COUSLAND GEOLOGICAL COMPLETION REPORT

by

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CONTENTS

APPENDICES

FIGURES

NLF/VIM

1. WELL DATA.

Cousland No.1.

Lat. 55° 54' 3.5" N.

Long.2° 59' 41" W.

Drilling commenced 5.9.37

" suspended 12.9.38

Final Depth 2917'

Drilled rotary 0-1303'

" cable tool 1303-1586'

" rotary 1586-2917'

Elevation of Rotary Table 565' (basis of measurements)

11¾" casing cemented to surface at 268' 4".

When at 2917' the bit stuck in the bottom of the hole. The drill pipe was backed off to 2086' and a 5' wooden plug was placed on the fish, followed by cement to 2060'.

8¾" casing cemented to surface at 2057' 2½".

The 8¾" casing was perforated subsequently by Schlumberger gun as follows, using ½" bullets:-

Between 1760' and 1806' by 186 bullets.

(The hole was then filled with cement to 1740').

Between 1720' and 1735' by 61 bullets.

" 1582' and 1630' by 164 " .

A Schlumberger electrical survey was made at 2716'.

Cousland No.2.

Lat. 55° 54' 0.5 N.

Long. 3° 0' 24.45" W.

Drilling commenced 8.11.38

" suspended 3.5.39

Final depth 2432'.

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Cousland No.2. (contd).

Drilled cable tool 0-615'

" rotary 615-2432'

Elevation of rotary table 431'(basis of all measurements)

11¾" casing cemented to surface at 357' 6".

When at 2417' the 7⅞" bit stuck and the drill pipe was backed off to 1999' 4". The hole was then plugged with mud balls to 1960'.

8¾" casing set at 1958' and cemented to 1270'. During subsequent fishing the lost drill pipe was cut at 2063' 4". Further fishing attempts failed, the top of the fish remaining at 2063' 4".

The hole was left full of water, the water level being at 195' from surface on 31.12.39.

A Schlumberger electrical survey was made at 1881'.

Cousland No.3.

Lat. 55° 55' 50.5" N.

Long. 2° 59' 27.7" W.

Drilling commenced 11.3.39

" suspended 1.8.39

Final Depth 2168'

Hole drilled rotary throughout.

Elevation of rotary table 468' (basis of all measurements)

15⅝" casing cemented to surface at 189'.

A 5' wooden plug was placed at the top of the 10⅝" hole at 1400' and covered with cement to 1393'. A 5' wooden plug was then placed in the 14¾" hole at 449' and the hole filled with cement to the surface.

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2. HISTORICAL

The presence of numerous bituminous sandstones, shows of oil and gas found in mines and elsewhere, and particularly the natural seep at St. Catherine's Well Liberton, have long turned the thoughts of geologists towards the oil possibilities of the Calciferous Sandstone Series of the Midland Valley of Scotland. The Cousland - D'Arcy anticline as the largest suitable structure in the area was the obvious first choice for a test well to explore the series. The anticline was first tested at D'Arcy farm, where in 1922 a yield of about 7 tons of oil was obtained at a depth of 1810/20 feet, in a well drilled by Pearsons. This well was subsequently abandoned for reasons other than geological. As a test it was encouraging but inconclusive.

There were two schools of thought on the subject of the formation of the numerous oil indications in the Calciferous Sandstone Series. The first school maintained that the oil was probably produced by the destructive distillation of the various oil shale beds present in the series, by the action of intrusive igneous rocks, which are common in the shale field area. The second school while admitting the possibility of such a process on a small scale, thought that in view of the widespread distribution of the oil indications, many of which occur in areas far removed from igneous intrusions, a normal mode of origin was far more likely. The encouraging result at D'Arcy favoured the second school, for this is an area in which no nearby intrusions have been recorded.

The evidence which decided the D.R.C. to undertake further exploratory drilling on the Cousland - D'Arcy axis was assembled by B.K.N. Wyllie in his note "Oil in the Carboniferous of Scotland" dated 14.6.33 (see also Oil Shale and Cannel Coal Inst. of Pet. 1938, p.19).

2. Historical - Contd.

During the summer of 1936 the area was examined in the field by A. Allison. As a result of Allison's report (on the Cousland - D'Arcy Structure Filed 5.10.36) a location was chosen ½ mile south of Cousland village. This report included a structural contour map of the area, showing the estimated contours of the top of the Calciferous Sandstone Series, giving a minimum closure of 400 feet.

The results of this well, Cousland No.1, which produced a few gallons of oil and a considerable quantity of gas from several sandstone zones, was considered sufficiently favourable to justify a second well further down flank. A second location was therefore chosen ½ mile west of well No.1. This location was planned to strike the gas bearing sandstones of well No.1 at a structural elevation about 250 to 300 feet lower, where it was hoped they might prove oil bearing.

Before selecting the site for well No.2 the structural contour map of the area was revised. The record of No.1 well had shown a marked thinning of the upper part of the Calciferous Sandstone Series in the 2 miles separating this well from the original D'Arcy well and the new Midlothian No.1 well (drilled concurrently with Cousland No.1 by the Anglo-American Oil Co. close by the old D'Arcy well). Although the thinning greatly reduced the value of contours drawn on the top of the Calciferous Sandstone Series for estimating depths to lower horizons, the contour map remained the best evidence available for the choice of locations.

During the revision of the contour map it had become apparent that further information was necessary to delineate with any certainty the northern part of the anticlinal region in the Carberry Hill and Falside area. Carberry Hill and Falside Hill were thought to be the topographic expressions of domes in the underlying lower limestone group, but depths were very

2. Historical - Contd.

doubtful To complete the structural picture of the northern end of the anticline it was decided therefore to undertake a programme of shallow drilling. Three shallow wells, C.1, C.2 and C.3, were drilled, the results showing that the Cousland axis plunges north from well No.1, and rises again en echelon about ½ mile to the west to form a dome including Carberry Hill, Hillhead and Falside Hill. This northerly crest maximum then plunges northwards without further reversal. (See Cousland Shallow Tests. A.H. Taitt, Dec. 1938)

A third deep test was then located on Falside Hill, about ½ mile north of the crest maximum according to the contour map. This location, apart from being exploratory, was thought to have a reasonable chance of finding oil in the gas bearing sands of well No.1.

Before the spudding in of well No.3, and during the drilling of well No.2, a shallow water well (C.4) was drilled near Fordel Mains Farm for Stair Estates Ltd, and subsequently another water well was drilled about 800 feet west of C.4 by the A.A.O.C. . Both of these wells provided further evidence for a slight modification of the contour map in this area. They showed that the crest maximum for the Cousland structure was probably about 1500 feet south west of Fordel Mains. Another deep test was therefore proposed on this crest maximum (Location No.4) as a gas production well, but was never carried out.

It should be mentioned that it was previously decided to drill a No.4 well between wells No.1 and No.2 as a possible oil producer from the 1720/1806 sandstone zone of No.1 well, but this idea was abandoned when further production tests in well No.1 (combined with the results of No.2 well) showed that it was most unlikely that there was any oil column in this sand. Location No.4 was then transferred to the Fordel Mains crest maximum

2. Historical - Contd.

referred to above, but work never began.

Drilling in the whole area was suspended when well No.3 proved saline water in the part of the succession which was gas bearing in well No.1. The gas zones of No.1 well had also proved water bearing in well No.2.

The compilation of this report suggests that before the Cousland area is definitely abandoned there is a good case for drilling location No.4, in the neighbourhood of the Fordel Mains crest maximum. A depth of 1750 feet for this test would suffice. It would have a good prospect of getting oil in the 1248 sandstone of No.1 well, and of tapping the 1582 sandstone in the most favourable area for gas production.

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3. SUMMARY OF STRATIGRAPHY OF COUSLAND - D'ARCY ANTICLINE

Carboniferous Limestone Series

Edge Coal Group — Sandstones and Shales with Coals.

Lower Limestone Group ca 550'

No.3 Limestone 5' ca	100' ca Sandstone, some Shale
Bilston Burn Limestone 5' ca	40' ca Shale, some sandstone, thin coals.
Upper Vexhim Limestone 5' ca	40' ca sandstone shale
Middle Vexhim Limestone 2' ca	25' ca sandstone & shale
Lower Vexhim Limestone 4' ca	50' ca sandstone
No.2 Limestone 90' ca	100' ca sandstone with some shale
Upper No.1 Limestone 20-30'	10-20' shale, marl or sandstone
Lower No.1 Limestone 20-30'	

Calciferous Sandstone Series

2968' in Midlothian No.1

(The series is also referred to as the Oil Shale Group)

A variable series of shales, sandstones, fireclays, thin limestones, occasional thin coals and bituminous shales. Sandstones frequently bituminous.

Arthur's Seat Volcanic Group

250' in Midlothian No.1

Red and green lavas.

Upper Old Red Sandstone — White and Red Sandstones.

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4. REGIONAL CORRELATION

In the publication by F. W. Anderson and J. B. Simpson, "Geological Notes on Borings for Oil now in Progress at Cousland and D'Arcy, Midlothian" (see Oil Shale and Cannel Coal. Inst. of Pet. 1938. p.19), various useful suggestions are made, partly confirming suggestions already made by the Company's Geologists, which help to link the Cousland succession with the general succession of the shale fields. A useful correlation table for the oil-shale field region will be found in Plate XI of "The Oil-Shales of the Lothians".

The correlations suggested by Anderson and Simpson (of H.M. Survey) are as follows :-

Cousland No.1		Oil Shale Group Succession
330/36	Bituminous Shale with Lingula, Myalina	
337/39	Crinoidal Limestone	Fraser Shell Bed.
339/348	Black shales with Lingula, Pinna, Aviculopecten & Goniatites	
348/478	Mostly fireclay & rooty sandstones of ganister type (recorded as black shale & sandstone in well log)	
407/13	Marine crinoidal limestone	Raeburn Shell Bed.
413/38	Richly fossilferous shale with crinoids, brachiopods, lamellibranchs & goniatites	
522/24	Coal	Two Foot Coal
624/32	Oil Shale, black shales with Estheria	Dunnet Shale.
727/757	Shales with marine fauna in calcareous rib near top Productids, Rhynchonellids, Lingula, Orbiculoidea	
758/67	Lava (olivine basalt)	cf. Lava in Carlops section.
810/17	Ostracod Limestone	Burdiehouse Limestone representative.
849/51	Ostracod Limestone	

4. Regional Correlation - Contd.

The following notes comparing the Cousland Succession with that in other areas are only to be regarded as suggestions.

