Reference P.T. 134 — 3rd October, 1945.

Kirkleatham No. 1 Well.

Rotary Table Elevation 76.

Formation tests carried out in Carboniferous Limestone on 19th & 20th Sept.

SUMMARY OF TESTS.

When the top of the Carboniferous Limestone was encountered at 3610' (6466' U.G.C.) the formation was cored to a depth of 3648' (6428' U.G.C.), so that the limestone could be tested independently of any other production horizon by setting the rubber in shale at 3600'. However, the shale was soft, and the rubber did not hold, so that a separate test of the limestone was not obtained.

As the limestone was solid and compact with the fissures filled with calcite, it did not look particularly promising from the production standpoint. Therefore, in the second test the rubber was set at 3429' (6647' U.G.C.) [after the well had been deepened to 3674' (6402' U.G.C.)] to include a number of higher sandstones in the interval tested; the objective being to re-test a smaller interval if any reasonable production had been obtained, in order to ascertain the horizon from which it was derived.

However, in a 1 hour 21 mins. test only two cubic feet of fluid approx. entered the drill pipe, equivalent to a production rate of 210 gallons per day, although the meter throughput was some 24 cubic feet, indicating the possible production of a very small quantity of gas; but this production rate was insufficient to justify further tests in an attempt to isolate the producing horizon.

PARTICULARS OF TESTS.

1. Horizons tested.

	Depth.	U.G.C.
Sandstone	3427'-3435'	6649'-6641'
Various sandstones	3453'-3467'	6623'-6609'
Limestone	3482'-3486'	6594'-6590'
Limestone	3529'-3545'	6547'-6531'
Thin sandstones	3547'-3561'	6529'-6515'
Carboniferous Limestone	3610'-3626'	6466'-6450'

2. Particulars of borehole.

When tested:- The depth of the well was	Depth	U.G.C.
(a) In Test 1	3648'	6428'
(b) In Test 2	3674'	6402'
consisting of 7¾" hole to	3138'	6938'
and 5⅜" hole to bottom.		

3. Details of test 1 on 19th September.

Diary:-

3.40 pm.	Wound up R.P.G. - 3 Amerada clock.
4.35 pm.	Running in drill pipe, Halliburton tester and straight wall packer.
5.38 pm.	"Set" packer rubber
6.02 pm.	Opened and shut tester valve. A.S. fluid level did not hold.
6.08 pm.	Opened and shut tester valve. A.S. fluid level did not hold.
6.12 pm.	Pulled packer free.

Packer String - This consisted of Amerada pony, a single and a perforated pony, total length 48'.

Reservoir Temp. The recorded B.H.T. was 94°F at a depth of 3647'

P.T.O.

4. Details of test 2 on 20th September.

Diary:-

10.20 am.	Wound up R.P.G.-3 Amerada clock.
11.20 am.	Running in drill pipe. Halliburton tester and straight wall packer.
12.44 pm.	Set packer rubber.
12.58 pm.	Opening tester valve, but joint backing off, so closed tester valve
1.02 pm.	Opened tester valve.
2.23 pm.	Closed tester valve.
2.26 pm.	Pulled packer free.

Packer string - This consisted of Amerada pony, (7'-6") seven singles (215'-3"), two plain ponies (12'-0"), one perforated pony (6'-0"), below rubber (3'-10"). Total 244'-7". Hence rubber was set at 3429', in the top sandstone tested.

Production rates. - (a) From gas meter Initial - 3ft^3 in 5 mins. or 860 cubic feet per day.
Final-1ft.^{3} in 8 mins. or 180 cu.ft.per day
(b) From rise in D.P. Rise = 47' in 5½" D.P. or 12 gallons in 81 mins:

Hence production rate = 210 gallons per day (34 cubic feet per day)

Capacity of Sump. - The capacity of the sump was approx. 138 gallons, so that a volume equivalent to about 9% of the volume of the sump was produced into the drill pipe.

Fluid Samples.

Sample.	% water separation by settling.	sp. gr. of filtrate @ 60°F.	Fluorescein conc: parts per million.
(a) from above tester valve	5	1.1793	4
(b) from 47' above tester valve	5	1.1776	4
(c) Circulating mud	3	1.1813	6

Reservoir Temp: - The recorded B.H.T. was 99°F at a depth of 3673'.

AMERADA CHARTS The charts for both tests are attached hereto

CMA/JS.

C.M. Adcock

Reference P.T. - 132 A

31st January, 1946.

KIRKLEATHAM NO.1 WELL

Rotary Table Elevation 76.

ADDENDUM TO P. T. -132

The following is a brief summary of two tests carried out in the Carboniferous and not covered by the report P.T. - 132

Test 1 on 11th September 1945 of interval 3170' - 3365'.

The tester held up at about 3' off bottom, and when the tester valve was opened the rubber did not hold, the test therefore being unsuccessful.

Test 2 on 12th September 1945 of interval 3176' - 3377'

The tester valve was opened for 68 minutes, and during this period the meter throughput was 1.4 cubic feet, so that the interval tested was essentially not productive.

Amerada Charts.

The R. P. G. - 3 Amerada was run and the charts for both tests are attached herewith.

C. M. Adcock

1st February, 1946.

EAKRING
CMA/FJB

Ref. P.T. 132

Kirkleatham No. 1 Well

Tests between 2954' and 3121'

30.8.45 - 3. 9.45

Rotary Table Elevation
76'

Formation Tested. The formation tested is a brown Dolomite which changes from Dolomite and Anhydrite at about 3016' and becomes less porous downwards. There is a change to limestone about 3116'.

Summary of Tests. Three tests in all were carried out. The first test on the 30th August, was made when depth was 3116' with the top of the 5⅜" pilot hole at 3031'. Difficulty was experienced in setting the rat hole packer in the top of the pilot hole, probably due to mud ringing in the 7¾" hole, and the holes in the tester plugged when the trip valve was opened. However, the rapid fall in pressure below the packer when it was set proved that there was a substantial show. The measured reservoir pressure at 3040' is 1418 lbs/in. and the temperature 96°F.

The second test, on the 1st September, was made after the pilot hole had been reamed to bottom to 7¾" diam. The Johnson packer was used and the rubber set at 2978'. The valve was open for 40 minutes and some 135 cubic feet of fluid entered the drill pipe. The test was not wholly sucessful as the samples of fluid collected from above the tester valve. contained a substantial proportion of drilling fluid. It was therefore decided to repeat the test and allow the valve to be open for as long as considered safe.

The third test was carried out on the 3rd of September when the well had been deepened five feet to 3121'. The packer rubber was set at 2954'. The tester valve (Johnson) was open for 2 hours and 8 minutes and 2443 feet of fluid entered the drill pipe (191 cubic feet). The amount of air displaced at the surface was about 190 cubic feet. The initial rate of production was about 43,000 gallons per day against a back pressure of 190 lbs/sq. in. The formation fluid is evidently saline water but even the sample above the tester valve was heavily contaminated by drilling fluid. The fluid in the drill pipe contained gas in solution which burned with a yellow flame. Samples were obtained and the analysis shows that the gas is about 35% nitrogen and the remainder methane with about 2% of Ethane and heavier.

The reservoir pressure at 3119 feet was 1460 lbs/sq. in.

Test No. 1 Rat hole packer was used on Johnson tester. 7¾" hole to 3031', bottom of 5⅜" hole to 3116'. Position of thermometer and Amerada gauge 3040'. Date 30th August, 1945.

3 p.m.	wound up clock
5-10	set packer
5-42½	opened trip valve
5-47½	meter recorded production of 1 cu. ft.
6-55	meter recorded ¼ cu. ft. less than at 5-47½ p.m. (pulled packer free).

It was evident from the record of the Amerada gauge that there was a large show in the pilot hole and that the holes in the tester or anchor had plugged.
A very good record of the reservoir pressure was obtained, this gave a pressure of 1418 lbs/sq. in. at 3040', at a temperature of 96°F.

Test No. 2

Since the last test the pilot hole was reamed to bottom (3116').

The Johnson tester was used and a straight wall packer set at 2978'. Pressure recorder at 3114'. Date 1st September, 1945.

11.40 a.m.	wound clock	
1.10 p.m.	set packer	
1.22 p.m.	dropped go-devil	
1.24	2 cu. ft. produced	
1.25½	4 " "	
1.26½	6 " "	
1.28¼	10 " "	
1.32½	20 " "	
1.39½	40 " "	(pressure Ca. 7 lbs/sq. in.)
1.42	50 " "	-do-
1.45	60 " "	-do-
1.59	100 " "	(pressure Ca. 6 lbs/sq. in.)
2.00	Clased retaining valve.	

The drill pipe was found to contain 1740' or 136 cu. ft. of fluid. At the top the fluid had much the same fluorsceine content as the circulating fluid, decreasing to about half the fluorsceine content lower down, but increasing to the full fluorsceine content above the tester valve. From the behaviour of the fluid it appeared that there was some interchange of fluid when pulling out, although the retaining valve was found to be tight when the packer was pulled. It was therefore decided to repeat the test and leave the packer set for the maximum period considered safe. The bit had to be run in to condition the hole and 6 feet were drilled to 3121'.

Test No. 3 Johnson tester used with rubber set at 2954' in 7¾" hole. Bottom at 3121'. Pressure recorder at 3119'. Date 3rd September, 1945.

