Feet	U.G.C.	Pressure p.s.i.g.	Remarks
C1	1632'	8933'	640	By calculation from C.I.P. of 615 p.s.i.g.
C1	1770'	8795'	687	" " "659 "
C1	1800'	8765'	689	
C2	2039'	8393'	850	Formation Test. Equivalent "1720" sand in C1
C2'	2308'	8124'	955	Formation Test
C4	1454'	9177'	576	Formation Test. Report P.T.165
C4	1483'	9148'	592	" " " "
C5	910'	9641'	354	Formation Test. Equilibrium pressure reached
C5	1082'	9269'	480	Formation Test. Falling R.P. Probably not true Equilibrium pressure
C5	1368'	9183'	538	Formation Test. Rising R.P. Extrapolated to equilibrium
C5	1700'	8851'	650	Formation Test. Rising R.P. Uncertain, due to stylus arm turning
C5	1720'	8831'	664	Formation Test. Rising R.P. Equilibrium pressure
C5	1753'	8798'	681	" " " " "
C5	1901'	8650'	718	" " " " "

2. Correlation of recorded pressures

(a) Possible gas/water equilibrium between 1582'-1632' sand group of well 1 and 1693'-1760' sand group of well 5

i. Reservoir pressure at 1632' in well 1 from C.I.P. of 615 p.s.i.g.

$$\text{Log}_{10} P_2 = \text{Log}_{10} P_1 + \frac{qsl}{144 \times 2.3026 \times AY}$$

where:-

P_2 = reservoir pressure at 1632' - p.s.i.a.
P_1 = closed-in pressure at top of column - 630 p.s.i.a.
q = density of air at atmospheric pressure and average temperature of gas column - 0.07565 lbs/cu.ft.
s = sp.gr. of gas c.f. air - 0.6
l = length of gas column - 1632'
A = atmospheric pressure - 14.7 p.s.i.
y = deviation factor for gas under average pressure and temperature of column - 0.899

$$\log P_2 = \log 630 + \frac{0.07565 \times 0.6 \times 1632}{144 \times 2.3026 \times 14.7 \times 0.899}$$

$\log P_2 = 2.7993 + 0.01697 = 2.8163$
Hence $P_2 = 655.1$ p.s.i.a. = 640 p.s.i.g.

Hence average weight of gas column

$$= \frac{640 - 615}{1632} = 0.0153 \text{ lbs/sq.in. per foot}$$

ii. Gas column pressure gradient at 655 p.s.i.a. and 70° F. from gas analysis

Component	Mole Fraction n	Molecular weight of component M	nM	Critical temperature of component Tc	nTc	Critical pressure of component Pc	nPc
N_2	0.117	28	3.28	227	26.6	492	57.5
C_1	0.852	16	13.63	344	293	673	573
C_2	0.030	30	0.90	550	16.5	709	21.3
C_3	0.001	44	0.04	666	0.7	618	0.6
-	1.000	-	17.85	-	336.8	-	652.4

Pseudo reduced temperature = $\frac{530}{336.8}$ = 1.58

Pseudo reduced pressure = $\frac{655}{652.4}$ = 1.003

Compressibility factor (from graph) = 0.920 (Z)

Average molecular weight = 17.85 (M)

Density = $\frac{1}{V} = \frac{PM}{ZRT} = \frac{655 \times 17.85}{0.920 \times 10.73 \times 530}$

Density = 2.23 lbs. per cu.ft.
Gas gradient = $\frac{2.23}{144}$ = 0.0155 p.s.i. per foot

iii. Indicated Gas/water level

Well 5 R.P. 681 p.s.i.g. at 1202' below M.S.L.

Well 1 R.P. 640 p.s.i.g. at 1067' below M.S.L.
Difference 41 p.s.i.g.for 135' column.