Carlops

As mentioned above, the Cousland 758/67 lava, with the ostracod limestones underlying it representing the Burdiehouse limestone, is probably a product of the same volcanic episode that formed the Carlops lava which also overlies what is considered to be a Burdiehouse representative. A description of the Carlops section will be found in "The Geology of the Neighbourhood of Edinburgh" Mem. Geol. Surv. 1919 p.172." The section, which is exposed down to about 150 feet below the Burdiehouse Limestone, is remarkable for its attenuation.

E. Fife.

The E. Fife coast section, between Coal Farm and Pittenweem, agrees tolerably well with the Cousland succession at the top, but lower down turns dominantly sandy and gritty. (See E. Fife Memoir 1902. p.77-99).

The Cousland No.1 Crinoidal Limestones at 337/39 and 407/13, seem to compare with the Fife Crinoidal limestones at 288' and 345' below the Hurlet Limestone. The lava episode may be represented by the mottled marl bed 954/90 feet below the Hurlet Limestone.

Northumberland

The correlation by Messrs. Anderson and Simpson shows that the upper 600 feet of the Cousland Oil Shale Group succession compares quite well with the typical Oil Shale Group sections developed further west in Midlothian and West Lothian. Below this it is not possible to find in the Oil Shale Group any marine zones corresponding with the marine zone in Cousland No.1 between 760 and 900 below the top of the group. It appears possible that this marine zone is a representative of the Northumberland facies

4. Regional Correlation - Contd.

of the Lower Carboniferous, with which the Dunbar Calciferous Sandstone Series has been compared. It may very tentatively be correlated with the strata including the Woodend and Dun limestones of the Lower Limestone Group of Northumberland, which are possibly represented by the Pumpherston Shell bed in the Oil Shale Group. The 1324/26 Crinoidal band of Cousland No.1 may represent the Duddo Limestone. (See Mem. Geol. Survey "Geology of the Cheviot Hills" 1932).

It should be mentioned that the Acre Limestone and the Belwell Limestone of the Northumberland Middle Limestone Group have been correlated with the No.2 and No.1 Limestones of the Midlothian Lower Limestone Group.

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5. DETAILED STRATIGRAPHY & WELL CORRELATION

1. Carboniferous Limestone Series.

Well No.3 began drilling in the lower part of the Edge Coal Group and therefore gives a complete section through the Lower Limestone Group. This section may be taken as standard for the area. For the general succession see Figure 5, and for details refer to the Well Log.

Other detailed sections in the Lower Limestone Group were given by the shallow boreholes C.1, C.2, C.3 and C.4 and the Anglo-American Oil Co's shallow bore near C.4 (see A.H.Taitt "Cousland Shallow Boreholes" Dec. 1938).

The most important index bed in the Lower Limestone Group is No.1 Limestone (sometimes called the Gilmerton Limestone). This is 60 - 80 feet thick, and may develop a shaley parting in the middle. Immediately below No.1 Limestone a thin black shale is usually developed and marks the top of the Calciferous Sandstone Series.

2. Calciferous Sandstone Series (or Oil Shale Group).

The rapidly alternating nature of the Calciferous Sandstone stratigraphy is well illustrated by the detailed well logs. The log of Well No. 1, which was cored almost continuously (apart from between 1303 feet and 1586 feet drilled by cable tool) provides the best standard.

Little purpose would be served by recapitulating the details of the lithology noted on the well logs but it will be useful to comment on various features of the succession.

The sandstones which frequently show current bedding, the dip of the current bedding sometimes being as much as 40° more than the true dip, must be expected to vary in thickness in different parts of the area, and in places may die out altogether. It will be noticed for example on the correlation

5. Detailed Stratigraphy & Well Correlation - Contd.

2. Calciferous Sandstone Series - Contd.

diagram (Fig. 6) that the thick 913/91 sandstone of Well No.1 is represented by only 10 feet of sandstone in Well No.2, and that the 1582/1632 sandstone zone of Well No.1 is only represented by 8 feet of sandstone in Well No.2. On comparing the total thickness of sandstone down to the base of the 1582 sand in the Wells No.1, 2 and 3 we get 445, 335 and 475 feet to 1391, 1579 and 1461 feet of formation respectively. This suggests that general thinning takes place more at the expense of shales than sandstones.

A feature of the sandstones is the irregular development of thin (a few inches to five feet) very well cemented bands, locally known as "kingle". These are extremely hard and abrasive and cause great wear on rock bits. Micaceous flaggy sandstones are locally termed "fakes".

The sandstones frequently merge gradually into sandy shale or sandy fireclay. The purer sandstones are wll composed of angular or sub-angular quartz grains cemented by calcite.

Fireclays are not uncommon in the succession and are particularly well developed in No.1 Well between 275 and 665 feet below the top of the series.

The shales are of very variable type. The shales of normal type are known locally as "blaes", and when sandy and micaceous as "fakey blaes". A characteristic feature of the shales is the development of thin bands or irregular concretions of siderite ironstone, particularly in the zones associated with thin bands of Ostracod Limestone. These ironstones may be extremely hard to drill, but rarely exceed 6 inches in thickness. They are sometimes themselves Ostracod bearing.

Plant fragments are comparatively common in the shales

5. Detailed Stratigraphy & Well Correlation - Contd.

2. Calciferous Sandstone Series - Contd.

where they are associated with Ostracod Limestones, but have not been recorded above the Carlops lava. Various zones with abundant shell fragments occur, but the fragmentary nature of the fossils usually makes accurate identification impossible. Many of the indentifications on the detailed logs should be accepted with reserve.

Apart from the Crinoidal Limestones and zones with marine fossils (see later) the most characteristic fossils are Ostracods, which frequently swarm in the shales and thin limestones. Except for a 2 inch Ostracod limestone below the Dunnet Oil Shale recorded in Well No.1, Ostracods appear to be confined to the strata below the Carlops lava. The abundance of Ostracods makes them of little value for correlation purposes.

In addition to the few occurrences of actual oil shales there are several zones where more or less bituminous dark shales are developed. These are sometimes particularly rich in Ostracods, fish debris and plants. They have a confirmatory value for correlation purposes.

Correlation.

The upper part of the Calciferous Sandstone Series contains a number of definite marker beds, which from present evidence may be expected to occur over the whole anticlinal area.

These markers and their approximate positions in the Cousland Falside area are given below :-

"Frazer" Crinoidal Limestone	ca 100'	below top of Calciferous Sandstone Series.
"Raeburn" " "	ca 200'	" " " " "
"Two Foot" Coal	ca 300'	" " " " "
"Dunnet" Oil Shale	400-500'	" " " " "
"Carlops" Lava	500-600'	" " " " "
"Burdiehouse" Lst. (Ostracod Lst. in Bit. Shales	575-700'	" " " " "
"Burdiehouse" Lst. Ostracod Lst.	600-750'	" " " " "

Correlation - Contd.

(At the D'Arcy end of the anticline there is a marked increase in thickness down to the Lava bed. Here the Oil Shale is 600', and the Lava 900' below the top of the Calciferous Sandstone Series.)

Deeper in the succession definite markers are scarce, but the rapidly alternating lithology gives a useful correlation. Even if confidence cannot be felt in correlating the various beds individually, when taken together the general agreement is good. In addition to the beds shown on the correlation diagram it is possible from the detailed well logs to find many other points of agreement in lithology. These will be readily apparent by placing the well logs side by side. To have recorded everything on the correlation diagram would have confused the picture unnecessarily.

It should be remarked that several zones of steep and disturbed dips occurred in the cores below the 1720/1806 sandstone horizon, such as would be expected to interfere with accurate correlation.

Very useful markers are the deeper Crinoidal bands. In No.1 Well two marked Crinoidal horizons were developed at 1002/22' and 1106/23', that is at 761/81' and 865/82' below the top of the Calciferous Sandstone Series. These horizons were first recorded in the log of the old D'Arcy well. In No.2 Cousland only one of these Crinoidal bands was recognised, probably the upper band, and the lower is considered to be represented by a marine band with Posidoniella 80' below. In No.3 well both bands are present in positions closely comparable to the development in No.1 well.

A third Crinoidal band occurred in No.1 well at 1320', that is 980' below the top of the series. In No.2 well three Crinoidal bands occurred between 1246' and 1313' below the top of the series. In No.3 no Crinoidal material was found in this position.

Correlation - Contd.

Correlation with the deeper parts of the Midlothian Wells is not possible, as the record is largely based on cuttings. There are no definite markers, and the cores recovered gave evidence of frequent minor disturbance.

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6. DIP EVIDENCE FROM CORES

Dip evidence is necessarily incomplete, depending on the amount of coring. The best evidence is available from well No.1 where coring was almost continuous.

In wells No.1 and No.2 dips appear to be regular, conforming to the general structure of the area, down to the base of the 1720/1806 sandstone. Below this horizon zones of steep dips occur occasionally, usually in dominantly shaley zones, and are probably due to minor disharmonic folding in relatively incompetent beds. Although they are accompanied by slickensiding there is no reason to assume important faulting. The lower beds which were cored in Midlothian No.1 also showed frequent high dips, particularly in an incompetent zone between 2350 feet and 3000 feet.

The evidence from Cousland No.3 is very incomplete. The first dip recorded, 50 feet below the lava, is 40°, and below this recorded dips vary from 5° to 80°.

NO.1 WELL

0 - 1250'	All dips 5° or less, except for one dip of 10° recorded at 800'.
1280	15°.
1600 - 1800'	5 - 10°.
At 1807'	below the 1720/1806 sandstone, the dip suddenly increased to 55° and then fell irregularly back to 10° at 2100'.
2100 - 2290'	10°.
At 2300'	there was a sudden increase to the vertical for a few feet followed by an irregular fall to 5° at 2370'.
2370 - 2917'	Dips vary between 0° and 35° but average 10°. Some of the steeper dips over this range are suspect, as they were measured in sandstone.

Dip Evidence from Cores - Contd.

WELL NO.2

Dips were recorded as follows :-

1762'	10°
1785'	12°
1834'	10°
2174'	10°
2192'	10°
2250'	5°
2300'	20°
2340'	15°
2409'	15°

Two dips of 40° recorded in sandstone at 2302' and 2313' are suspect, and probably the result of current bedding.

WELL NO.3

Dips were recorded as follows :-

1425'	40°
1430'	25°
1440 - 1520'	30°
1520 - 1550'	35°
1550 - 1570'	30°
1700'	45°
1745'	60°
1945'	25°
1995'	20°
2010 - 2040'	10°
2060'	20°
2080'	40°
2100'	70° - 80°
2100 - 2120'	50°
2120 - 2140'	30°

Dip Evidence from Cores - Contd.

Well No.3 - Contd.

2150'	10°
2160'	5°

These relatively steep dips are probably due to the E - W fault immediately North of well No.3.

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7. CALCIFEROUS SANDSTONE THICKNESSES

GENERAL

Owing to the incomplete nature of the various sections in the shale field country and the uncertainty of correlation elsewhere, it is not possible to construct a general isopach diagram for the Calciferous Sandstone Series.