5.8 p.m.	wound up clock		
7.30	set packer		
7.40	dropped go-devil		
7-45	Meter had passed 8 cu. ft.	pressure	2½ lbs/sq. in.
7-50	-do- 20		3
8.00	54		3¾
8.10	89		4½
8.20	117		3½
8.30	140		23
8.40	156		1.5
8.50	166		1.0
9.00	174		0.5
9.10	179		-
9.20	183		-
1-30	187		
9-40	189		
9.48	pulled packer free.		

On pulling out 2443 feet or 191 cu. ft. of fluid were found in the drill pipe, which corresponds very well with the amount recorded by the meter at surface. After pulling about 1800' of drill pipe gas was observed bubbling in the fluid and a sample was collected for analysis. The analysis is given below. It is unlikely that there is a gas show in the formation tested as the fluid produced corresponds so closely in volume with the volume of air expelled from the drill pipe. The gas is probably dissolved in the formation water.

The fluid produced was heavily contaminated with drilling fluid as the fluorsceine content of the ~~test~~ least contaminated sample indicated that it contained some 50% drilling water. The gravities of the various samples were:-

Circulating fluid	1.1861
Middle of column	1.1758
Above tester valve	1.1623

It is therefore evident that the formation water is not saturated brine though probably of rather high gravity. As this show will be tested when the well is completed full information regarding the formation fluid will be available later.

Rate of production The initial rate of production against a back pressure of some 190 lbs/sq. in is estimated at 43,000 gallons per day from the slope of the Amerada gauge curve. The average rate throughout the test was 14,000 gallons per day.

Gas Analysis The following is an analysis of the gas produced:-

	%
CO_2	0. 45
N_2	35. 15
C_1	62. 4
C_2 and heavier	2. 0

Reservoir Temperature In the first test a reservoir pressure of 96°F at 3040'. In the third test the temperature at 3119' was 85°F. The latter figure is suspect and the higher figure has been used when calculating pressures.

Reservoir Pressurss In both the first and third tests good records of the reservoir pressure were obtained. These are calculated to be as follows:-

1st. test pressure at 3040' on 30.8.45 1418 lbs/sq. in.

3rd test " " 3118' on 3. 9. 45 1460 lbs/sq. in.

Taking the gravity of the reservoir fluid as 1.16 the difference between these two measurements is only 3 lbs/sq. in.

R.K. Dickens

1st October, 1945.
EAKRING
RKD/FJB

Reference P.T. - 130

27th September, 1945.

Kirkleatham No. 1 Well

Rotary Table Elevation 76.

Formation tests carried out in Magnesian Limestone from 1st-25th August.

SUMMARY OF TESTS

Altogether in the period 1st-25th August six tests were carried out in the Magnesian Limestone with the following results:-

Test No.	Date	Interval Tested	Limestone interval exposed.	Type of packer	Length of test	Max. prdn. rate g.p.h	Remarks
1	1st	2405-2495'	2405-2479'	Johnston & wall packer	1hr.16mins.	--	Meter throughput 0.37 cu.ft Hence the limestone interval tested was too tight to be productive.
2	10th	2551-2665'	2551-2665'	Johnston & rat hole packer	1hr.9mins.	60g.p.h.	Only drilling mud was produced into the drill pipe, the production rate tailing off to some 40g.p.h. at the end of the test. The test was not continued for a long enough time to determine the nature of the probable brine production, since such a low production rate was not of economic interest.
3	22nd	2820-2965'	2820-2880'	Johnston & rat hole packer	---	---	Two attempts to test were carried out, but both were unsuccessful due to there having been a hole in a length of drill pipe.
4	23rd	2820-2965'	2820-2880'	Johnston & rat hole packer	---	---	Test unsuccessful due to go-devil sticking in a length of drill pipe.
5	23rd.	2820-2965'	2820-2880'	Johnston & rat hole packer	4 hrs.	see remarks	Gas was produced during the test, & it was apparent that the formation was being continuously de-mudded during the whole period, as production rates increased from the initial rate of about 5,000cu.ft. per day to the final rate of about 73,000 cu.ft. per day against a back pressure of approx. 350lbs. Some reservoir fluid may have been produced as the equivalent of about 2.4 times the vol. of the sump was produced into the drill pipe. However no potash was detected in the samples & fluoresceine results also gave no definite indication of reservoir fluid prdn.

P.T.O.

Test No.	Date	Interval Tested	Limestone interval exposed	Type of packer.	Length of test	Max. prdn. rate.c.f.p.h.	Remarks.
6	25th	2885-2965'	---	Johnston & rat hole packer	1hr.	---	The test was carried out to confirm that the gas production obtained in the previous test was being derived from the limestone, & therefore the hole was reamed out past the limestone interval, so that the exposed horizon now consisted of anhydrite only. In a 1 hr. test no production was obtained, thus proving that the gas was derived from the limestone.

P. M. Adcock

DETAILED REPORT.

In all tests the Johnston tester was used, and in all tests except the first a rat hole packer was run, so that in these cases the rubber was set in the top of the 5⅜" pilot hole, the anchor string consisting simply of Amerada pony and a perforated pony. In the first test the normal practice for wall packers was adhered to of running the Amerada pony and plain drill pipe at the bottom of the tester string, the perforated pony being placed immediately belo the rubber.

Diaries of Tests.

Test 1 1st August (2405-2495') - (Top of pilot hole 2402')

2.30 pm.	Wound up R.P.G. - 3 Amerada clock.
5.00 pm.	Set packer rubber - Johnston tester and wall packer
5.29 pm.	Dropped go-devil opening tester valve.
6.45 pm.	Closed tester valve and pulled packer free. Meter throughput 0.37 cubic feet.

Test 2 10th August (2551-2665')

12.30 pm.	Wound up R.P.G. - 3 Amerada clock.
2.52 pm.	Set packer rubber - Johnston tester and rat hole rubber
3.14 pm.	Dropped go-devil opening tester valve
4.23 pm.	Closed tester valve and pulled packer free. Meter throughput 9 cubic feet.

Test 3 22nd August (2820-2965')

10.00 pm.	1st. attempt. Wound up R.P.G. - 3 Amerada clock.
12.00 am.	2nd attempt. Ran in again, but found hole in drill pipe on pulling out.

Test 4 23rd August (2820-2965')

8.40 am.	Wound up R.P.G.-3 Amerada clock.
12.45pm	Set packer rubber - Johnston tester and rat hole rubber.
12.53 pm.	Dropped go-devil (which was afterwards found stuck in a length of drill pipe.)
2.10 pm.	Pulled packer free - No production.

Test 5 23rd August (2820-2965')

5.00 pm.	Wound up R.P.G. - 3 Amerada clock.
5.10 pm.	Running in drill pipe - looking for go-devil
6.23 pm.	Found go-devil. Set packer rubber - Johnston tester and rat hole rubber.
6.32 pm.	Dropped go-devil opening tester valve
6.52 pm.	Total meter throughput 55 cubic feet. Gauge pressure 4½ p.s.i.
53 7.22 pm.	Total meter throughput 263 cu. ft. Gauge pressure 11¾ p.s.i.
7.25 pm.	Gas production being obtained. Closed in valve at top of drill stem.
7.55 pm.	Closed in pressure 46 p.s.i. gauge
8.25 pm.	" " " 91 p.s.i. "
8.55 pm.	" " " 141 p.s.i. "
9.25 pm.	" " " 199 p.s.i. "
9.30 pm.	" " " 209 p.s.i. " Blowing down gas pressure.
9.45 pm.	Completed blowing do n gas pressure.
9.50 pm.	Filling gas burettes and inchester quart bottles with gas.
10.14½ pm.	Closed in well C.I.P. 25 p.s.i. gauge
10.17½ pm.	C.I.P. - 35 p.s.i. gauge
10.19 pm.	C.I.P. - 45 p.s.i. gauge
10.33 pm.	Shut tester valve.
11.03 pm.	Pulled packer free.

P.T.O.

Test 6 25th August (2855-2965 ')

4.30 pm. Wound up R.P.G. - 3 Amerada clock.
5.35 pm. Running in packer string - Johnston tester and rat hole rubber.
6.45 pm. Set packer rubber.
7.57 pm. Dropped go-devil opening tester valve.
8.57 pm. Closed tester valve and pulled packer free, no production obtained.

Particulars of borehole

15" casing cemented at 88'
8⅝" " " " 1186'
10⅝" hole to 1840'

Thereafter the size of the open hole was 7⅞", and the size of the pilot hole 5⅞".

Production rates and details of fluid production.

Test 2 - Production Rates

10th Aug. I. From Gas Meter

(a) Initial - ½ cubic foot in 3 mins: or 1500 g.p.d.
(b) Final - ½ " " " 5 " or 900 g.p.d.
(c) Overall - 9 " " " 69 " or 1170 g.p.d.

II. From fluid rise in D.P.

Rise was 110' in 4½" D.P. or 54 gallons (8.6 cubic feet)
Hence production rate 1130 g.p.d.

Capacity of sump.

The volume of the sump was approx: 110 gallons, and hence the equivalent of half the volume of the sump was produced into the drill pipe.