Suppose there is x feet of water
Then there is (135 - x) feet of gas

$0.436\,x + (135-x)\,0.0155 = 41$
$0.4205x = 38.91$
$x = 93'$

Hence C.W.L. = 8798' + 93' = 8891' U.G.C.
say 8890' contour

(b) Possible gas/water equilibrium between 1720' - 1806' sand group of well 1 & 1835' - 1890' sand group of well 5.

In well 5 measured pressure 718 p.s.i.g. at 1901'
Base of sand 1890'. Mud 1.14 = 0.493 p.s.i./ft.
Correction for 11' mud column = 5.4 p.s.i.
Hence R.P. 712.6 p.s.i.g. at 1890'

Well 5 R.P. 713 p.s.i.g. at 1339' below M.S.L.

Well 1 R.P. 687 p.s.i.g. at 1205' below M.S.L.
Difference 26 p.s.i.g.for 134' column.

$0.435\,x + (134- x)\,0.0167 = 26$
$0.4183\,x = 23.76$
$x = 57'$

Hence C.W.L. = 8661' + 57' = 8718' U.G.C.
Say 8720' contour

Appendix B

Cousland Gas Analysis

Air Free Gas % Volume

Well	Sand	Nitrogen	Acid gases	Methane	Ethane	Propane & heavier
C1	1188'-1209'	-	-	95.85	2.30	1.84
	1248'-1279'	-	-	90.75	3.10	6.15
	1582'-1632'	1.55	-	95.85	2.60	-
	1720'-1806'	4.05	-	94.60	0.75	0.60
	2094'-2122'	6.55	-	87.90	3.85	1.70
C4	964'- 975'	1.65	0.4	97.0	0.95	-
	1038'-1056'	5.52	0.1	91.4	2.38	0.6
	1234'-1272''	6.9	0.3	89.5	2.4	0.9
	1480'-1490'	6.2	-	91.9	1.1	0.8
	1480'-1490'	6.1	-	90.6	2.5	0.8
C5	1656'-1665'	6.0	-	89.9	2.85	1.20
	1712'-1720'	3.8	-	93.25	2.5	0.45
	1730'-1760'	11.75	-	85.15	2.95	0.15

APPENDIX C

I. Detailed correlation of Cousland Reservoir Waters

(1) Cousland wells 1, 2 & 5

(a) Water shows from sands correlating with 1248'-1279' sand in well 1.

When well 1 was bailed over 5 days, a few gallons of oil and mud were obtained. When the formation test of the corresponding sand in well 2 was carried out, saline water flowed at surface: the sample is considered to be true edge-water, the total solids content being 3436 per 10^5 parts. This compares with a solids content of 137 in well 1; so that this sample of water is considered to be returned drilling fluid.

The equivalent sand in well 5 is from 1350'-1376'. The production consisted of oil, edge-water, and returned drilling mud. The fact that the fluoresceine content was still 24 parts per million indicated considerable contamination with drilling mud. However, the total solids content of 1134 per 10^5 parts indicates that some reservoir water was produced. From these considerations, the oil/water level is put tentatively at the 9180' contour.

(b) Water shows from sands correlating with the 1582'-1632' sand in well 1

This is the top main gas sand in well 1, and no water production was obtained. The corresponding sand in well 2 is from 1900'-1908'. This sand was not tested, and no reservoir water sample has been obtained.

The equivalent horizon in well 5 consists of three thin sands which were tested individually. In the test of the 1693'-1700' sand, only 20' fluid was produced into the drill pipe. This had a total solids concentration of 565 parts per 10^5, and must have been considerably contaminated with drilling mud. In the test of the 1712'-1720' sand some 1400' fluid was obtained in the drill pipe, and the fluoresceine concentration decreased from 8 parts per million to nil. This is considered to be a true sample of edge-water. In the test of the third sand from 1730'-1760' edge-water was again obtained, practically free from drilling mud, having a total solids concentration of 1127 parts. These last two samples of reservoir water are nearly identical, and this is shown clearly by the analysis diagram.