It may be remarked however that there is a suggestion, admittedly based on slender evidence, for a reduction of thickness in the post-Burdiehouse part of the oil shale group, associated with the Pentland Hills/Burntisland and D'Arcy/ Cousland anticlinal lines. It will be seen on referring to Plate XI of "The Oil Shales of the Lothians" that the partial sections of Burntisland and Carlops are much thinner than the same parts of the succession elsewhere, and that the Cousland sequence is more comparable to these sections than the others. The straiton section, which lies in the Midlothian syncline, is thicker than the Carlops section, and the D'Arcy and Cousland sections which lie on either side of it. It seems possible that the folding movements along these anticlinal lines were already making themselves felt during the deposition of the upper part of the Calciferous Sandstone Series.

LOCAL

The following table shows the thicknesses encountered down to the "1248' sandstone" in the Cousland and Midlothian wells. This sandstone has been called C_1 in the Anglo-American Oil Co. nomenclature. The figures in each case give the thickness encountered between the base of No.1 Limestone and the top of the sand. No deductions have been made for dip.

What information there is from the wells indicates that dips are perfectly regular down to the lava, and that in No.1 and No.2 wells they are normal down to the base of the 1720/1806 sandstone. In well No.3 dips recorded between the lava and the base of the 1582 sand vary between 10° and 80°,

7. Calciferous Sandstone Thicknesses - Contd.

Local - Contd.

so that for this well the thickness figures are certainly too large.

Cousland No.1	1007 feet
" " 2	1161 "
" " 3	1091 "
Midlothian No.1	1555 "
" " 2	1715 "
" " 3	1535 "
" " 4	1310 "
" " 5	1417 "

The "1582' sandstone" of Cousland No.1, equivalent to B.14 in the A.A.O.C. nomenclature, gives the following figures:-

Cousland No.1	1341 feet
" " 2	1571 "
" " 3	1419 "
Midlothian No.1	1820 "
" " 2	1905 "

From these figures an isopach diagram has been drawn (Fig.3) for the D'Arcy - Cousland region. It will be seen that Cousland No.2 and Midlothian No.2 both show a thickening down the flank of the anticline. The Midlothian wells Nos. 1, 3, 4 and 5 show more irregular variation, which makes the structural contour map of the top of the Calciferous Sandstone Series a very unreliable guide in this region.

In general the evidence from the wells is in agreement with the suggestion that the upper part of the Calciferous Sandstone Series shows a tendency to be thinnest in the region of the anticlinal axis.

In drawing the longtitudinal section from D'Arcy to Cousland (Fig.2) the isopach diagram has been followed, but an alternative position has been shown for the 1248 and 1582 sands. This alternative position assumes a gradual increase in thickness from Cousland No.1 to Midlothian No.2, but ignores the evidence

7. Calciferous Sandstone Thicknesses - Contd.

Local - Contd.

from the other Midlothian wells. As it is not possible to draw a convincing isopach diagram on this basis, the alternative position seems most unlikely.

It is hardly necessary to point out that the isopach diagram is based on very slender evidence. The East flank of the structure is quite unknown, and it is possible that instead of the thinning stopping at the axis, as has been suggested, it continues further Eastwards.

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8. PRODUCING AREAS AND PROSPECTS

By using the isopach diagram (Fig. 3) in conjunction with the underground contour map of the top of the Calciferous Sandstone Series (Fig. 1A), and accepting figures for water levels, it is possible to show roughly on the map the areas of the various sands which lie above their respective water levels. This has been done in Fig. 4 for the 1248/79, 1582/1632 and 1720/1806 sandstones in the Cousland - Fordel Mains region. The results must be considered as extremely tentative in view of the many assumptions made.

(1) Approximate Producing Area of the 1720/1806 Sandstone.

The value of this procedure is much reduced for this sandstone because the water level is now not definitely known as a result of the disturbance of equilibrium by the gun perforation tests, apart from the fact that it lies somewhere between the 8786 and 8825 U.G. Contours. Before these tests, evidence from No.1 and No.2 wells indicated that equilibrium existed between the gas in No.1 and the water in No.2, with a water level at 8760 U.G.C., that is at about the base of the sand in No.1 well. After the gun perforation tests, when 35.4 million feet of gas had been produced from the 1760/1806 sandstone in No.1 well, followed by a controlled water free production test in which 600,000 cu. ft. of gas was produced in one week (at a rate which settled down at 70,000 cu. ft. per day) the water level gradually rose. It had reached at least 1780 feet when the sandstone was cemented off at 1740'. (The final recorded closed in pressure was 593 lbs. it was still rising, having risen from 555 lbs. at the end of the last production test). During tests of the upper part of the zone (1720/40) no water entered the hole, so the water level was below 1740'.

Working from the old water level figure of 8760 U.G.C., the original producing area of the sand was about 5 million cubic feet. As over much of this area the water level must have been

8. Producing Areas and Prospects - Contd.

(1) Approximate producing Area, etc. - Contd.

in the sandstone (see Fig. 2) it is difficult to estimate what volume of sand was available as a gas reservoir, but a cautious estimate would be about 150 million cubic feet. This figure may be regarded as a maximum. Taking into account the rise of the water level, the commercial importance of this sand, compared with the others, is small.

(2) Approximate Producing Area of the 1582/1632 Sandstone.

Taking the gas/water level at 8830 U.G.C., as calculated by the Petroleum Engineering Dept., the area of the sand above water level is 10 million square feet. Assuming an average thickness of 30 feet for the sand throughout the area, 300 million cubic feet of sandstone are available as a gas reservoir.

(3) Approximate Producing Area of the 1248/79 sand.

If we accept 9000 U.G.C. as the water level for this sand on the evidence of the Midlothian Wells, by using the underground contour map and isopach diagram as before, we find that the area of the sand above water level is 25 million square feet.

From this figure it is possible to make a rough estimate of the possible oil reserves, assuming that the sand is oil bearing throughout and that No.1 well penetrated it in a tight zone. This may seem a very unwarrantable assumption, but the sustained oil production from the sand in Midlothian No.1 cannot be ignored.

Area of sand 25,000,000 square feet.

If the average producing thickness of the sand is taken as 20 feet, which is a conservative estimate, the volume becomes

25^{6} x 20 = 500 million cubic feet

8. Producing Areas and Prospects - Contd.

(3) Approximate Producing Area etc. - Contd.

Assuming that 5% of the sandstone volume is oil occupied pore space the total volume of oil is

$$\frac{500^6}{20} = 25^6 \text{ cubic feet} \quad (4.45 \text{ million bbls})$$

and the weight, taking the specific gravity of the oil as .86 is

$$\frac{25^6 \times 62.4 \times .86}{2240} = 600{,}000 \text{ tons about.}$$

If one quarter of any oil present is considered to be recoverable, this gives 150,000 tons for recoverable reserves.

In considering the problem of the oil prospects of the 1248/79 sand the temperature factor is most important. In Midlothian No.1 well the oil from this horizon had a pour point of 60°F. The few gallons of similar oil recovered from the 1248/79 sand in Cousland No.1 had a setting point of about 54°F., the temperature of the sample when recovered from the hole being 57°F.

It is possible but not probable that the setting point of the oil is too high for any oil recovery from the Cousland structural high, and that the production from the Midlothian wells is due to their greater depth from the surface and consequent higher temperature.

An accurate temperature determination in No.1 well would help to settle this point. The temperature of 67°F. recorded on the Schlumberger log (see appendix) for the 1248/79 sand had certainly not reached equilibrium under the conditions of the test.

(4) The Carberry Hill Crest Maximum.

On the Carberry Hill crest maximum the highest part of the structure according to the contour map is about 250 feet above the contour of No.3 well. As thickness changes in the Calciferous Sandstone Series in the short distance between

8. Producing Areas and Prospects - Contd.

(4) The Carberry Hill Crest Maximum - Contd.

well No.3 and the crest maximum are most unlikely, the contour map can be used as a fairly reliable guide in this area. A well drilled on the Carberry Hill crest maximum would be expected to strike the 1248 sand at the 8934 U.O.C. and the 1582 sand at the 8606 U.O.C.

In well No.2 the 1248 sand contained salt water at the 8941 U.O.C., and the 1582 sand was also salt water bearing at 8661 U.O.C.

In well No.3 both the sands were again water bearing, the 1248 sand at the 8688 U.O.C. and the 1582 sand at the 8360 U.O.C.

From this evidence and the 175 foot closure shown on the contour map, we can conclude that the maximum possible area for a gas (or oil) producing zone in the Carberry Hill region is outlined approximately by the 9850 contour, and that the probable area of any gas (or oil) trapped in this crest maximum is likely to be much smaller than this. In other words there may be a small quantity of gas trapped in this crest maximum, but assuming the most favourable conditions the prospects are not as good as those of the 1720 sand in the Cousland - Fordel Mains region.

(5) The Chalkie Side Dome.

This small dome with a closure of approximately 175 feet is too small in the light of present evidence to have any commercial importance.

Suggestions for further work.

The prospects of the area now seem to be confined to the 1248 and 1582 sands, although the 1720 sand still retains some value as a gas producer.

It is strongly suggested that the large area of the 1248 sand which may lie above water level in our concession, combined with the evidence of sustained oil production from the

8. Producing Areas and Prospects - Contd.

Suggestions for further work - Contd.

Sand in Midlothian No.1, make another test for oil advisable before finally abandoning the area.

The best place for such a test would be in the neighbourhood of the Fordel Mains Crest Maximum. A well here, carried down to 1750 feet, would test the potentialities of all three sands besides giving valuable evidence on the nature of the thinning in the Calciferous Sandstone Series on which the prospects of the area now so largely depend.

If our isopach diagram is approximately correct this area would be the most favourable for tapping the gas reserves of the 1582 sand, and the remaining reserves in the 1720 sand.

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9. BITUMINOUS SANDSTONES

The distribution of bituminous sandstones can be seen on the detailed well logs. Bitumen was very common in well No.1 and somewhat less common in wells Nos. 2 and 3. Apart from the fact that bituminous residues at any horizon appear to be more concentrated at structurally higher levels, nothing can be interpreted from the occurrences.

The distribution of bitumen at structurally high levels is well illustrated by the thick sandstone development between No. 1 and No.2 Limestone. The sandstone was richly bituminous in No.1 well and also in shallow hole G.4 and the Anglo-American shallow water bore near Fordel Mains. In well No.2 a little bitumen was recorded; in the colliery bore near EasterrCowden only a trace was recorded; and in well No.3 none was recorded.

A chloroform extraction of 500 grams of sandstone at 247 feet in well No.1 gave 5% of bitumen by weight.