Test 5 - Production Rates. (Volume of drill pipe = 220 cubic feet)

23rd Aug. (a) from 6.32 pm - 6.52 pm. Meter throughput 55 cu.ft. Gauge pressure 4½ p.s.i. Hence make = 123 cu.ft. & production rate = 4,500 cu.ft. per d
(b) from 6.52 pm.-7.22 pm. Meter throughput 208 cu. ft. Rise in pressure 7½ p.s.i. Hence make = 318 cubic feet, and production rate = 15,000 cubic feet per day.

Production during blow down?

(c) from 7.25 pm. - 8.25 pm. Pressure rise = 79 p.s.i. or 5.4 atmospheres. Hence make = 1100 cubic feet approx: and production rate = 26,000 cubic feet per day.

(d) from 8.25 pm. - 9.30 pm. Pressure rise = 118 p.s.i. or 8 atmospheres. Hence make = 1600 cubic feet approx: and production rate = 35,000 cubic feet pe day.

(e) from 10.14½ pm - 10.19 pm. Pressure rise = 20 p.s.i. or 1.36 atmospheres. Volume of fluid in D.P. = 690' hence effective volume of D.P. = 167 cubic feet. Hence make = 227 cubic feet and production rate = 73,000 cubic feet per day.
Back pressure on formation = 350 p.s.i. approx:

Capacity of Sump

The volume of the sump was aprox: 140 gallons and as approx: 336 gallons (690') of fluid entered the drill pipe, the equivalent of 2.4 times the volume of the sump was produced into the drill pipe.

Fluid Samples.

Date	Test	Sample	% water separation by settling.	Sp. gr. of Filtrate at 60°F.	Fluoresceine Concentration Parts/million.
10th Aug.	2	Circulating mud	40%	1.2214	12
"	"	70' above tester valve	50%	1.2210	12
"	"	above tester valve	50%	1.2210	12
23rd Aug.	5	Circulating mud	20%	1.1955	3
		690' above tester valve	5%	1.1834	2
		330' " " "	5%	1.1839	2
		above tester valve	5%	1.1822	2

Particulars of circulating mud.

	1st. Aug	10th Aug	23rd Aug.	24th Aug.
Density	1.27	1.27	1.26	1.28
Density filtrate	1.20	1.19	1.19	1.17
Viscosity	15	14½	15	15
Permeability	320	364	320	345
Fluoresceine	6	-	3	24
pH.	-	-	5	8

Analysis of gas samples obtained in Test 5.

The following is the result of an analysis carried out be the A.I.O.C. Research Station, Sunbury-on-Thames, of the gas sample collected during test 5.

Constituent	Vol.%
CO_2	0.1
O_2	0.23
N_2	4.17
C_1	83.6
C_2	9.5
C_3	1.3
C_4	1.1

27th September, 1945.

CMA/JS.

C.M. Alcock

How about reservoir pressure ??

Reference P.T. - 127 — 19th August, 1945.

Kirkleatham No. 1 Well

Rotary Table elevation 76

Formation tests carried out in Bunter Sandstone from 4th July - 9th July.

(including echo-meter results obtained at the conclusion of the pumping tests).

SUMMARY OF TESTS

	Depth	U.G.C.
The Bunter sandstone covered the interval	1148' - 1978'	8928'-8098'

Altogether six tests were carried out with the following results:-

Maximum productivity

Test No.	Date	Interval	Type of Packer	Galls per hour	Back pressure p.s.i.	Remarks
1	4th	1173' - 1400'	Johnston rat hole packer	6300	332	The large sump gave only a rough indication of the quality of the water production, so that the next test was carried out with a much smaller sump.
2	6th	1625'-1660'	Johnston rat hole packer	3900	150 app.	Approx.11 times Vol.of sump was produced in drill pipe, so that the quality of the Bunter water could be established.
3	7th	1814'-1873'	Johnston rat hole packer	-	-	On opening the tester valve the rubber failed to hold. However, prior to this a falling reservoir pressure was obtained. This was also the first occassion in which fluoresceine was used as an indicator of reservoir fluid
4	8th	1841'-1873'	Johnston rat hole packer	—	—	Tester valve plugged and no production was obtained.
5	9th	1841'-1890'	Johnston rat hole packer	—	—	In this and the foregoing tests a rat hole packer had been used. In the present test the size of the packer had been increased to 9", but the hole had become enlarged and the rubber did not hold.
6	9th	1843'-1890'	Halliburton wall packer	300	600 app.	A satisfactory test was obtained using a 9"straight wall packer. The tester valve leaked on the way in, but in spite of this the fluorsceine indicator showed that a fairly representative sample of Bunter watr was obtained. *

The following reservoir pressure and temperature results were obtained:-

Test No.	Depth	Temp °F	Measured Pressure psi	* Pressure corrected to top of Bunter @ 148'	Remarks
1	1188'	-	494.9	477	This was a falling pressure before opening the tester valve and the equilibrium value had not been reached.
1	1188'	-	484.7	467	This was a rising pressure at the end of the production test. The equilibrium pressure is circa 470 p.s.i.
2	1640'	74.8°F	675.4	458	This was a rising pressure at the end of the production test which had not reached equilibrium
3	1829	75.2	777.4	476	This was a falling pressure which appeared to have reached equilibrium, but this is a little uncertain owing to the chart carriage having stopped.
6	1889	75.3	795	467	This was a rising pressure at the end of the production test which had very nearly reached it equilibrium value.

Free water level

Assuming an equilibrium reservoir pressure of 470 p.s.i. the calculated free water level would be 85' below the rotary table. After the pumping test on the well, the free water level was measured by float to be 93' below the R.T., and by the echo-meter this was determined to be 87' below the R.T. corresponding to reservoir pressures of 466 p.s.i. and 469 p.s.i. respectively.

Productivity

There was no perceptible decline in the reservoir pressures measured before and after the pumping test, when a total of 1160 cubic metres or 255,000 gallons water was produced. The echo-meter showed that the water level was approx. 204 from surface, exerting a back pressure of 417 p.s.i. on the top of the Bunter sst, whilst the well was pumping at a rate of 25 cubic metres per hour or 5500 gallons per hour. Basing on a reservoir pressure of 469 p.s.i. the bottom hole differential pressure is thus seen to be 52 p.s.i., equivalent to a productivity index of 106 gallons per hour per 1 lb. B.H.D.P. Assuming a linear B.H.D.P. production curve, the maximum pumped down capacity of the well could be of the order of 50,000 gallons per hour. However, allowing for some reservoir pressure decline, and for a non-linear B.H.D.P. production curve, it appears probable that the well should have a sustained pumpdown production capacity of about half a million gallons water per day, with the possibility of this being as much as one million g.p.d.

Particulars of the formation tests, water analysis, salinites, fluorsceine test, and echo-meter results are given in the detailed report.

C.M. Adcock

* The average specific gravity of the Bunter water has been taken to be 1.0197 @ 60°F, making the pressure per 1 foot column 0.442 p.s.i., and this figure has been used to correct measured reservoir pressures to the top of the Bunter sandstone.

Detailed Report

In all tests except the sixth a rat hole packer was run and Johnston tester, so that the annhor string consisted simply of Amerada pony (the R.P.G.-2 Amerada being run) and a perforated pony having six ½" holes. Thus the length of the anchor string was always 15'. For the sixth test a wall packer and Halliburton tester was used, the rubber being set at 1840'; and the 47' of anchor string was made up according to the standard practice of having one perforated pony immediately below the rubber, the rest of the string consisting of plain drill pipe with the Amerada pony joint on bottom.

Diaries of Tests.

Test 1 4th July (1173'-1400')

4.00 p.m.	Wound up R.P.G.-2 Amerada clock.
6.07 p.m.	Set packer rubber - Johnston tester.
6.17 p.m.	Dropped go-devil opening tester valve.
7.00 p.m.	Closed tester valve and pulled packer free.

Test 2 6th July (1625'-1660')

12.20 p.m.	Wound up R.P.G.-2. Amerada clock.
1.32 p.m.	Set packer rubber - Johnston tester.
1.40 p.m.	Dropped go-devil opening tester valve.
2.23 p.m.	Closed tester valve and pulled packer free.

Test 3 7th July (1814'-1873')

6.15 p.m.	Wound up R.P.G.-2 Amerada clock.
7.00 p.m.	"Set" packer rubber - Johnston tester.
7.30 p.m.	Dropped go-devil, but rubber did not hold.
8.00 p.m.	Pulled packer free.

Test 4 8th July (1841'-1873')

3.45 p.m.	Wound up R.P.G. -2 Amerada clock.
5.15 p.m.	"Set" packer rubber, which went down to 1848' Johnston tester.
5.23 p.m.	Dropped go-devil, and drill pipe dropped 3'.
6.00 p.m.	No production obtained. Pulled packer free.

Test 5 9th July (1841'-1890')

10.00 a.m.	Wound up R.P.G.-2 Amerada clock.
11.33 a.m.	"Set" packer rubber - Johnston tester.
11.52 a.m.	Dropped go-devil, but rubber did not hold.
12.15 p.m.	Pulled packer free.

Test 6 9th July (1843'-1890')

2.20 p.m.	Wound up R.P.G.-2. Amerada clock.
4.20 p.m.	Set packer rubber - Halliburton tester.
4.37 p.m.	Opened tester valve. N.B. Tester valve had been leaking on way in.
7.48 p.m.	Closed tester valve.
7.50 p.m.	Pulled packer free.