(c) Water shows from sands correlating with the 1720'-1806' sand in well 1.

Reservoir water samples were obtained from this horizon in wells 1, 2 & 5. The sample from well 1 was collected from the flow line during gas production tests. The total solids, at 571 parts, are on the low side as compared with wells 2 & 5, suggesting that some drilling water was still being reproduced at the time.

During the test in well 2 of the 2016'-2136' sand, the fluid rose in the drill pipe nearly to surface. This suggests that a good sample of edge-water was obtained, having a total solids concentration of 964 parts.

During the test in well 5 of the 1874'-1890' sand, 550' fluid were obtained in the drill pipe, and the fluoresceine concentration decreased from 32 parts to 1 part. There was possibly a little contamination with drilling water, in view of the total solids concentration of 617 parts.

(d) Sundry water analyses from uncorrelated sands

(i) Sulphate type fresh water shows of well 1

These fresh water shows were obtained over the interval 270'-836'; and contain about 100 parts solids per 10^5, consisting chiefly of sulphates, with smaller quantities of Carbonates (and bicarbonates).

(ii) Chloride type waters of well 1

The one sample was collected from the 2180'-2210' sand, and the second sample from the 2371'-2404'. The first sample is considered to be mostly drilling mud; and the second sample is probably edge-water with some contamination.

(iii) Chloride type waters of well 5

The two uncorrelated water samples from well 5 are from the 885'-911' sand, and from the 1656'-1665' sand. Both are considered to be fair samples of edge-water. The 1656'-1665' sand gave gas production at about 4,000 cubic feet per day.

(iv) Chloride type waters of well 2

The sample collected from the 1770'-1780' sand is considered to be a fair sample of edge-water. This sand probably correlates with the 1432'-1465' sand of well 1, which was drilled by cable tools, but was not tested. The other sample from well 2 was collected from the 2280'-2410' sand, and probably consists of substantially uncontaminated edge-water. The sand correlates with the 2000'-2036' sand of well 1, which was tested with only negative results. It is not certain whether this was due to lack of production, or to a mechanical defect.

(2) Well 3 Reservoir Waters

(a) Water show from 1468'-1505' sand

This sample possibly consists of nearly uncontaminated edge-water. It is thought that this sand correlates with the 913'-991' sand in well 1, which produced on test a little muddy fluid and a trace of oil.

(b) Water show from 1723'-1750' sand

This sample is possibly appreciably contaminated with drilling mud. This sand may correlate with the 1188'-1209' sand of well 1, which produced gas at a rate of circa 20,000 cubic feet per day.

(c) Water show from the 1782'-1802' sand

This is probably a fair sample of edge-water, with a total solids concentration of 4028 parts per 10^5. The sand is thought to correlate with the 1248'-79' sand of well 1, from which probably no edge-water was obtained. It will be notedthat the analysis of the water sample from well 3 is similar to the analysis of the equivalent sand in well 2.

(d) Water show from the 2102'-2150' sand

This is probably largely uncontaminated edge-water, with a total solids of 6684 parts per 10^5. This sand has been correlated with the 1582'-1632' sand of well 1, which yielded only gas production. But the equivalent sand in well 5 gave a reservoir water with a total solids concentration of 1169 parts. Thus the edge-waters from the corresponding sands in wells 3 and 5 are of different types.

(3) Well 4 Reservoir Waters

(a) Water sample from 735'-760' sand

This sample consists of substantially uncontaminated edge-water. It is thought that this sand correlates with the 913'-991' sand of well 1, which produced a little muddy fluid, and trace of oil. It will be noted that the correspondence with the equivalent sand in well 3 from 1468'-1505' is poor, so that these two sands have probably distinct edge-waters.

(b) Water sample from 1234'-1293' sand

This sample is somewhat contaminated with drilling water. It is thought that this sand correlates with the 1582'-1632' sand of well 1, which gave only gas production. It will be noted that the reservoir water has similar characteristics to the equivalent sands in No. 5 well from 1693'-1760'. Again there is no correspondence with the edge-water from the related sand in well 3 from 2102'-2150'.