The bitumen in the richer sandstones is thick but soft, and under a lens can clearly be seen sticking to the quartz grains

The abundance of bitumen presumably indicates that much oil has been lost from the Cousland structure owing to lack of cover. (migration direction?)

NLF/VIM

10. FORMATION TESTS

As a supplement to the tabular record of formation tests which follows, it will be useful to give a summary of some of the special methods used in well No.1, apart from normal packer tests, in attempts to bring oil into the hole from sandstones which looked promising in the cores. There was some controversy at the time over the question of mudding off, and the advisability of drilling cable tool or rotary.

In order to test the 831/35 oil saturated sandstone the 8¾" casing was set at 822 (when the depth was 858') and the hole washed and bailed. Not a drop of oil was produced in spite of the core having oozed oil freely. This oil had remained fluid under the low surface temperatures (40°F. or less) prevailing at the time, but waxed up as the light fractions evaporated.

Before carrying out a packer test of the oil saturated sandstone between 938' and 955', the bottom of the hole was washed with hot water, and scraped by rotating a fish tail bit. The amount of hot water used was 160 gallons at a temperature of 160°F. This was poured into the drill pipe (which was fitted with a non-return valve above the fish tail bit) and followed by enough cold water to bring it into position. The test proved negative.

When the depth was 1303' the 8¾" casing was set at 1240', and, after washing, the pilot hole was bailed dry in order to test the 1248/79 sandstone, the cores of which had oozed oil. After 48 hours about half a pint of thick oil was recovered with the bailer. After another 48 hours another pint of oil and a few gallons of muddy saline water were recovered. Twenty-four hours later thorough bailing yielded 5 gallons of muddy water and 3 gallons of oil. The s.g. of the oil was 0.86 and the setting point 12°C. As the fluid on reaching the surface had a temperature of 14°C. it appeared that the temperature of the oil in the formation must have been several degrees above the setting point. However in order to make sure that waxing up had

10. Formation Tests - Contd.

not occurred the hole was then bailed dry, and into the pilot hole were poured 55 gallons of water followed by 75 gallons of kerosene. The kerosene, which should have been opposite the sand, was stirred by a bailer with the valve removed. The test was spoiled by the collapse of the casing shoe.

Later when the casing had been reset and bailed, the pilot hole was cleaned, the walls of the oil sand scraped, and 50 gallons of water followed by 80 gallons of Tractor Vapourising Oil (kerosene plus a little fuel oil) were run in. Twenty-four hours afterwards the T.V.O. and water were bailed out and the hole left standing for 48 hours.

At the end of this period all that was recovered was about 20 gallons of saline mud and a few pints of light oil, presumably T.V.O. slightly enriched by heavy oil from the 1248/79 sandstone.

While preparing to drill cable tool after this the hole was not bailed for a fortnight. During that time about 10 gallons of muddy water and 3 gallons of oil collected and were recovered by bailing.

The negative results given by this very thorough testing of the 1248/79 sandstone might be due to No.1 well having struck a tight zone (recorded permeabilities were 1.5, 3.5, 9.83 and 27.25 millidarcees; porosities 23.0 and 18.0).

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COUSLAND NO. 1

DATE	DEPTH	METHOD OF TEST	FORMATION TESTED	LENGTH OF TEST	RESULT
14.10.37	495'	Bailing	268' – 495'		Fresh water entered hole, standing level 95'. Unable to bail below 180'. By S.G. observations on samples from various depths, water thought to be coming from 330/335'. Later mud ringing suggested 265/315 as position of show.
3.11.37	744'	Packer	407' – 744'	½ hour	Mud rose in D.P. to 74' from surface. Water probably coming from 440/60 sandstone, confirmed by later mud ringing.
3.11.37	744'	Packer	643' – 744'		Fresh water rose in D.P. to 200' from surface. Water probably came from 633/50 sandstone.
5.11.37	780'	Packer	752' – 780'	1½ hours	12 feet fresh water rose in D.P. Probably came from limestone at 763/65.
13.11.37	852'	Packer	821' – 852'	6 hours	30 feet of mud in D.P. after test. Annular space mud level dropped 8'.
22.11.37	858'	Casing set. Bailing after reaming and washing.	822' – 858'	ca. 4 hours	Fresh water entered hole at 68 gals. per hour. Probably came from oil sand 831/35 limestone 835/36.
2.12.37	938'	Packer	917' – 938'	2 hours	40' drilling mud entered D.P.
3.12.37	955'	Packer. Hot water placed on bottom. D.P. bailed.	917' – 955	ca. 2 hours	Little muddy fluid trace oil bailed.
21.12.37	1240'	Packer	1153' – 1240' } 1188/1209 sand	11 hours	Gas show giving 15,000 – 20,000 cu. ft. p. d. calculated production. C.I.P. ca 500 – 600 lbs. sq. in. coming from 1188/1209.
23.12.37	1294'	Packer	1220' – 1294' } 1248/79 sand	2 hours	15' mud entered D.P.

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COUSLAND NO. 1 - CONTD.

DATE	DEPTH	METHOD OF TEST	FORMATION TESTED		LENGTH OF TEST	RESULT
11. 1.39	1303'	Casing set & Bailed.	1240' - 1303'	1249/79 sand	5 days	Few gallons oil and mud obtained, including slightly saline water of S.G. 1.001.
31. 1.39	1303'	do. do. Washed formation with T.V.D.	1244' - 1303'		48 hours	ca. 15 gals. muddy saline water recovered.
1. 2.39	1310'	Casing & Flowline	1244' - 1310'			ca. 30,000 cu. ft. p. d. gas.
15-25.2.39	1446'	" "	1244' - 1446'			Observations on gas pressures during erection Standard Cable Tool Rig.
10. 3.39	1591'	Burning off.	1527' - 1591'	1582/1632 sand	5 days	Gas ca. 800,000 cu. ft. p. d.
9. 4.39	1642'	Packer	1596' - 1642'		1 hour	Much gas.
10. 4.39	1646'	Packer	1618' - 1646'		½ hour	4 cu. ft. mud in D.P.
13. 4.39	1652'	Packer	1596' - 1652'		5 hours	ca. 3,000,000 cu. ft. gas p. d. at 615 lbs. per sq. inch.
13. 4.39	1652'	Packer	1618' - 1652'		1 hour	ca. 250,000 cu. ft. gas p. d.
7. 5.39	1652'	Packer	1627' - 1652'		1 hour	133' mud entered D.P.
22-23.5.39	1758'	Packer	1700' - 1758'	1720/1806 sand	8 hours	ca. 12 million cu. ft. gas p. d. C.I.P. 650 lbs. per sq. inch.
27. 5.39	1806'	Packer	1759' - 1806'		7½ hours	ca. 4.4 million cu. ft. gas per day, at 643 lbs. per sq. inch.
16. 6.39	1985'	Packer	1957' - 1985'		½ hour	Negative.
23. 6.39	2053'	Packer	2004' - 2053'		½ hour	Negative.
2. 7.39	2127'	Packer	2086' - 2127'		2½ hours	Gas production of 150,000 cu. ft. p. d. obtained.

NLP/VIM

COUSLAND NO. 1 - CONTD.

DATE	DEPTH	METHOD OF TEST	FORMATION TESTED	LENGTH OF TEST	RESULT
19. 7.39	2227'	Packer	2178' - 2227'	35 mins.	130' Slightly gassy saline muddy water entered D.P. S.G. water (contaminated ?) 1.005.
4. 8.39	2404'	Packer	2371' - 2404'	70 mins.	400' Slightly gassy saline water entered D.P. S.G. 1.024 (contaminated ?)
30. 8.39	2772'	Packer	2263' - 2772'	8 hours	Muddy salt water entered D.P. and rose to 650'. S.G. water (contaminated ?) 1.011.

NO. 1 WELL. SCHLUMBERGER PERFORATION TESTS THROUGH 8⅝" CASING.
(CASING CEMENTED AT 2057)

DATE	ZONE PERFORATED	SIZE OF BULLETS	NUMBER OF BULLETS	RESULT
March, 1939	1760 - 1806	3/8"	185	C.I.P. 669 lbs. per sq. in. Gas/Water level calculated from evidence in No.2 well 8760 U.G.C. (ca 1805'). During 7 days production 25.4 million cu. ft. Gas 72,500 gals. Water Gas declined 13 million - 7 million cu. ft. p. d. in first 3 days during which time water production rate increased from 17,000 g. p. d. to 22,000 g. p. d.
17-24.4.39				
24. 4.39 to 9. 5.39				Well closed in. Max. C.I.P. 552 lbs. per sq. in. As gas [illegible] water level during period down to bottom of perforations (1805').
9. 5.39 to 15. 5.39				Flowed 600,000 cu. ft. gas (total). Water free production is 70,000 cu. ft. p. d. at flowhead pressure of 5 lbs. per sq. in. Under these conditions water level in well was 120 ft. from surface.
16. 5.39				C.I.P. 595 lbs. per sq. in. Rise in C.I.P. indicates that feed of gas from remote parts of sand to vicinity of well is in excess of 100,000 cu. ft. p. d.
13. 8.39				Up to 13.8.39 rise of water level in formation was at least 26 feet, while on that date flowhead pressure was 593 lbs. per sq. in. and still rising. Rise of water considered to be compressing gas in reservoir. Hole filled with cement to 1740'.
21. 8.39	1720 - 1739	3/8"	61	

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NO. 1 WELL. SCHLUMBERGER PERFORATION TESTS THROUGH 9⅝" CASING - CONTD.

DATE	ZONE PERFORATED	SIZE OF BULLETS	NUMBER OF BULLETS	RESULT
10. 9.39				After hole had remained dry since bailing on 25.8.39 C.I.P. was 595 lbs. per sq. inch. Gas production 300,000 cu. ft. p. d. No water. Well flowed 8 hours and then shut in.
16.10.39				C.I.P. 585.5 lbs. per sq. inch.
17-20.10.39	1592 - 1613	5/8"	131	
"	1623 - 1630	5/8"	33	
3.11.39				C.I.P. 630.5 lbs. per sq. inch. (Constant from 25.10.39 - 3.11.39). Fluid level 1738'.
3.11.39 to 2.12.39				30½ million cu. feet of gas produced and then well closed in. Production rate restricted and drilling and shooting water not reproduced. F.P. declines from 580 lbs. per sq. inch to 550 lbs. per sq. inch. Production rate of 1 million cu. ft. p. d. partly due to rise of water in hole to 1500'.
10.12.39				C.I.P. 590 lbs. per sq. inch. Gas/Water level about 1708' but still falling.