Particulars of borehole

Surface casing (15") had been cemented at 88'. As rat hole packers were run for the first five tests the hole was alwa reamed out 10⅝" to the top of the interval to be tested, the si of the pilot hole being 7¼". For tests 4 and 5 the seating toc had been run to 1841', and hence in test 6 the rubber was set 2' inside the pilot hole. It is also seen that the size of th pilot hole had become enlarged, for it was found possible to s

P.T.O.

a 9½" rubber in a supposedly 7¾" hole!

Production rates and details of fluid production

Test 1 Initial production rate

4th July (a) Meter throughput = 20 cubic feet in 3 minutes.
(b) Pressure gauge reading = 5 lbs = .34 atmospheres. Now vol: drill pipe = 92 cubic feet. Hence 0.34 atm: are equivalent to 30 ft³ production.
(c) Hence prodn: in 3 mins: = 50 cubic feet or 6300 g.p.h. approx:

Total fluid production

Meter throughput = 76 cubic feet.
Fluid volume in drill pipe 965' above T.V. or 210' from R.T.
Volume = 470 gallons or 75 cubic feet.

Capacity of sump

Volume of sump = approx: 74 cubic feet, and hence only the equivalent of the volume of the sump was produced into the drill pipe.

Test 2. Initial production rate

6th July (a) Meter throughput = 22 cubic feet in 5 mins:
(b) Pressure gauge reading = 3½ lbs = 0.24 atmospheres. Now vol: drill pipe = 127 cubic feet. Hence 0.24 atm: are equivalent to 30 ft³ production.
(c) Hence prodn: in 5 mins: = 52 cubic feet or 3900 g.p.h. approx:

Total fluid production

Meter throughput = 114 cubic feet.
Fluid volume in drill pipe 1450' above T.V. or 170' from R.T.
Volume = 700 gallons or 113 cubic feet.

Capacity of Sump

Volume of sump = approx: 10 cubic feet; and hence about 11 times the volume of the sump was produced into the drill pipe.

Test 6 Initial production rate

9th July The tester valve leaked whilst running in the drill pipe, and hence the initial production rate of 300 gallons per hour was obtained against a back pressure of about 600 p.s.i.

Total fluid production

The meter throughput was 36 cubic feet equivalent to 460' fluid in the drill pipe. But the actual vol: of fluid in the drill pipe was 1560' above T.V. or 270' from surface. Hence 1100' of mud fluid had entered the drill pipe equivalent to 540 gallons or 86 cubic feet.

Capacity of sump

The capacity is unknown due to the enlargement of the hole. Suppose the capacity is approx: 20 ft³ then nearly twice the volume of the sump was produced into

the drill pipe.

Fluid Samples

Date	Test	Sample	% water separation by settling.	Sp: gr: of filtrate @ 60°F	Salinity- parts/ 100,000 Cl. D'Arcy	I.C.I	Fluorescien concentration parts/ million.
4th July	1	Circulating mud	25%	1.0117	70	62	
		Top of drill stem (935')	35%	1.0099	70	71	-
		Middle of drill stem (480')	40%	1.0105	88	74	-
		Above tester valve	65%	1.0127	250	174	-
6th July	2	Circulating mud	20%	1.0140	80	36	-
		1450' above TV	60%	1.0172	220	334	-
		1150' " "	-	-	-	934	-
		850' " "	-	-	-	1128	-
		550' " "	100%	1.0208	1170	1158	-
		250' " "	-	-	-	1172	-
		50' " "	98%	1.0210	1268	1183	-
9th July	6	Circulating mud	5%	1.0082	80	27	8 to 16
		1560' above TV	5%	1.0104	104	29	8 to 16
		1140' " "	-	-	-	32	8 to 16
		780' " "	-	-	-	31	8 to 16
		420' " "	-	-	-	167	4 to 8
		240' " "	-	-	-	661	4
		120' " "	-	-	-	1080	2 to 4
		60' " "	80%	1.0227	1300	1244	2
		Above tester valve	60%	1.0230	1320	1300	1 to 2

P.T.O.

Analyses of water samples carried out by W.W. Taylor B.Sc: F.R.I.C. Public Analyst, Nottingham.

Reference Number	TJ	TK	TL	TM	TN
Date Collected	6th July	6th July	9th July	9th July	17th July
How collected	Drill stem fluid from 550' above tester valve	circulating mud	Drill stem fluid from 60' above tester valve	Circulating mud	Water sample collected at end of pumping test
Interval of open hole	1625'-1660'	-	1841'-1890'	-	1186'-2050'*
pH Value	7.7	8.1	8.1	above 9.6	8.3
sp: gr: @ 15.5 oc	1.0207	1.0149	1.0228	1.0084	1.0
Total solids (parts/100,000)	2821.4	1609.8	3040.3	781.4	2628.5
Parts per 100,000					
CO_3	5.4	9.6	12.0"	147.6	4.5
SO_4	509.8	1043.3	556.2"	393.4	411.5
CL	1260.2	49.7	1349.0"	30.5	1242.5
Ca	96.4	52.1	59.3	-	97.2
Mg	6.8	27.9	22.7	-	24.0
Na	940.8	425.2	1034.3	205.4	846.5
K	2.0	2.0	6.8	4.5	2.3

* It is known that TN is an uncontaminated sample of Bunter sandstone water, and comparing this with samples Nos. TJ and TL, the suggestion is that the salinity of the water in the Bunter sandstone increases somewhat with the depth from which it is produced. This is also supported by the fact that after the pumping test the hole was found to be quite solidly bridged at 1208', suggesting that the water production was being derived in large measure from the upper part of the Bunter sandstone.

Particulars of circulating mud

	4th July	6th July	7th July	8th July	9th July
Density	1.26	1.3	1.17	1.19	1.11
Viscosity	15	17.5	15	16	15
Permeability	192	152	64	49.5	39
pH	8.5	8.5	10.5	-	-

Echo-meter results

Prior to the air lift water production tests :-

8⅝" casing had been cemented at 1186'
6⅝" casing had been run to 324'
2" tubing was run inside the 6⅝" casing to 298'.

Compressed air at a pressure of 58 lbs was admitted to the tubing (volume about 300 cubic feet per min: ?) and the water was produced through the annulus between the 2" tubing and the 6⅝" casing. Equilibrium conditions were reached when the water level was 204' from the rotary table, the steady water production rate then being 25 cubic metres per hour or 5500 gallons per hour. The echo-meter was used to determine the following results :-

(1) Determination of free-water level - checked by float

(2) Determination of pumped down water level when air lift was operating at maximum capacity.
(3) Determination of rate of rise of water level after shutting off air lift.

The following diary shows the sequence of operations :-

17th July	8.25 p.m.	Free water level by float 93' below R.T.
	9.30 p.m.	Determining free water level by echo-meter
	9.47 p.m.	Commenced water production by air lift, taking echo-meter results continuously.
	10.42 p.m.	Shut off air lift, and took echo-results for use in water level.
	11.18 p.m. approx:	Re-commenced water production by air lift.
18th July	9.30 a.m.	Taking echo-meter results to determine pumped down water level.
	10.15 a.m.	Shut off air lift, and took echo-meter result, for rise in water level.
	11.44 a.m.	Completed echo-meter tests.

In calculating fluid levels the velocity of sound in air saturated with water vapour has been taken to be 1150 feet per second, the speed of travel of the recording paper being 8 cms. per second. The following tables summarise the results obtained :-

1. Free water level

Average distance between reflections for 5 water level reflections 1.20 cms. Hence water level 87' below R.T.

2. Pumping down water levels. (17th July)

Time	Mins:	No. of reflections	Av: dist: between reflections cms.	Water level below R.T.	Remarks
9.47 p.m.	-	-	-	-	Started air lift.
9.53 p.m.	6	4	2.53	182'	
9.59p.m.	12	4	2.77	199'	
10.09 p.m.	22	3	2.79	200'	
10.19 p.m.	32	5	2.83	204'	
10.37 p.m.	50	4	2.83	204'	

3. Water level rise. (17th July)

Time	Mins:	No. of reflections	Av: dist: between reflections cms.	Water level below R.T.	Remarks
10.42 p.m.	-	-	-	-	Shut down air lift.
10.45 p.m.	3	7	2.53	182'	
10.46 p.m.	4	8	1.94	139'	
10.47 p.m.	5	6	1.68	121'	
10.50 p.m.	8	7	1.47	106'	
11.00 p.m.	-	-	-	-	Started up air lift.

4. Water level rise (18th July)

P.T.O.

Time	Mins:	No. of reflections	Av: dist: between reflections cms.	Water level below R.T.	Remarks
10.06 a.m.	-	6	2.80	202'	Air lift still in operation.
10.15 a.m.	-	-	-	-	Shut down air lift.
10.15½ a.m.	½	6	2.7	194'	
10.17 a.m.	2	5	2.1	151'	
10.18 a.m.	3	6	1.9	136'	
10.19 a.m.	4	5	1.75	126'	
10.21 a.m.	6	6	1.6	115'	
10.29 a.m.	14	6	1.45	104'	
10.59 a.m.	44	5	1.3	94'	
11.44 a.m.	89	5	1.3	90'	Complete echo-meter tests.

Graph No. 1.

The pumping down water levels (Section 2) and the water level rise recorded on 18th July (Section 4) have been plotted on the graph attached herewith.

22nd August, 1945
CMA/IBR

C. M. Alcock

Amerada Charts

The amerada-charts for all three tests are attached herewith.