(c) Water samples from 1827'-1832' and 1972'-1990' sands.

These are two reasonably good samples of reservoir waters. As usual the edge-waters consist mainly of sodium chloride. The sands have not been correlated with any corresponding sands in other wells.

II. Cousland Reservoir Water Analyses

(1) Wells 1, 2 & 5

(a) Water Shows from sands correlating with 1248'-1279' sand in Well 1

Well	C1	C5	C2
Interval	1303'-1240'	1327'-1370'	1461'-1528'
Sand	1248'-1279'	1350'-1376'	1490'-1530'
S.G. @ 60°F.	1.001	1.0074	1.0245
Solids per 10^5	137	1134	3436
Gram Equivalent			
Sodium (& K)	1.69	17.57	43.83
Calcium	0.56	1.12	11.37
Magnesium	0.08	1.003	4.73
Chlorides	2.04	18.02	59.40
Sulphates	0.16	0.31	0.03
Carbonates	0.09	1.37	0.50
Ionic %			
Sodium (& K)	36.8	44.6	36.65
Calcium	12.1	2.8	9.50
Magnesium	1.6	2.6	3.95
Chlorides	44.1	45.7	49.57
Sulphates	3.4	0.8	0.01
Carbonates	2.0	3.5	0.42
Sunbury Ref.(or W.W.T)	AP.N/144	W.W.T.	N/180
Remarks	Sample obtained by bailing with casing set at 1240'.	Some 146' fluid in d.p. Mostly gas-cut mud produced. Fluoresceine decrsd. from 64 to 24 parts. A little oil also produced.	3 hours test. Saline water flowed at surface.

(b) Water shows from sands correlating with 1582'-1632' sand in Well 1.

Well	05	05	05
Interval	1686'-1702'	1706'-1722'	1724'-1755'
Sand	1693'-1700'	1712'-1720'	1730'-1760'
S.G. @ 60°F.	1.0041	1.0106	1.0077
Solids per 10^5	565	1169	1127
Gram Equivalents			
Sodium (& K)	8.83	17.39	16.94
Calcium	0.61	1.98	1.92
Magnesium	0.34	1.03	0.76
Chlorides	8.01	19.02	18.02
Sulphates	0.44	0.01	0.01
Carbonates	1.34	1.37	1.60
Ionic %			
Sodium (& K)	45.2	42.6	43.2
Calcium	3.1	4.9	4.9
Magnesium	1.7	2.5	1.9
Chlorides	40.9	46.6	45.9
Sulphates	2.2	trace	trace
Carbonates	6.9	3.4	4.1
Sunbury Ref. (or W.W.T.)	W.W.T.	W.W.T.	W.W.T.
Remarks:	Only 20' fluid produced. Fluoresceine decreased from 24 to 4 parts. A little gas produced.	Some 1400' fluid in d.p. No fluoresceine. Good sample of edge-water obtained. A little gas produced.	Some 1100' fluid in d.p. Fluoresceine decreased from 48 to 1 part. Edge-water obtained. A little gas produced.

(c) Water shows from sands correlating with 1720'-1806' sand in well 1

Well	Q1	Q2	Q5
Interval	-	2021'-2120'	1868'-1903'
Sand	1760'-1806'	2016'-2136'	1874'-1890'
S.G. @ 60°F.	1.0025	1.007	1.0051
Solids per 10^5	571	964	617
Gram Equivalents			
Sodium (& K)	8.14	14.02	9.75
Calcium	0.71	2.01	0.77
Magnesium	0.06	-	0.23
Chlorides	6.83	15.02	9.41
Sulphates	0.02	0.19	0.02
Carbonates	2.06	0.89	1.32
Ionic %			
Sodium (& K)	45.72	43.55	45.3
Calcium	3.96	6.23	3.6
Magnesium	0.32	-	1.1
Chlorides	38.38	46.66	43.8
Sulphates	0.09	0.59	0.1
Carbonates	11.53	2.76	6.1
Sunbury Ref.(or W.W.T.)	N/186	N/185	W.W.T.
Remarks:	Water sample collected from flow line during gas prodn. tests	Probably uncontaminated edge-water. Fluid rose in d.p.to 137' below R.T.	Some 550' fluid in d.p. Fluoresceine decreased from 32 to 1 part. A little gas produced.