C O U S L A N D N O. 3

DATE	DEPTH	METHOD OF TEST	FORMATION TESTED	LENGTH OF TEST	RESULT
14. 6.39	1581'	Packer	1468' - 1581'	1 hr. 27 mins.	Saline water rose to 1202' below table in 87 minutes. No equilibrium. S. G. water 1.0050.
22. 6.39	1792'	Packer	1726' - 1792' "1248" sand	1 hr. 44 mins.	Saline water rose to 1628' below table. No equilibrium. S.G. water 1.0035.
26. 6.39	1830'	Packer	1743' - 1830' "1248" sand	1 hr. 43 mins.	Saline water rose to 1024' below table in 103 minutes. No equilibrium. Trace Gas. S.G. water 1.0280.
31. 7.39	2164'	Packer	2117' - 2164' "1592" sand	1½ hrs.	Saline water rose to 1907' below table in 90 minutes. No equilibrium. S.G. water 1.0480.

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COUSLAND NO. 2

DATE	DEPTH	METHOD OF TEST	FORMATION TESTED	LENGTH OF TEST	RESULT
1. 5.39	1529'	Packer	1461' - 1529' "1248" sand	3 hrs.	Saline water flowed at surface.C.I.P. 15 lbs. per sq. inch. Lowest sample S.G. 1.025. Pressure on sandstone at 1500' is 690 lbs. per sq. inch.
15. 5.39	1878'	Packer	1726' - 1878'	158 mins.	Saline water S.G. 1.035 rose to 1117 below table and still rising at 1 ft. per min. About 5000 cu. ft. p. d. gas produced.
15. 4.39	2120'	Packer	2021' - 2120' "1720" sand	140 mins.	Saline water and mud rose to 1378 below table. Pressure recorded by Amerada gauge set below packer at 2039' was 850 lbs. per sq. inch. S.G. water 1.007. From the results of this test a gas/water level of about 3760' M.G.G. was calculated by Pet. Eng. Dept. for the 1720/1805 sand. This makes it highly improbable that there is any oil in this sand. Later tests in No.1 well confirmed this.
3. 5.39	2432'	Packer	2290' - 2432'	135 mins.	Saline water rose in drill pipe to 142' below table in 135 mins. Pressure on recording gauge at 2305' was 955 lbs. per sq. inch. S.G. water 1.0375. Water equilibrium almost attained.

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WELL NO. 1 COUSLAND

11. POROSITY AND PERMEABILITY RESULTS FROM SANDSTONE CORES

(For Porous Zones Which Caused Mud Ringing See Under Mud)

Depth	% Porosity	Permeability in Millidarcies After Extraction	% Oil Content by Wt.
928		26.01 and 26.32	
931/32			3.17
938/39			6.0
949/50		108.6	2.6
969/70			4.8
971		61.37	
1192/202			1.4
1200		2.06 and 1.91	
1248		9.83	
1248/58	23.0	1.5	
1262	18.1	3.5	
1265		27.25	
1586/8	17.0		0.5
1590		256, 280, 284.6, 327.9	
1613		72.8, 26.55, 48.53, 32.44	
1625/6	15.4		2.1
1631		1.94, 2.73, 6.98, 5.64	
1724/25		4.35, 5.23	1.5
1791/92		189	0.77
1804/5		189	0.99
2013/17	1.9, 2.0	9.46	2.73, 1.2
2026/27	2.5, 1.8	15.77, 16.45	
2105/06	1.5, 1.6	166.8, 190.6	
2187/89		37.68	
		45.22	
		18.73	
		19.94	
		7.0	

WELL NO.2 COUSLAND

POROSITIES OF SANDSTONES.

Depth	% Porosity	Permeability in Millidarcies (Without Extraction)
1496	8.6	197.0, 198.3
1512	1.2	1.88, 3.32
1515	10.4	2.96, 2.73
2028	10.2	53.72, 55.2
2057	6.6	
2072/73	3.6	
2095	6.7	186.3
2286	5.6	
2295	11.7	
2310	9.4	
2330	5.2	
2340	7.2	
2360	3.1	
2365	4.1	
2375	11.1	
2385	10.7	
2392	4.6	
2404	7.5	

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12. MUD.

Very little mud trouble was experienced in any of the Cousland wells, apart from a certain amount of ringing at the porous water or gas bearing sandstone zones. Fluid losses were confined to small amounts of water expressed into the formation. The mud used was obtained in the form of puddled clay from the Carluke Brick and Tile works, and although not always very clean on delivery it proved very suitable. In well No. 1 mud gravities used varied between 1.12 and 1.25, in well No.2 between 1.1 and 1.26 and in well No.3 between 1.17 and 1.26.

Aquagel was only used once in well No.1, to prevent the 3⅜" casing freezing preparatory to drilling cable tool, when the depth was 1303 feet. The danger at the time was due to mud ringing in water sands at 276/323' and 434/461', and it was finally overcome by rapid bailing before running the casing. This had the effect of bringing in the water shows, so that during the running of the casing, and when it was on its seat at 1235', only water was present between the casing and the wall of the hole opposite the porous zones. This procedure proved so effective that the casing remained on its seat for 13 weeks without freezing.

In well No. 2 a little aquagel was also added to the mud when the depth was 1400 feet, in order to prevent the casing freezing when an attempt (given up) was made to change over from rotary to cable tool.

In well No.3 Aquagel and gelsil were used almost continuously below 850 feet to overcome ringing at 720/86' in the 699/800' sandstone.

Particulars of the zones at which mud ringing occurred in the Cousland wells are as follows :-

Well	Position of Mud Rings	Formation
No.1	276 - 323	Water sand
"	434 - 461	Water sand
"	1178 - 1209	Gas sand
	1246 - 1250	" "
	1267 - 1276	" "

12. Mud - Contd.

Well	Position of Mud Rings	Formation
	1580 - 1620	Gas Sand
	1720 - 1807	" "
	2110	" "
	2370 - 2420	Water Sand
	2794	Sandstone
No.2	2120	Water Sand
No.3	720 - 786	Sandstone
"	943 - 966	Sandstone
"	992 - 1009	Muddy Sandstone
"	1100 - 1105	Sandstone & Shale

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13. WATER SHOWS.

A record of all the water shows encountered is shown in Fig. 6. This diagram also gives particulars of all analyses (reaction equivalents) and specific gravities (Sunbury determinations), and indicates how the various water horizons are correlated stratigraphically.

The main fact that has come out of the water analyses is that the upper waters, that is the waters occurring above the Burdiehouse horizon, are bicarbonate water, whereas the lower waters are chloride waters. The chloride waters occur associated with the various producing horizons.

It is interesting to note that a chloride water recorded in the old D'Arcy well at 1200' appears to occur in the representative of the 913/91 sandstone of Cousland No.1 well, which smelt strongly of kerosene and oozed a light oil. It is also to be noted that the water from the 633/50 show in Cousland No.1 contained more chloride than the other upper bicarbonate waters. This show is correlated with the 705/15 gas show in Midlothian No.1 (D'Arcy 720/35) with which it appears to be in equilibrium. Once again chloride content appears to bear a relation to the presence of mobile hydrocarbons.

Complete analyses of the various water shows as received from Chemical Branch will be found in the Appendix.

In No.1 well it was recorded that below 2560 feet all the cores were salty on recovery, tasting salty on fresh fracture when wet, and showing a salty deposit outlining cracks when dry. This suggests that all the lower part of the formation is saturated with salt water.

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APPENDIX A

For core identifications See Resident Geologist's Monthly Reports - Files Nos. UK/COUS/T.3 and UK/SCOT/T.6.

APPENDIX B. WATER ANALYSES

ANGLO-IRANIAN OIL COMPANY, LTD.

RESEARCH STATION

P. O. BOX 1,
CHERTSEY ROAD,
SUNBURY-ON-THAMES.

14. 1. 38.

REPORT NO. AP.N/142

Sunbury Ref. G. 809

WATER SAMPLES FROM COUSLAND NO.1

Requested by: D'Arcy Exploration Co. Ltd., London, via Refining and Technical Branch in memo UK/T2 of 16.12.37 (H.O. No. 1003)

Object: To carry out analyses of samples of water produced from Cousland No. 1 well.

HISTORY:

The samples received were as follows :-

(1) Water produced from Cousland No.1 at 270 - 325 feet
(2) " " " " " " 635 - 650 "
(3) " " " " " " 752 - 780 "
(4) " " " " " " 831 - 836 "

EXPERIMENTAL:

All four samples were filtered before analysis to free the water from suspended matter. The following tables give the required analysis :-

SAMPLE NO. 1 (270 - 325 feet)

CONSTITUENT	PARTS/100,000 PTS. WATER	EQUIVALENTS PER 100,000 PARTS X 1000	
		Acidic	Basic
Sulphate (SO_4)	35.9	748	
Chloride (Cl.)	2.5	71	
Bicarbonate (HCO_3)	8.9	146	
Calcium (Ca)	15.0		750
Magnesium (Mg)	Heavy Trace		-
Sodium (Na) (by difference)	4.9		215
TOTALS	67.2	965	965

Total Solids dried @ 110°C. 75.4 parts/100,000
" " ignited 61.4 " "
pH value 8.0 - 8.5

SAMPLE NO. 2 (635 - 650 feet)

CONSTITUENT	PARTS/100,000 PTS. WATER	EQUIVALENTS PER 100,000 PARTS X 1000	
		Acidic	Basic
Sulphate (SO_4)	27.7	577	
Chloride (Cl)	14.6	412	
Bicarbonate (HCO_3)	34.4	564	
Calcium (Ca)	8.7		435
Magnesium (Mg)	Heavy Trace		-
Sodium (Na) (by difference)	25.7		1118
TOTALS	111.1	1553	1553

Total Solids dried @ 110°C. 96.2 parts/100,000
" " ignited 78.6 " "
pH value 8.5

(P. T. O.)

SAMPLE NO. 3 (752 - 280 feet)

CONSTITUENT	PARTS /100,000 PTS. WATER	EQUIVALENTS PER 100,000 PARTS X 1000	
		Acidic	Basic
Sulphate (SO_4)	33.2	692	
Chloride (Cl)	4.6	130	
Bicarbonate (HCO_3)	23.1	379	
Calcium (Ca)	10.9		545
Magnesium (Mg)	Heavy Trace		-
Sodium (Na) (by difference)	15.1		656
TOTALS	86.9	1201	1201

Total Solids dried @ 110°C. 98.4 pts/100,000
" " ignited 71.2 " "
pH value 8.0 - 8.5

SAMPLE NO. 4 (831 - 836 feet)

CONSTITUENT	PARTS/100,000 PTS. WATER	EQUIVALENTS PER 100,000 PARTS X 1000	
		Acidic	Basic
Sulphate (SO_4)	34.8	726	
Chloride (Cl)	6.4	180	
Bicarbonate (HCO_3)	22.5	369	
Calcium (Ca)	10.2		510
Magnesium (Mg)	Heavy Trace		-
Sodium (Na) (by difference)	17.6		765
TOTALS	91.5	1275	1275

Total Solids dried @ 110°C. 97.6 pts/100,000
" " ignited 78.0 " "
pH value 8.0 - 8.5

Although these waters are all alkali bicarbonate type, sample No. 2 shows a decidedly different composition from the other three.