GRAPH Nº 1

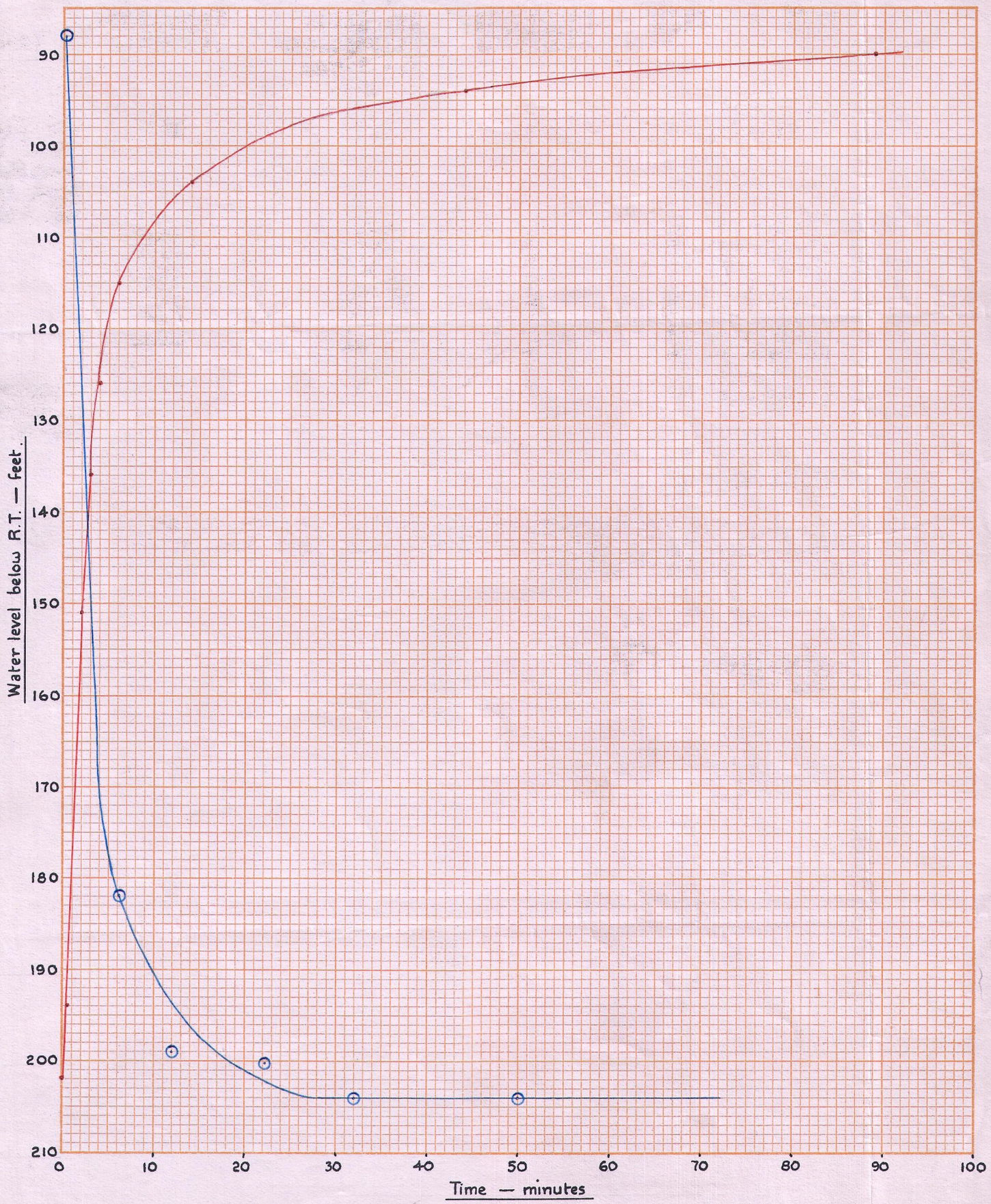
—— 18th July – Water level rise after shutting down air lift

—— 17th July – Pumping down water levels after starting up Air lift. Pumped down production rate 25 cubic metres water per hour.

KIRKLEATHAM Nº 1

BOREHOLE

Graph showing echo-meter results obtained at the end of the pumping test on the Bunter Sandstone.



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From Senior Petroleum Engineer U.K., Eakring. **To** Chief Petroleum Engineer, BP House.

Our Ref. EXP/1/PE2485 **Your Ref.** **Date** 24th July, 1963.

Subject Kirkleatham Gas Prospects

The attached report on the Kirkleatham Gas Prospects has been prepared in view of the I.C.I. interest in the discovery of a significant deposit of natural gas in the Wilton Area, which could be exploited concurrently with the drilling of Main Salt delimitation wells.

Kirkleatham well 1 may be convertible into an immediate commercial gas well, following a production stimulation workover. This well has not been abandoned, and the casing is full with brine to surface.

The workover would be inexpensive, particularly if, in the event of failure, the drilling outfit costs were to be debited to the ultimate abandonment of the well, which would have to be undertaken to fulfill our statutory obligations.

An open flow potential, in excess of one million S.C.F. per day, could reasonably be expected as a result of commissioning well K1 as a gas well.

C.M. Adcock

c.c. Manager, Eakring.
Exploration Records, BP House.
Senior Geologist, Eakring.
Mr. Archer.

CMA/BW

22nd July, 1963.

Kirkleatham natural gas prospects

Present significance

This review of the Kirkleatham natural gas prospects is based on the following considerations:-

1. The recent report by F.R.E. Malden on "The economics of producing Natural Gas from the four fields of Calow, Cousland, Trumfleet and Ironville", dated 27th June 1963. This report demonstrates the profitability of natural gas production in the U.K.

2. The drilling of the I.C.I. Kirkleatham No.3 borehole, in which a gas show was obtained in the Main Anhydrite above the Permian Upper Magnesian Limestone.

3. The ability to convert uneconomic gas wells to profitable production by the application of production stimulation techniques.

4. An evident desire on the part of I.C.I. to undertake further exploration work for natural gas in the Kirkleatham area. However, since this structure occurs within the Home Oil Farm Out Area, it is presumed that the I.C.I. would wish to have a participation agreement with the interested parties.

Kirkleatham No.3 borehole

Well K.3 was drilled for the I.C.I. by the Boldon Engineering Company to a depth of 690' with a Failing rig; and was deepened by BP Exploration Company to the final depth of 2217' with a Cardwell outfit.

The borehole was drilled to determine the thickness of the Main Salt bed above the Permian Upper Magnesian Limestone. The well was located in the Wilton Works area, about ½ mile north west of well K.1. (See attached location map).

The top of the Main Anhydrite, assuming that it has been correctly identified, was penetrated over 100 feet higher structurally in well K3 as compared with well K1.

The show of gas in well K3 was between 2215' 6" and 2217'. Since a casing string had not been run to the top of the Main Anhydrite, the well could not have been controlled in the event of a "blow-out", so that it was not safe to evaluate the gas show in a drill stem test.

The gas show may have been produced through fractures extending into the Upper Magnesian Limestone reservoir. However, the attached Kirkleatham correlation diagram shows that this reservoir was most unpromising in wells K1 and K2, due to the absence of porosity and fissures. Nevertheless, well K3 may have been located in an area where the upper limestone is fractured, so that natural gas might have been producible in commercial quantities.

Additional Exploration Work

The I.C.I. propose to drill another well near K3 for cavity storage in the Main Salt. It is their intention to request BP to undertake a formation test in the Main Anhydrite to ensure the exclusion of natural gas from the salt beds.

Since a number of wells are scheduled to be drilled to the Main Salt in the Kirkleatham Area, the search for natural gas could be combined with the delimitation of the Main Salt. Hence, costs would be shared, and the attractiveness of the gas exploration programme would be enhanced.

A new well for such a combined project would be a location ½ mile to the north west of K3, there being apparently some evidence that a minor culmination occurs to the North in association with a fault crossing the northern part of the Wilton Works.

Should there prove to be a significant deposit of natural gas within the Wilton Area the I.C.I. might wish to deepen a number of the Main Salt boreholes into the Magnesian Limestone.

Since prolific water shows were obtained with gas in solution when the basal Permian beds were tested in wells K1 and K2, the most favourably sited of the new wells should be drilled into the Carboniferous, in view of the possibility of obtaining substantial gas reserves at higher structural elevations in these reservoirs.