(d) Sundry water analyses from uncorrelated shows

(1) Fresh water shows from No. 1 well of sulphate type

Interval	270'-325'	635'-650'	752'-780'	831'-836'
S.G. @ 60°F.	1.0004	1.0007	1.0005	1.0005
Solids per 10^5	67	111	87	91
Gram Equivalent				
Sodium (&K)	0.22	1.12	0.66	0.77
Calcium	0.75	0.43	0.54	0.51
Magnesium	-	-	-	-
Chlorides	0.07	0.41	0.13	0.18
Sulphates	0.75	0.58	0.69	0.73
Carbonates	0.15	0.56	0.38	0.37
Ionic %				
Sodium (& K)	11.1	36.0	27.3	30.0
Calcium	38.9	14.0	22.7	20.0
Magnesium	-	-	-	-
Chlorides	3.7	13.3	5.4	7.1
Sulphates	28.7	18.6	28.8	28.5
Carbonates	17.6	18.2	15.8	14.5
Sunbury Ref.	AP.N/142			

(2) Chloride type waters of well 1

Interval	2178' - 2227'	2371' - 2404'
Sand	2180' - 2210'	2371' - 2404'
S.G. @ 60°F.	1.003	1.023
Solids per 10^5	356	3350
Gram Equivalents		
Sodium (& K)	4.30	42.35
Calcium	1.10	12.30
Magnesium	0.46	3.52
Chlorides	4.78	57.16
Sulphates	0.48	0.02
Carbonates	0.60	0.99
Ionic %		
Sodium (& K)	36.7	36.4
Calcium	9.38	10.6
Magnesium	3.92	3.0
Chlorides	40.80	49.1
Sulphates	4.10	-
Carbonates	5.10	0.9
Sunbury Ref.(or W.W.T.)	A.PN/150	APN/155
Remarks:	Only 180' fluid in d.p. Sample considered to be mostly drilling mud.	Some 400' fluid entered d.p. Probably a fair sample of edge-water.

(3) Chloride type waters of well 5

Interval	887'-912'	1646'-1694'
Sand	885'-911'	1656'-1665'
S.G. @ 60°F.	1.004	1.020
Solids per 10^5	364	3002
Gram Equivalents		
Sodium (& K)	5.5	40.03
Calcium	0.48	8.78
Magnesium	0.29	3.66
Chlorides	5.69	52.06
Sulphates	0.01	0.03
Carbonates	0.64	0.43
Ionic %		
Sodium (& K)	43.9	38.1
Calcium	3.8	8.4
Magnesium	2.3	3.5
Chlorides	44.8	49.6
Sulphates	0.1	trace
Carbonates	5.1	0.4
Sunbury Ref.(or W.W.T.)	W.W.T.	W.W.T.
Remarks:	Some 312' of gas-cut fluid entered the d.p. Probably a fair sample of edge-water.	Some 350' fluid entered the d.p. Fluoresceine decreased from 32 to 2 parts. Probably nearly uncontaminated edge-water. Gas produced at 4000 ft^3/ day.