It will be observed that the alkali metals have been determined by difference and calculated as sodium. The small quantities of material available made this necessary.

For ANGLO-IRANIAN OIL CO. LTD.

(Sgd.)

CHIEF RESEARCH CHEMIST.

HCR/ (Sgd.) HCR

JH (Sgd.)

REPORT NO. AP.N/144

Sunbury Ref. G. 809

12. 2. 38.

WATER SAMPLES FROM COUSLAND NO. 1 TEST WELL

Requested by: D'Arcy Exploration Company, Ltd.
via Refining and Technical Branch
in memo of 25.1.38 (H.O. No. 1047)

Object: To carry out an analysis of a sample of water produced at Cousland No.1 well.

CONCLUSIONS:

This sample differs from the previous ones drawn from this well in its higher total solids content and also in its chloride/carbonate ratio, which in the present case is very much higher.

HISTORY:

The sample received was obtained during bailing tests of the 1248'-1275' oily sandzone.

EXPERIMENTAL:

The sample as received was filtered and the following data obtained on the filtrate :-

Total Solids dried @ 110°C. 158.8 pts/100,000
" " ignited 133.4 " "
pH value 8.0

REPORT NO. AP.N/144 - Contd. 12. 2. 38

Sunbury Ref. G. 809

CONSTITUENT	PARTS/100,000 PTS. WATER	EQUIVALENTS PER 100,000 PARTS X 1000	
		Acidic	Basic
Sulphate (SO_4)	7.6	158	
Chloride (Cl)	72.2	2036	
Bicarbonate (HCO_3)	5.6	92	
Magnesium (Mg)	0.9		75
Calcium (Ca)	11.2		560
Sodium (Na)	38.7		1683
Potassium (K)	0.5		13
Ammonium (NH_4)	extremely slight trace		-
TOTALS	136.7	2286	2331

For ANGLO-IRANIAN OIL CO. LTD.

HCR/ HCR (Sgd.) H. G. SMITH

JH CHIEF RESEARCH CHEMIST

(Sgd.) A. K. STARK.

REPORT NO. N/186 3. 5. 39

Sunbury Ref. G. 849

WATER SAMPLE - COUSLAND NO.1 1760 - 1806'

Requested by: d D'Arcy Exploration Co. Ltd. via Refining Branch in memo of 27th April, 1939. (H.O. No. 1526)

Object: Analysis.

CONCLUSIONS:

This sample, which was received on 29th April, 1939, is a brine of total solids content 570.85 parts per 100,000, consisting mainly of sodium chloride and bicarbonate. The sulphate and magnesium contents are small.

HISTORY:

The sample was collected on the 21st April, 1939, from the flow line of Cousland No.1 when flowing gas and water from the 1760' to 1806' sand.

EXPERIMENTAL:

The analysis of this water after filtration is as follows :-

Specific Gravity at 60°F.	1.0025
Total solids (dried at 110°C.) pts./100,000	527.8
Total solids (dried at 600°C.) pts./100,000	486.8
P.h. before boiling	8.5
P.h. after boiling	10.0

CONSTITUENT	PARTS PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGE
		Acidic	Basic	
Sulphate	0.82	17.09	-	0.09
Chloride	242.6	6834.0		38.38
Bicarbonate	125.3	2054.0		11.53
Calcium	14.15		707.5	3.96
Magnesium	0.68		56.67	0.32
Potassium	Heavy Trace		-	-
Sodium *	187.30		8140.92	45.72
TOTALS	570.85	8905.09	8905.09	100.00

* By difference.

For ANGLO-IRANIAN OIL CO. LTD.

(Sgd.)

CHIEF RESEARCH CHEMIST.

JO'D. JO'D. (Sgd.)

MSK

REPORT NO. AP. N/150

Sunbury Ref. G. 849

5. 8. 38

WATER SAMPLE FROM COUSLAND NO.1 WELL

Requested by: D'Arcy Exploration Company, Ltd.
via Refining Branch in memo of 21.7.38. (H.O. No. 1238)

Object: To carry out an analysis of a sample of water produced from Cousland No.1 well, and to compare it with the analysis of a water sample from Midlothian No.1 well of the Anglo-American Oil Company, Ltd.

CONCLUSIONS:

This is a brine containing an appreciable quantity of bicarbonate. Its total solids content is practically three times as great as that of the water drawn at 1248 - 1275' examined in AP.N/144.

HISTORY:

This sample was obtained from a packer test on the formation in Cousland No.1. well between 2178 and 2227 feet. Traces of gas were associated with the water which probably comes from the sandstone between 2181 and 2189 feet.

EXPERIMENTAL:

The following analysis was performed on the sample as received without preliminary filtration, as it was perfectly clear and transparent.

Total Solids dried at 110°C.		376 parts/100,000
" " ignited at 750°C.		319 parts/100,000
pH of water (original)	8.0	
pH " " (after boiling)	9.5	

CONSTITUENT	PTS/100,000	EQUIVALENTS PTS./100,000 X 1000	
		Basic	Acidic
Sulphate (SO_4)	23.1		480
Chloride (Cl)	170.0		4780
Bicarbonate (HCO_3)	36.6		600
Magnesium (Mg)	5.5	460	
Calcium (Ca)	22.1	1100	
Sodium (Na) *	99.0	4300	
Potassium (K)	Absent	-	
	356.3	5860	5860

* Obtained by difference.

DISCUSSION:

The following table gives a comparison of the above analysis with that of water from the Anglo-American Oil Co.'s Midlothian No.1 Well. (Data in parts/100,000).

	Water ex Cousland No.1 D'Arcy Ex. Co.Ltd.	Water ex Midlothian No.1 A-A. Oil Co. Ltd.
Total Alkalinity as $CaCO_3$	30	50
Caustic alkalinity as NaOH	Nil	30.5
Chloride as NaCl	280	292
Sulphate as $NaSO_4$	34.2	11.6
Total solids in solution	376	353
" " " " ignited	319	326
pH	8.0	Not determined

The principle difference in these analyses is in the alkalinity.

The Midlothian sample is stated to have "a slight caustic alkalinity" which incidentally is also stated to amount to more than half the total alkalinity when calculated as NaOH.

The absence of calcium hydroxide from the Cousland sample is shown by the pH value of 8.0.

It is suggested that the alkalinity reported as NaOH in the Midlothian No.1 sample may be adventitious as free sodium hydroxide in solution in natural waters is rare.

For ANGLO-IRANIAN OIL COMPANY, LTD.

(Sgd.)

CHIEF RESEARCH CHEMIST

RAL RAL
EFF.

(Sgd.)

REPORT NO. AP.N/160

Sunbury Ref. G. 849 22. 9. 38

WATER SAMPLE FROM COUSLAND
NO. 1 WELL 2243 - 2772 FT.

Requested by: D'Arcy Exploration Co. Ltd.
(Mr. A. H. Taitt)
in memo of 9.9.38 (H.O. No. 1280)

Object: Analysis.

CONCLUSIONS:

This is a brine containing an appreciable quantity of calcium but only a small quantity of bicarbonate. Its total solids content is 1422 pts/100,000, which is less than half that of the water drawn at 2371 - 2404 feet, and four times as much as the water drawn at 2178-2227. The analyses of the total solids derived from these three samples of water are, however, very similar to one another.

HISTORY: Lab. No. 1321

This water was collected from the drill pipe immediately above the valve after a Halliburton packer test of the formation between 2243' and 2772'.

EXPERIMENTAL:

The sample was given a preliminary filtration to render it free from suspended drilling mud. It then gave the following figures on analysis :-

Specific Gravity at 60°F.		1.0095
Total solids dried at 110°C.	pts/100,000	1670
" " ignited at 600°C.	"	1422
pH as received		8.0
pH after boiling		10.0

CONSTITUENT	PARTS PRESENT PER 100,000	EQUIVALENTS X 1000		IONIC PERCENTAGES
		Acidic	Basic	
Sulphate	11.6	242		0.5
Chloride	866.0	24300		48.0
Bicarbonate	46.8	768		1.5
Magnesium	19.7		1623	3.2
Calcium	119.2		5950	11.8
Sodium *	408.0		17737	35.0
TOTALS	1471.3	25310	25310	100.0

* By difference.

For ANGLO-IRANIAN OIL COMPANY, LTD.
(Sgd.) D.G. SMITH
CHIEF RESEARCH CHEMIST
(Sgd.) A.K. STARK.

RAL. RAL.
PH.

REPORT NO. AP.N/155 24. 8. 38

Sunbury Ref. G. 849

WATER SAMPLE FROM COUSLAND NO.1 WELL
BETWEEN 2371 FEET AND 2404 FEET

Requested by : D'Arcy Exploration Company, Ltd.
via Refining Branch in memo of 5.8.38 (H.O. No. 1261)

Object: Analysis.

CONCLUSION:

This is a brine containing an appreciable quantity of calcium but only a small quantity of bicarbonate. Its total solids content is approximately ten times as great as that of the water drawn at 2178-2227' examined in A.P. N/150.

HISTORY: Lab. No. 623

The sample which was received on 6.8.38 was obtained from the formation in Cousland No.1 well between 2371 and 2404 feet.

The water was slightly gassy when receivdd.

REPORT NO. AP.N/155 - Contd. 24.8.38.

EXPERIMENTAL:

The following analysis was performed on the sample after preliminary filtration to r remove suspended matter.

Total Solids dried at 110°C.	3674 pts/100,000
" " ignited at 600°C.	3199 pts/100,000
pH of water (original)	8.0
" " " (after boiling)	10.0

CONSTITUENT	PARTS PER 100,000	EQUIVALENTS X 1000	
		Basic	Acidic
Sulphate $SO_4^{=}$	1.0	21	
Chloride Cl	2026.0	57160	
Bicarbonate HCO_3	60.5	992	
Magnesium Mg^{++}	42.8		3525
Calcium Ca^{++}	246.0		12300
*Sodium Na^{+}	973.8		42348
Potassium K^{+}	Trace only		
TOTALS	3350.1	58173	58173

* Obtained by difference.

For ANGLO-IRANIAN OIL COMPANY, LTD.

(Sgd.)

CHIEF RESEARCH CHEMIST.

RAL. RAL.

PH.

(Sgd.)

REPORT NO. N/180

Sunbury Ref. G.849

16.3.39.