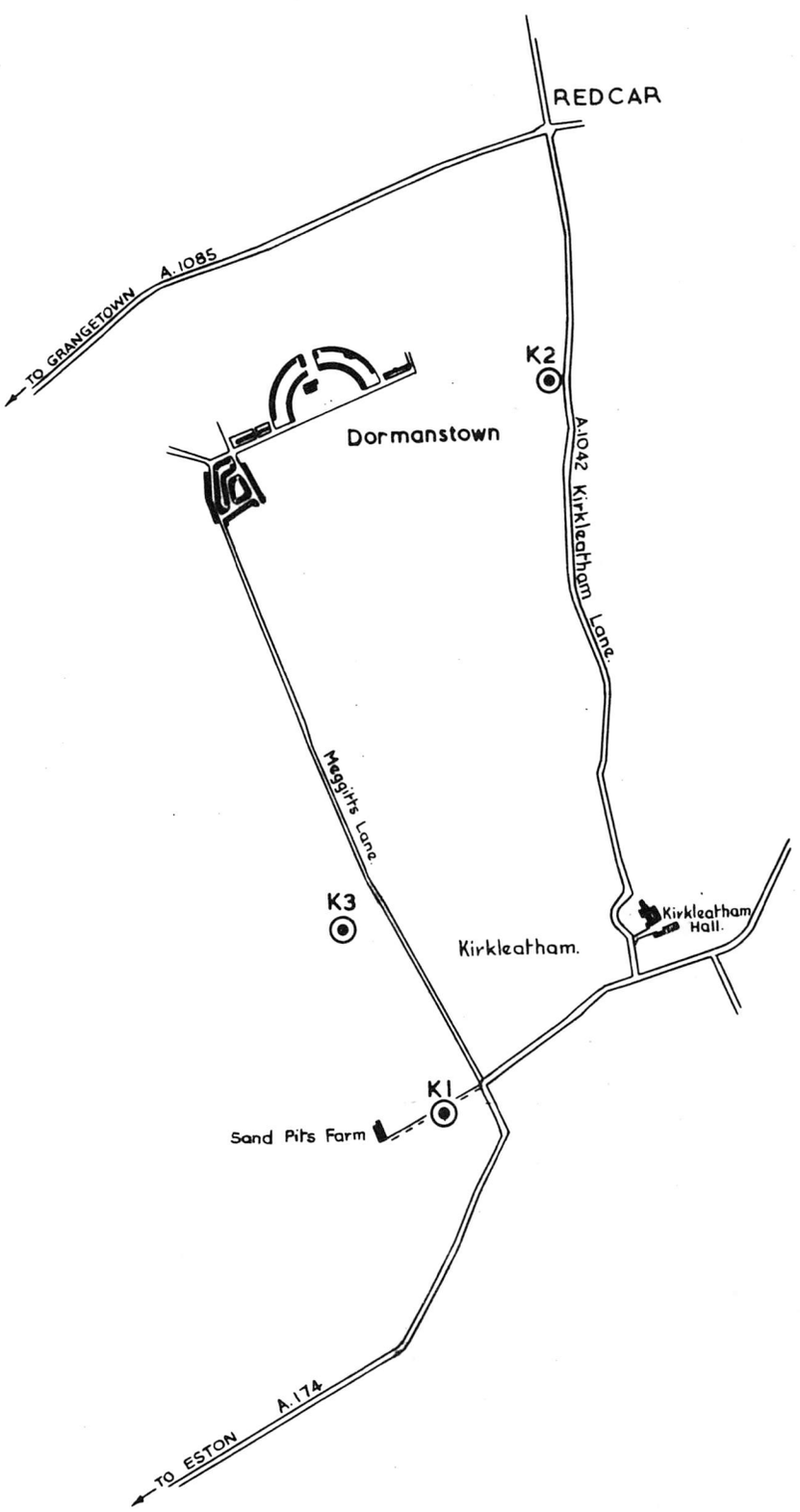
The gas horizons in wells K1 and K2 have been protected by casing strings. There is no case for opening up well K2 in view of the very minor gas shows obtained in the Upper Limestone, and the doubt as to whether the production could be stimulated sufficiently to be of commercial value. The bottom gas show of 20,000 S.C.F. per day, from a fissure at 2760', is too near the bottom water show to warrant a production stimulation workover.

Conversion of K1 to a gas well

The cost of converting K1 to a gas well would be small. The work could be undertaken with a Cardwell outfit and a Jack-knife derrick. Well K1 is shut-in with brine to surface. During October 1945 the I.C.I. undertook a brine productivity test of the dolomite from 3016' - 3125', the open hole having been plugged back to 3120', and a string of 6¼" casing having been cemented at 3000'. A deep well pump was run to 1819', and brine was pumped at a rate of 18,000 gallons per day. This brine show would have to be cemented off before perforating the casing for gas production.

The main gas show in K1 was obtained from dolomite over the interval 2820' - 2880'. Natural gas was produced during a formation test at a rate of 5,000 S.C.F. per day increasing to 73,000 S.C.F. per day against an average back pressure of 350 p.s.i. After a production stimulation workover, the open flow potential should be at least one million S.C.F. per day.

Since 2.4 sump volumes of fluid were produced into the drill pipe during the formation test which established the gas production rate of 73,000 S.C.F. per day, there is the possibility that some reservoir fluid may have been produced. However, the examination of the drill pipe fluid samples failed to detect the production of formation water. Mud losses to the limestone commenced at a depth of circa 2802'. It is proposed that the casing be perforated over the interval 2800' - 2830', with the lowest perforation 50' above the base of the limestone at 2880'. The production stimulation procedure would be to carry out a water frac to create a fissure, and to follow this up by acidisation to enlarge the production channel. This was the technique employed successfully at Eskdale.

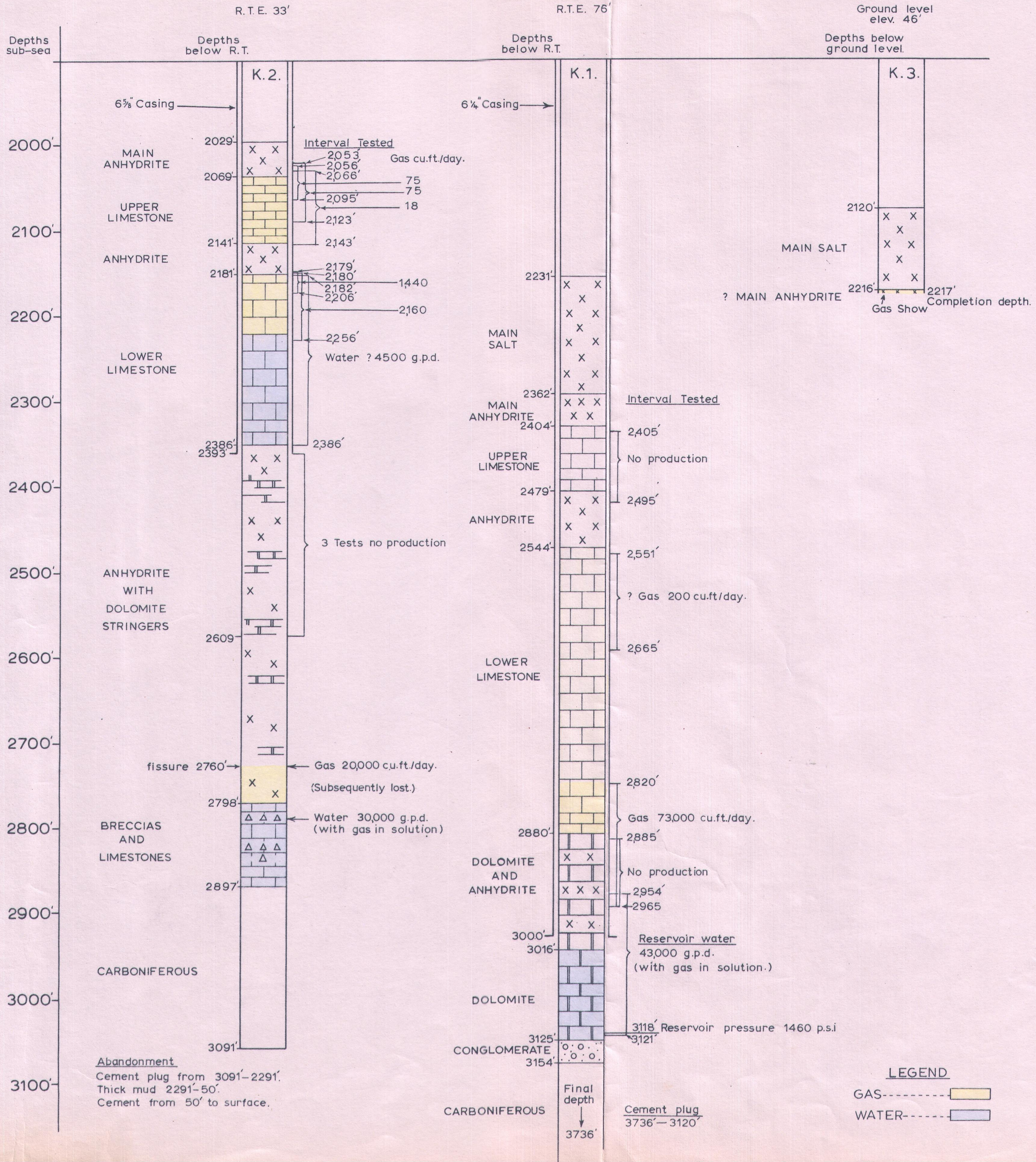


LOCATION OF KIRKLEATHAM BOREHOLES

SCALE 2½" to 1 MILE

ORDNANCE SURVEY SHEET 45/52

KIRKLEATHAM CORRELATION DIAGRAM



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Mr. Brumstrom

RSB
Dr Hewitt
File

NORTH EASTERN GAS BOARD

Head Office Bridge Street Leeds 2.

RSE/ABS

17th October, 1961.

C.M. Adcock, Esq.,
BP Exploration Company Ltd.,
Eakring,
P.O. Box No.1,
Southwell,
Notts.

Dear Mr. Adcock,

You may remember that the last time we met you suggested it might be helpful if I read through Falcon's Memoir on the "Geological Results of Petroleum Exploration in Britain 1945 - 1957". I have done so and found it exceedingly interesting.