(4) Chloride type water of well 2

Interval	1726' - 1878'	2290'-2432'
Sand	1770' - 1780'	2280'-2410'
S.G. @ 60°F.	1.0335	1.0075
Solids per 10^5	4832	994
Gram Equivalents		
Sodium (& K)	47.34	13.26
Calcium	24.05	1.98
Magnesium	14.90	0.77
Chlorides	86.15	14.09
Sulphates	0.04	0.14
Carbonates	0.28	1.78
Ionic %		
Sodium (& K)	27.38	41.42
Calcium	13.90	6.18
Magnesium	8.62	2.41
Chlorides	49.82	44.00
Sulphates	0.02	0.43
Carbonates	0.16	5.56
Sunbury Ref.(or W.W.T.)	N/183	N/188
Remarks:	Saline water rose to 1117' below R.T. About 5000 ft^3/day gas produced.	Saline water rose to 142' below R.T. Probably substantially uncontaminated edge-water.

(2) Well 3 Reservoir Waters

Interval	1468'-1581'	1735'-1792'	1749'-1830'	2117-2164'
Sand	1468'-1505'	1723'-1750'	1782'-1802'	2102-2150'
S.G. @ 60°F.	1.0050	1.0035	1.0280	1.0480
Solids per 10^5	717	649	4028	6684
Gram Equivalents				
Sodium (& K)	9.66	8.39	46.40	70.30
Calcium	1.64	1.81	18.05	38.15
Magnesium	0.86	0.90	6.20	9.27
Chlorides	11.36	10.53	70.30	117.60
Sulphates	0.23	0.20	0.01	0.01
Carbonates	0.57	0.37	0.34	0.20
Ionic %				
Sodium (& K)	39.71	37.80	32.84	29.79
Calcium	6.73	8.12	12.78	16.24
Magnesium	3.56	4.08	4.38	3.94
Chlorides	46.70	47.43	49.75	49.90
Sulphates	0.93	0.92	0.01	0.01
Carbonates	2.37	1.65	0.24	0.09
Sunbury Ref.(or W.W.T.)	N/198	N/204	N/204	N/209
Remarks:	Saline water rose to 1202' below R.T. Possibly nearly uncontaminated edge-water.	Saline water rose to 1628' below R.T. Possibly fairly contaminated with drilling mud.	Saline water rose to 1024' below R.T. Probably a fair sample of edge-water.	Saline water ro to 1907' below R. Possibly largely uncontaminated edge-wat

(3) Well 4 Reservoir Waters

Interval	750'-760'	1238'-1291'	1797'-1842'	1943'-1995'
Sand	735'-760'	1234'-1293'	1827'-1832'	1972'-1990'
S.G. @ 60°F.	1.0033	1.0065	1.0126	1.0091
Solids per 10^5	384	897	1498	1206
Gram Equivalents				
Sodium (& K)	5.80	13.92	21.35	16.77
Calcium	0.44	1.16	3.40	3.11
Magnesium	0.54	0.48	1.30	1.17
Chlorides	5.60	14.21	25.03	20.02
Sulphates	-	0.14	0.03	-
Carbonates	1.18	1.22	0.99	1.05
Ionic %				
Sodium (& K)	42.8	44.7	41.0	39.8
Calcium	3.2	3.7	6.5	7.4
Magnesium	4.0	1.6	2.5	2.8
Chlorides	41.3	45.7	48.0	47.5
Sulphates	-	0.4	0.1	-
Carbonates	8.7	3.9	1.9	2.5
Sunbury Ref. (or W.W.T.)	W.W.T.	W.W.T.	W.W.T.	W.W.T.
Remarks:	Good sample of edge-water. Some 25 sump volumes prod. into d.p. Fluoresceine decreased from 32 to Nil parts. Gas produced.	Probably some contamination with drillg. mud. Some 2 sump volumes produced into d.p. Fluoresceine decreasd. from 16 to 3 parts. Gas produced.	Good sample of edge-water. Some 19 sump volumes prodcd. into d.p. Fluoresceine decreased from 6 to Nil parts. Gas prodcd.	Fairly good sampl of edge-water. Som 8 sump vol umes prod. into d.p. Fluorescei decreased from 16 to ½ part. Ga produced.