WATER SAMPLE FROM COUSLAND NO.2 WELL

FROM 1490 - 1528 FT. SAND

CONCLUSIONS:

This is a slightly alkaline brine containing small quantities of calcium and magnesium chlorides. Sulphates are present in traces only. Its total solids content is practically ten times that of the water drawn from Cousland No.1 well between 2178' and 2227', examined in Report No. AP.N/150. This latter contained a higher concentration of sulphate and bicarbonate than the present sample.

HISTORY:

Lab. No. 5059. One Winchester quart of this sample was received on 6.3.39. The water was obtained from a Halliburton packer test, and consists of unfiltered fluid taken from just above the packer after the latter had been pulled.

Date of Collection	1.3.39
Position of Packer	1461' below rotary table.
Bottom of Hole.	1528' below rotary table.

EXPERIMENTAL:

The analysis, after filtration, of this sample is as follows :-

Specific Gravity at 60°F.	1.0245
Total solids dried at 110°C. pts. per 100,000 -	3,791
Total solids ignited at 600°C. pts. per 100,000 -	3,271
pH value as received	8.0
pH value after boiling	9.5

(Continued on Page 7)

REPORT NO. N/180 - Contd.
Sunbury Ref. G.849

CONSTITUENT	PARTS PRESENT per 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGE
		Acidic	Basic	
Sulphate	1.6	33		0.01
Chloride	2110	59400		49.57
Bicarbonate	30.5	500		0.42
Magnesium	57.5		4730	3.95
Calcium	227.5		11375	9.50
Iron & Potassium	absent		-	-
Sodium *	1009		43828	36.65
Totals	3436	59933	59933	100.00

* by difference.

The analysis of the water from Cousland No.1 between 2187' and 2227', taken from Report AP.N/150 of 5.8.38, is given below for comparison :-

Total solids dried at 110°C. (pts. per 100,000).	e 376
Total solids ignited at 750°C. (pts. per 100,000).	319
p.H. of water (original)	8.0
p.H. of water (after boiling)	9.5

CONSTITUENT	PARTS PRESENT PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGE
		Acidic	Basic	
Sulphate	23.1	480		4.10
Chloride	170.0	4780		40.80
Bicarbonate	36.6	600		5.10
Magnesium	5.5		460	3.92
Calcium	22.1		1100	9.38
Potassium	absent		-	-
Sodium *	99.0		4300	36.7
Total	356.3	5860	5860	100.00

REPORT NO. N/183
Sunbury Ref. G.849

29.3.39

WATER SAMPLE EX COUSLAND NO.2 WELL
Depth 1878 ft.

CONCLUSIONS:

This is a brine containing fairly large quantities of calcium and magnesium chlorides. Sulphates, bicarbonates and iron are present in traces only. Its total solids content, 4800 p.p. 100,000, is rather greater than that of the sample of water from 1490' to 1528' sand examined in Report No. N/180.

HISTORY:

Lab. No. 5435. This water was collected during a Halliburton Packer test carried out on 1.3.39.

Depth of Hole	1878' below rotary table.
Position of Packer	1726' below rotary table.

The sample sas taken from just above valve in tester.

EXPERIMENTAL:

The analysis of this water, after filtration, is as follows :-

Specific Gravity at 60°F.	1.0335
Total Solids dried at 110°C. parts per 100,000	5,488
Total Solids ignited at 600°C. " " "	4,585
pH value as received	7.5
pH value after boiling	9.5

(P.T.O.)

REPORT NO. N/183 - Continued.

Sunbury Ref. G.849

CONSTITUENTS	PARTS PRESENT PER 100,000	EQUIVALENTS X 1000		EQUIVALENTS PERCENTAGE
		Acidic	Basic	
Sulphate	2.0	42		0.02
Chloride	3058	86150		49.82
Bicarbonate	17	279		0.16
Iron (ferrous)	3.3		177	0.10
Magnesium	181		14900	8.62
Calcium	481		24050	13.90
Potassium	absent		-	-
Sodium *	1090		47344	27.38
Totals	4832.3	86471	86471	100.00

* by difference.

Since the filtered water deposited ferric hydroxide on standing, it is presumed that the iron is present as ferrous bicarbonate.

REPORT NO. N/188

Sunbury Ref. G.849 10.5.39

WATER SAMPLE EX COUSLAND NO. 2 WELL

at 2290 - 2432'.

CONCLUSIONS:

This is a brine of total solids content 994.2 parts per 100,000. It differs but slightly from the previous sample from the 2016 - 2020' sandstone. The bicarbonate content is greater in the present sample but there is little difference in the sulphate contents.

HISTORY:

Lab. No. 6294 - received on the 8th May, 1939. This sample was obtained during a packer test of the formation between 2290 - 2432' in Cousland No.2. It represents formation water from the 2284 - 2412' sandstones.

EXPERIMENTAL:

The analysis of this water after filtration is as follows :-

Specific Gravity at 60°F.	1.0055
Total Solids dried at 110°C. pts./100,000	1043
Total Solids ignited at 800°C. pts./100,000	885.6
pH before boiling	8.5
pH after boiling	9.0

CONSTITUENTS	PARTS PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGE
		Acidic	Basic	
Sulphate	6.65	138		0.43
Chloride	500.0	14090		44.00
Bicarbonate	108.5	1779		5.56
Magnesium	9.4		773	2.41
Calcium	39.5		1975	6.18
Potassium	5.15		131	0.41
Sodium *	325.0		13128	41.01
Totals	994.2	16007	16007	100.00

* by difference.

REPORT NO. N/189

Sunbury Ref. G.849 19.5.39

WATER SAMPLES FROM COUSLAND

CONCLUSIONS:

Sample No.1. This sample differs from the 2284' to 2412' sandstone water (Report No. N/188 dated 10th May, 1939) in containing larger proportions of sulphate and bicarbonate. Its total solids content is 293.6 parts per 100,000.

(Continued on p.9)

REPORT NO. N/189

Sunbury Ref. G.849

19.5.39.

WATER SAMPLES FROM COUSLAND

CONCLUSIONS - Continued.

Sample No.2. This is a hard water containing fair quantities of calcium, magnesium sulphates and bicarbonates. Its total solid content is 83 parts per 100,000.

Sample No.3. This sample resembles Sample No.1 in the relative proportions of the constituents but the total solids content of 160.5 parts per 100,000 is approximately half that of No.1.

HISTORY:

The following samples were received on 8th May, 1939.

Lab. No. 6363 - Sample No.1. Sample of water collected about 1000 ft. from bottom of drill pipe after formation test of the 2290' to 2432' interval in the Cousland No.2 well on the 3rd and 4hh May, 1939.

Lab. No. 6364 - Sample No.2. Sample of water used at Cousland No.2 for mixing drilling fluid. This sample was collected from the source of supply on the 5th May, 1939.

Lab. No. 6365 - Sample No.3. Sample of water filtered from the drilling fluid returns of Cousland No.2 well on the 5hh May, 1939.

EXPERIMENTAL:

Lab. No. 6363

Specific Gravity at 60°F.	1.0005
Total Solids dried at 110°C. parts/100,000	292.4
Total Solids ignited at 600°C. "	213.0
pH as received	8.5
pH after boiling	9.5

CONSTITUENTS	PARTS PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGES
		Acidic	Basic	
Sulphate	19.0	395		4.26
Chloride	121.5	3422		37.09
Bicarbonate	49.2	807		8.73
Calcium	13.3		665	7.19
Magnesium	2.1		171	1.84
Potassium	3.6		93	1.00
Sodium *	84.9		3695	39.89
Totals	293.6	4624	4624	100.00

* by difference.

Lab. No. 6364

Specific Gravity at 60°F.	1.0000
Total Solids dried at 110°C. parts/100,000	86.4
Total Solids ignited at 600°C. "	61.2
pH as received	8.5
pH after boiling	9.5

CONSTITUENTS	PARTS PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGES
		Acidic	Basic	
Sulphate	34.8	725		30.54
Chloride	2.6	74		3.09
Bicarbonate	23.7	388		16.36
Calcium	16.3		813	34.24
Magnesium	2.9		241	10.17
Potassium	1.0		61	2.57
Sodium *	1.7		72	3.03
Totals	83.0	1187	1187	100.00

* by difference.

(P.T.O.)

REPORT NO. N/189 - Continued.

Sunbury Ref. G. 849

Lab. No. 6365

Specific Gravity at 60°F.	1.0005
Total Solids dried at 110°C. parts / 100,000	152.6
Total Solids ignited at 600°C. " "	138.0
pH as received	8.5
pH after boiling	9.5

CONSTITUENT	PARTS PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGES
		Acidic	Basic	
Sulphate	17.7	368		7.29
Chloride	63.0	1775		35.19
Bicarbonate	23.1	379		7.51
Calcium	6.0		298	5.90
Magnesium	0.7		54	1.08
Potassium	0.3		8	0.15
Sodium *	49.7		2162	42.88
Totals	160.5	2522	2522	100.00

* by difference.

REPORT NO. N/198

Sunbury Ref. G.849

29. 6. 39.

COUSLAND NO. 3 WELL. WATER SAMPLE

1468/1581 FT.

CONCLUSIONS :

This is an alkaline brine containing 717.2 parts total solids per 100,000, of which the greater part is sodium chloride. It is very similar to the water produced from Cousland No.2 at 2290' - 2432' examined in Report No. N/188.

HISTORY :

Lab. No. 7289 - The sample, which was received on 19.6.39, consisted of one Winchester of saline mud obtained from just above the valve in the packer test carried out at Cousland No.3 on June 14th, 1939. The bottom of the packer was at 1468' and the bottom of the hole at 1581'.

EXPERIMENTAL :

The sample, after a preliminary filtration, was submitted to the standard procedure, with the following results :-

Specific Gravity at 60°F.	1.0050
Total Solids at 110°C. Pts.per 100,000	797
Total Solids at 600°C. " " "	672
pH. evalue as received	8.0
pH. after boiling	8.5

CONSTITUENT	PARTS PRESENT PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGES
		Acidic	Basic	
Sulphate	10.9	227		0.93
Chloride	403	11360		46.70
Bicarbonate	35.1	576		2.37
Magnesium	10.5		864	3.56
Calcium	32.7		1635	6.73
Potassium	6.0		154	0.63
Sodium *	219.0		9510	39.08
Totals	717.2	12163	12163	100.00

* by difference.

REPORT NO. N/204

Sunbury Ref. G.849 19. 7. 39.

MUD FLUID SAMPLES FROM COUSLAND NO.3 WELL.

CONCLUSIONS:

These waters are alkaline brines, that from 1749 feet containing 4028, and that from 1725 feet containing 649 pts. total solids per 100,000. This latter is similar to the sample obtained from 1468/1581 feet examined in Report No. N/198 of 29.6.39.