The Memoir contained a reference to two drillings called Kirkleatham Nos. 1 and 2, near Middlesbrough, (one apparently drilled on behalf of the I.C.I. and the other presumably for yourselves) and stated "Gas was found in quantities somewhat below commercial level". Referring to the Eskdale wells from which we are now drawing, the words were "Gas in potentially commercial quantities".

As of course you know, our angle on potentially usable quantities varies from the "oil man's" and I would be very pleased if you could tell me what information is available with regard to the Kirkleatham drillings in the way of possible gas yields. It would appear they go down to the limestones from which we are drawing at Eskdale. They apparently come within the concession which was formerly I.C.I. and is now yours and which is excluded from the Gas Council agreement.

I have had a word with my colleague, Mr. Crowther of the Northern Board, within whose territory the wells are situated and, dependent of course upon what information you can give us, he may be interested in their exploitation, and jointly we might be interested in further consideration of the region lying between Eskdale and Kirkleatham.

Yours sincerely,

R.S. Edwards

PE1784 26th October, 1961.

Dr. R.S. Edwards,
North Eastern Gas Board,
Bridge Street,
Leeds 2.

Dear Dr. Edwards,

Kirkleatham Gas Prospects

Thank you for your letter dated 17th October with regard to the Kirkleatham Nos. 1 and 2 boreholes. It is confirmed that the gas shows as found in the Permian Magnesian Limestone in both wells were below the commercial level.

Nevertheless, it may be possible to raise the productivity of an uneconomic gas show to a commercial level by the application of production stimulation methods. Casing has been cemented into the main Magnesian Limestone in both boreholes, so that the wells could be re-located and cleaned out, without having to be re-drilled, if the sites are still available.

In well 1, the best gas show occurred in the Permian Lower Magnesian Limestone, in a tested interval from 2820' - 2965'. The gas production attained a rate of 73,000 cubic feet per day against a back pressure of 350 p.s.i., with no firm evidence of reservoir water production. During the four hours test the gas production rate increased from a minimum of 4,500 cubic feet per day, so that it was concluded that the gas show was being continuously "de-mudded" during the whole of the test. This evidence suggests that a substantial increase in productivity may be obtainable, if the fissure which appears to be partially plugged, can be cleaned out. In consequence, the gas show could be of potential commercial value.

The 6½" casing string would have to be perforated since it has been cemented below the gas show. This would be followed by a hydraulic fracturing operation to establish connection with the natural fissure system, and by acidisation to clean out the flow channels. The true open flow potential of the well should then become manifest.

You will remember that we carried out a similar workover programme at Eskdale, except that no casing perforation was necessary, the wells having been open hole completions. A fourfold increase in productivity was obtained at Eskdale. A greater improvement is required at Kirkleatham well 1 to obtain an exploitable supply of natural gas. In view of the plugging evidence, such a substantial response to production stimulation could be expected.

In well 2, there were small gas shows in the magnesian limestone over the interval 2179' - 2386'. The sum of the initial production rates over three tested intervals was 4,600 cubic feet per day, which had declined to a total of 1,500 cubic feet per day at the end of the tests. These results show that the reservoir connection was not extensive enough to maintain the gas production rates during the formation tests. At least a hundredfold increase in productivity would be required to obtain exploitable gas production. The chances of attaining this degree of success are slim, and the workover expenditure could hardly be justified.

There is a second gas production horizon in well 2, the lost circulation zone at 2760'. The tested production rate was a maximum of 20,000 cubic feet per day. Unfortunately the production was lost completely when the horizon was re-tested, indicating that the fissure had been plugged. Reservoir water was produced when the depth of the well was 2820', and the lost circulation zone cannot have been far away from the gas/water level. Any attempt to bring the 2760' zone back on production might result mostly in the production of reservoir water.

It is evident that well 1 is the better prospect for commercial gas production. Well 1 is located approximately 1½ miles due south of well 2 and ½ mile south-west of Kirkleatham village. Well 2 is sited on the Redcar anticline. The Lower Magnesian Limestone occurs about 300 feet higher structurally in well 2 as compared with well 1.

There is no information as to the size or type of gas reservoir found by the drilling of well 1. No forecasts of gas reserves are possible. If it is assumed that the reservoir characteristics are similar to Eskdale, then the volume of producible gas, with a 200 feet gas column, might be approximately one million cubic feet per acre.

Yours sincerely,

C.M. Adcock

cc. Mr. M.H. Lowson
Britannic House
CMA/BR

27th October, 1961.

NOTE FOR RECORD

(Not sent to Dr. Edwards)

KIRKLEATHAM NATURAL GAS PROSPECTS

1. Well status at abandonment

	Well 1	Well 2
Rotary Table elevation	76'	33'
Casing. 11¾" cemented at	88'	131'
Casing. 8⅝" cemented at	1186'	-
Casing. 6¼" well 1, 6⅝" well 2, cemented at	3000'	2393'
Completion depth	3736'	3091'
Abandonment data		
Cement plug	3736' - 3120'	3091' - 2291'
Thick mud		2291' - 50'
Cement plug		50' - surface

2. Summary of stratigraphy from Permian Magnesian Limestone

	Well 1	Well 2
Upper Magnesian Limestone	2404' - 2479'	2069' - 2141'
Anhydrite series	2479' - 2544'	2141' - 2181'
Lower Magnesian Limestone	2544' - 3125'	2181' - 2396'
Permian Conglomerate (anhydrite, breccia and lmst. in well 2)	3125' - 3154'	2396' - 2897'
Carboniferous to final depth	3154' - 3736'	2897' - 3091'
Main gas shows		
Lower Mag. Limestone - tested intervals	2820' - 2965'	2179' - 2386'
Anhydrite & dolomite - lost circulation zone	-	2760'
Main reservoir water shows		
Lower Mag. Limestone - tested interval	3031' - 3121'	-
Anhydrite, breccia and lmst. - tested interval	-	2787' - 2820'

3. Gas Analyses

	Formation Test Intervals		
	Well 1		Well 2
	2820' - 2965'	2954' - 3121'(a)	2414' - 2760'
Composition (Mol %)			
Carbon Dioxide	0.1	0.45	Nil
Nitrogen	3.35	35.15	9.75
Methane	84.55	62.4	82.3
Ethane	9.6	2.0 (and heavier)	5.3
Propane	1.3	-	1.6
Butanes	1.1	-	0.6
Pentanes (and heavier)	-	-	0.45
	100.0	100.0	100.0

(a) gas sample separated from reservoir water production.

4. Reservoir Pressure and Reservoir Temperature data

Well 1			Well 2		
Depth below R.T.	Pressure p.s.i.g.	Temp. F.	Depth below R.T.	Pressure p.s.i.g.	Temp. F.
3040'	1418	96			
3118'	1460	85 ?	2819'	1212 *	96

* Not a particularly reliable pressure.

5. Gas production rates

Well 1 - Interval 2820' - 2965' - Production rate increased from 4,500 to 73,000 cubic feet gas per day, against a back pressure of 350 p.s.i., during a 4 hours test.

Well 2 - Interval 2179' - 2386' - Sum of production rates over three tested intervals. Initial 4,600, Final 1,500 cubic feet per day.

Lost circulation zone 2760' - An initial rate of 20,000 cubic feet per day in the first test was lost in subsequent tests.

6. Possible gas reserves over 1,000 acres with a 200 feet gas column in the main Permian Magnesian Limestone at well 1.

1. Reservoir Area unit	1,000 acres
2. Gas column in reservoir unit	200 feet
3. Average gas column ($\frac{2}{3}$rd of total)	130 feet
4. Porosity of limestone assumed	2%
5. Pore volume gas filled for 130 feet gas column (See pore size distribution graph attached to the report on the Eskdale Gas Prospects dated 29th May 1958)	20%
6. Reservoir Pressure at a datum of 2800' sub-sea (See reservoir pressure graph attached to Cleveland Hills report by D. Comins dated 27th Feb. 1956. The Kirkleatham pressures have been plotted on this graph, and the pressure at 2800' sub-sea has been obtained from the graph)	1320 p.s.i.g.
7. Reservoir Temperature at 2800' sub-sea	96°F
8. Abandonment Pressure	200 p.s.i.g.
9. Compressibility Factor z - at reservoir pressure	0.86
at abandonment pressure	0.97

10. Gas Volume Factor Bg — cubic feet per cubic foot of reservoir space

Bgi - Initial	99
Bga - At abandonment	14
Producible	85

11. Unit Recovery by volumetric expansion - 14,800 cubic feet per acre - foot.

12. Total Recovery by volumetric expansion - 1,900 million cubic feet. (Per 1,000 acres & 130 feet average gas column)

13. Actual recovery at circa 50% of volumetric expansion say 1000 million cu.ft (Pre-supposing a partial water drive and bypassing of gas reserves)

Gas Volume Factor $Bg = 35.35\ P/ZT$

where P = Reservoir Pressure - p.s.i.a.

Z = Compressibility Factor

T = Reservoir Temperature - °Rankine

Unit Recovery = $43{,}560 \times \Theta \times (1 - Sw) \times (Bgi - Bga)$ S.C.F. per acre - foot.

where Θ = porosity %

Sw = water saturation %

Bgi = Initial Gas Volume Factor

Bga = Final Gas Volume Factor

C.M. Adcock

CMA/BR

TELEPHONE
CENTRAL 7422.

BRITANNIC HOUSE,
FINSBURY CIRCUS,
LONDON, E.C. 2.

17th April, 1946.

Dear Strong,

In connection with the Kirkleatham problem, I had occasion to refer to the graphic log of Kirkleatham No.1 and have found a number of points not recorded on it which should have been.

The five-day pumping test of the Bunter, when the well was at 2050' depth, is not recorded, nor the fact that the free-water level was determined at 89' from the surface, and there is no record of the water gravity; also, two tests at 3429 and 3674 feet are not recorded. The column of oil, gas, water, and coal seams is completely blank, with the exception of the thin coals in the Millstone Grit. The occurrence of gas is mentioned in the "Remarks" column, but it should also be in the "Special Oil and Gas" column. The oily limestone at the base of the Permian is mentioned under "Details of Formation", but were there not also some oil traces in the Carboniferous?

The well logs are the most convenient way of studying such a problem and they should be kept as full and as accurate as possible. Will you please keep an eye on this in future?

Yours sincerely,

C. A. Lees

M. W. Strong, Esq.,
EAKRING.

Beaster. 5 day pumping test. P. T. — 127

19th Aug: 1945

F.W.L. - 93' below R.T. by float
87' " " by echo meter.

255,000 g water pumped. No decline in reservoir pressure.
pumping rate 5500 g.p.h. at a depth of 204' below R.T.
water Sp. gr: 1.023

P. R. for July

No mention made of pumping tests being I.I.S.

Test of interval 3429 - 3674

Top of Liner 3610

P. T. — 134

3rd Oct: 1945

Test 1 - 3600 - 3648
unsuccessful due to rubber not holding

Test 2 3429 - 3674
In 1 hr. 21 mins. possibly a very small gas show encountered.

Progress Report Sept: 1945

13.5'
68

FORM No. I.C.I./1625/x/1
K67314

IMPERIAL CHEMICAL INDUSTRIES LIMITED

88, High Street,
Norton, Stockton-on-Tees,
Co. Durham.

Tel.No. Stockton 53056

Ref: HSH/HMJ

26th September, 1945

Mr. A.H. Taitt,
D'Arcy Exploration Co. Ltd.,
P.O. Box 1, Eakring,
Southwell, Notts.

Dear Mr. Taitt,

During a talk with Mr. Bremner yesterday regarding our proposed tests of the fluid from the porous strata in Kirkleatham Borehole No.1, he mentioned that you had at Eakring a number of small pumps which were easily fitted to the well head and which were capable of delivering up to 12,000 gallons a day. He suggested that if we could borrow one of these pumping sets with the necessary suction tubing from D'Arcy, it would be far the simplest way of running a continuous production test for say two to three weeks so that we could be absolutely sure as to the quality and also get some idea of the quantity of this fluid. At the moment we have very little idea of what the standing level of the fluid in the hole will be but it appears as if it may well be some 400/500 ft. from surface. In this case we have available no air lift equipment which would enable us to install an air lift.

P.T.O.

When you leave the Kirkleatham hole you will no doubt be removing the transformer and all the electrical equipment so that after your gear is dismantled we shall have no supply of electric power there. I understand, however, that you have these pumping outfits equipped with a small diesel engine and if you could loan us one of these complete units it would save the time and expense necessary for us to arrange with Nesco for the provision of a power supply. We should, of course, pay all transport charges on this gear and any reasonable hire charge which you care to fix.

I hesitate to ask for the loan of further equipment from you in view of all you have done for us, but I hope you will be able to see your way to assist us in this matter as it will much simplify our work on this problem.

Yours sincerely,

H.S. Hirst

...1.

Postal Address: P.O.Box,1
Southwell,
Notts.

Dr. H.S.Hirst,
Imperial Chemical Industries Limited,
88, High Street,
Norton,
Stockton-on-Tees,
Co. Durham.

28th September, 1945.

Dear Hirst,

Thank you for your letter of 26th September. With regard to the loan of a deep well pump for the test of brine in Kirkleatham No.1, Mr. Dickie is looking into the question of a suitable pump for this test and we will arrange to send up to Kirkleatham a complete pumping unit with timbers for a base and we will arrange for the immediate despatch of tubing and pumping rods so that they can be run into the borehole before we dismantle our drilling equipment.

As far as power for the pumping unit is concerned, we have no immediate work for the transformer at present installed at Kirkleatham and we could arrange to hire this to Imperial Chemical Industries Limited for the period of the pumping test. This would be a more satisfactory arrangement, I think, than our supplying a diesel engine.

With regard to the completion of Kirkleatham No.1 borehole and our handing it over to you I have now had a letter from the Ministry of Fuel and Power stating that they agreed to our programme but that they wished to have a copy of a letter from you stating that Messrs. Imperial Chemical Industries Ltd. will, after the hanning over of the borehole, accept responsibility for that borehole and for any effluent from it. Would you therefore let us have this assurance so that we can comply with this request.

Yours sincerely,

AHT/JE

P.T.O.

P.S. I have looked into the question of the supply of electricity for the pumping test and I find that we have a monthly agreement with the NES.Co. with the proviso that they are given seven days notice prior to the end of the month in which we wish to terminate the agreement. Thus, since we are unable to comply with this clause as far as this month is concerned we will be responsible to the NES.Co. anyhow until the end of October. I imagine that the duration of the pumping test will be of the order of one month and we can, towards the end of October, give notice to NES.Co. of our wish to terminate the agreement.

Dickie has looked into the question of the pumping unit and on his reckoning we can let you have a unit that is capable of pumping at the rate of 12,000 gallons per day from a depth of 1,800' and this is the estimated capacity of Kirkleatham No.1. For this capacity a 10 H.P. motor would be required but to be on the safe side we are sending a 15 H.P. motor.

ANGLO-IRANIAN OIL COMPANY LIMITED

RESEARCH STATION

SUNBURY-ON-THAMES

MEMORANDUM No.595/45

File Ref: 1/6/1945

Job No: 1558/02.

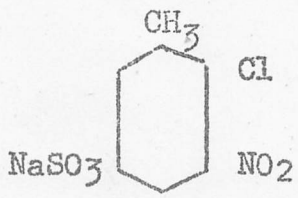
DETECTION OF POTASSIUM.

A request from Dr. G.M. Lees of 16/5/45, accompanied by Abadan (Geological) Memo No.40008 8/3/45 and Geological Laboratory Memo GL/I-8/439, solicits advice on the use of the spot test reagent

6-chloro-5-nitrotoluene-3-sulphonic acid (Sodium Salt)

for the detection of potassium.

The compound has the constitutional formula:-



and is designated:

(a) 6-chloro-5-nitrotoluene-3-sulphonic acid (Sodium Salt) by B.D.H.

(b) Sodium 2-chloro-3-nitrotoluene-5-sulphonate by Hopkins & Williams.

5g. of the reagent was obtained from Messrs. Hopkins & Williams, and the reagent tested on potassium solutions of the following concentrations:

1/1000, 1/2000, 1/2500, 1/3000, 1/4000, 1/5000.

By chilling the mixed solutions to 5°C. for one hour it was found that potassium could be readily detected down to a concentration of 1/5000.

It was confirmed that calcium does not interfere with the test, but that barium and ammonium do interfere.

The Geological Laboratory Memo. suggests the use of B.D.H. Spot Test Outfits, but with the potassium reagent only. As only simple apparatus, readily available in the ordinary laboratory, is necessary for carrying out the test for potassium alone, there would appear to be no point in supplying the complete Spot Test Outfit unless tests for other metals are required.

If this is the case, each outfit costs approximately £3. 10. 0d., plus an additional 50g. of the potassium reagent at £2. 10. 0d., bringing the total cost of seven such outfits to about £42.

In their publication "Organic Reagents for Metals", Messrs. Hopkinsand Williams recommend the use of 0.5g. of the reagent per test, which will require 1050g. of reagent at 1/- per g. (£52. 10. 0d.) for 2,100 tests suggested.

It is suggested, however, that if qualitative tests only are required the scale of test can be reduced to one fifth when seven 50g. bottles would provide enough reagent for 3,500 tests at a total cost of £17. 10. 0d.

The purchase of such a large quantity of the reagent at one time is unlikely to effect a marked reduction in the price.

Unless known to be available to the people concerned, seven copies each of the B.D.H., and the Hopkins & Williams descriptions of the use of the potassium reagent, should also be forwarded. Alternatively, if considered to be justified, seven copies of each of the books -

"The B.D.H. Book of Organic Reagents".
"Organic Reagents for Metals" (Hopkins & Williams)

at approximately 3/6d. per copy could be sent.

B.W.Samuel.

B.W. Samuel.

Pages 1-2.
BWS/KMG.

Files: Analytical Methods.
Geological
Miscellaneous.

Experiment with Rock Salt sample.

Measurements of sample before immersion.

Diameter 4½ inches.

Height 3½ "

State of mud.

Visc. 41. S.C.I.20 Filtrate 15. Thickness of cake. 2mm.

Perm. 3%. pH. 9.5. = Mud Viscous.

Temperature of Mud 72° at outflow.

Immersion for 10 minutes Measurements. diameter 4 3/16"

" height 3 7/16"

" " 20 " " same.

Immersion for 30 " " diameter 4 1/16"

" height 3 5/16"

Total reduction on length 3/16" in 1 hour, in flowing mud.