HISTORY:

Lab. Nos. 7563 and 7643 - received on 28hh and 30th of June, 1939.
Particulars of the samples are as follows :-

Lab. No. 7563 - 1 Winchester of fluid, labelled -
'Halliburton Flow Test 26.6.39'
Sample from immediately above valve
Packer set at 1749 feet.

Lab. No. 7643 - 2 Winchesters of mud fluid labelled -
'Halliburton Flow Test 22.6.39'
Sample from immediately above valve
Packer set at 1725 feet.

EXPERIMENTAL:

The samples, after a preliminary filtration, were submitted to the standardized procedure with the following results :-

REFERENCE	LAB. NO. 7563 PACKER AT 1749'	LAB. NO. 7643 PACKER AT 1725'
Specific Gravity @ 60°F.	1.0280	1.0035
Total Solids at 110°C. pts.per 100,000	4618	700
Total Solids at 600°C. pts.per 100,000	3833	608
pH value as received	8	8
pH value after boiling	9.5	8.5

CONSTITUENT	LAB. NO. 7563 PACKER AT 1749'				LAB. NO. 7643 PACKER AT 1725'			
	PTS.PRESENT PER 100,000	EQUIVALENT X 1000 Acidic	Basic	EQUIVALENT PERCENTAGE	PTS.PRESENT PER 100,000	EQUIV.X 1000 Acidic	Basic	EQUIV. PERCENTAGE
Chloride	2495	70,300		49.75	373.5	10,530		47.43
Sulphate	0.5	10.4		0.01	9.8	204		0.92
Bicarbonate	20.7	340		0.24	22.3	366		1.65
Magnesium	75.3		6200	4.38	11.0		906	4.08
Calcium	361.0		18050	12.78	36.1		1805	8.12
Potassium	18.2		466	0.33	7.7		197	0.89
Sodium *	1057		45934	32.51	188.5		8192	36.91
Totals	4028	70,650	70650	100.00	648.9	11,100	11100	100.00

* by difference.

REPORT NO. N/209

Sunbury Ref. G. 849 18. 8. 39.

WATER SAMPLE FROM COUSLAND NO.3 WELL

CONCLUSIONS:

This is a neutral brine of total solids content 6684 pts. per 100,000, mainly consisting of sodium and calcium chlorides. This is approximately 10 times that of the previous sample from Cousland No.3 at 1468/1581 feet, examined in Report No. N/198 of 29.6.39.

HISTORY:

Particulars of the sample which was received on 4.8.39 are as follows :-
Sample of saline water collected from Cousland No.3 on 31st July, 1939, from immediately above the valve, with packer set at 2117 feet with bottom of the hole at 2164 feet.

EXPERIMENTAL:

After a preliminary filtration, the sample has been analysed with the following results :-

(P.T.O.)

EXPERIMENTAL - CONTINUED

Specific Gravity at 60°F.	1.0480
Total Solids at 110°C. Pts. per 100,000	7,990
Total Solids at 600°C. " " "	6,440
pH value as received	7.0
pH after boiling	8.0

CONSTITUENT	PARTS PRESENT PER 100,000	EQUIVALENTS X 1000		EQUIVALENT PERCENTAGE
		Acidic	Basic	
Chloride	4170	117,600		49.90
Sulphate	0.5	10		0.01
Bicarbonate	12.2	200		0.09
Iron (ferrous)	2.2		79	0.03
Magnesium	112.6		9,270	3.94
Calcium	763.0		38,150	16.24
Potassium	17.9		458	0.19
Sodium *	1606		69,853	29.60
Totals	6684	117,810	117,810	100.00

* by difference.

APPENDIX C. GAS ANALYSES

COUSLAND NO.1 - GAS SAMPLE

Depth 1188 - 1209 Ft.

CONCLUSIONS:

This is a lean gas of the normal type associated with crude petroleum.

HISTORY:

The sample was taken between 1188 and 1209 feet at a pressure of about 300 lbs. per sq. inch.

EXPERIMENTAL:

The following is an analysis of the gas :-

Methane	95.85%
Ethane	2.30%
Propane	1.24%
Butanes	0.46%
Pentanes	0.14%

From the above data it will be observed that for rough calculation purposes the viscosity of the gas can be assumed to be equal to that of methane.

The calculated specific gravity is 0.047 lbs. per cu. ft. or 0.58 compared with air as 1.0.

Depth 1248 - 1275 Ft.

CONCLUSIONS:

This gas is of the same type as that examined from the same source in A.P. S/40.

Lab. No. 6883 - Gas collected at 50 lb. pressure at a depth of 1248/75 Ft.
Received from D.E.C. 4.2.38.

Podbielniak Gas Analysis

Methane %	90.75	Gas Volume
Ethane %	3.1	
Propane %	3.5	
Butanes %	2.05	
Pentanes %	0.60	

DEPTH 1584 - 1586 FT.

CONCLUSIONS:

The fact that there is more C_4 and C_5 than C_3 present suggests contamination. This sample should not be taken as truly representative of the show, without confirmation on a further sample.

HISTORY:

This sample was drawn on 5-4-38 into a two valves cylinder ex Sunbury.

EXPERIMENTAL:

LAB. NO. 8208	1ST DETERMINATION	Air Free Basis	2ND DETERMINATION	Air Free Basis
Oxygen % gas volume	1.95	-	2.16	-
Nitrogen "	14.2	7.6	14.1	6.6
Methane "	80.5	88.6	80.4	89.6
C_2 "	1.6	1.8	1.6	1.8
C_3 "	0.15	0.2	0.15	0.2
C_4 "	0.75	0.8	0.7	0.8
C_5 "	0.6	0.7	0.6	0.7
Residue boiling above 50°C. % gas volume	0.3	0.3	0.3	0.3
Total Unsaturated		0.7%		0.7%

DISCUSSION:

Although very great precautions were taken to free this cylinder from gas before despatch to Pevensey, the above analyses suggest that complete purging was not realised. It is therefore suggested that a further sample be drawn in order that a redetermination may be made.

DEPTH 1596 - 1652 FT.

CONCLUSIONS:

This sample resembles that drawn from 1589 - 1591 ft. and described in Report No. A.P.S/46. Both the above gases are absolutely dry containing no hydrocarbon higher than C_2.

HISTORY:

Gas was received in two cylinders and was described in memo. of 14.4.38 from Resident Geologist Cousland to Sunbury.

Lab. No. 8307 - Received ex D.E.C. 20.4.38.

			Air Free Basis
Oxygen	% Gas Volume	0.35	-
Nitrogen	"	2.8	1.55
Methane	"	94.3	95.85
Ethane	"	2.55	2.6

Due to the fact that one cylinder had leaked down to atmospheric pressure, it has not been possible to conserve a sample of this gas for the Petroleum Department's examination.

DEPTH 1760 - 1806 FT.

CONCLUSIONS:

This gas is very similar to that previously collected at the same depth (vide Report A.P. S/55 dated 10th June, 1938).

HISTORY:

The following sample was received on 26th May, 1939.

Lab. No. 6815 - Sample of gas from Cousland No.1, collected on 21.4.39 at 350 lbs. per sq. inch during a test of the 1760 - 1806 ft. sand.

EXPERIMENTAL:

The following data were obtained :-

	SAMPLE AS RECEIVED	AIR FREE BASIS
Oxygen %	0.85	-
Nitrogen %	7.15	4.05
Methane %	90.7	94.6
Ethane %	0.7	0.75
Propane & higher %	0.6	0.6
Density (calculated)(Air = 1)	0.597 = 0.0483 lbs. per cu.ft.	-
" (determined)(Air = 1)	0.602	-

DEPTH 2094 - 2122 FT.

CONCLUSIONS:

This gas shows a noticeable proportion of hydrocarbons higher than C_2. Earlier samples from this well have been shown to be quite free from hydrocarbons higher than C_2, but in the samples tested immediately prior to this (A.P. S/55), small quantities of C_3 and higher were detected. These quantities are sensibly increased in the sample under examination.

HISTORY:

D'Arcy Exploration Company write with reference to this sample :-

"The formation tested was between 2086 and 2127 ft., but the gas originates from the sandstone between 2094 and 2122 ft. The gas should be under a pressure of about 250 lbs. per sq. inch."

EXPERIMENTAL:

	SAMPLE AS RECEIVED	AIR FREE BASIS
Oxygen %	0.47	-
Nitrogen %	8.19	6.55
Methane %	85.95	87.9
Ethane %	3.75	3.85
Propane %	1.0	1.05
Butanes %	0.55	0.55
Pentanes %	0.1	0.1
Sp. Gr. (Air = 1)	0.628	
Density lbs. per cu. ft.	0.0507	

TABLE 2

ANALYSES OF COUSLAND & MIDLOTHIAN GAS SAMPLES CALCULATED ON AN AIR FREE BASIS

(FROM A NOTE BY G.W. LEPPER OF MINES DEPT.)

C — COUSLAND WELL: M — MIDLOTHIAN WELL: SH — SHEFFIELD: SN — SUNBURY: FA — FAWLEY: --- — NOT DETERMINED 0.0 — NOT PRESENT.

WELL	DEPTH FT.	ANALYSIS	LAB.REF. NO.	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	NITROGEN	CARBON DIOXIDE	PER CENT PARAFFINS	REMARKS
1.C	1188 - 1209	Sn	A.P. S.40	95.85	2.30	1.24	0.46	0.14	0.0 (?)	–	100	A slightly "wet" gas. Absence of Nitrogen is unusual.
2.C	1248 - 1275	Sn	A.P. S.42	90.75	3.1	3.35	2.05	0.60	0.0 (?)	–	100	A "wetter" gas. ditto.
3.C	1248 - 1275	Sh	T.Misc.154	83.79	7.2	–	–	–	8.43	0.58	90.99	
4.C	1570 - 1575	Sh	T.Misc.155	88.6	5.4	–	–	–	5.4	0.5	94.0	These samples come from gas sands which are closely related geologically. The gas is to be classed as "dry".
5.C	1584 - 1586	Sn	A.P. S.46	94.65	1.79	0.0	0.0	0.0	3.55	–	96.44	
7.C	1584 - 1586	Sh	T.Misc.159	88.8	5.2	–	–	–	5.4	0.5	94.0	
8.C	1596 - 1652	Sn	A.P. S.51	95.85	2.6	0.0	0.0	0.0	1.55	–	98.45	
9.M	1,997 - 2012	Sh	?	87.3	4.25	–	–	–	7.94	0.51	91.55	
11.M	2318 - 2400	Sh	T.Misc.151	76.5	13.1	–	–	–	10.3	0.1	89.6	
12.M	2318 - 2400	Fa	?	79.06	7.07	3.03	0.0	0.0	10.74	0.1	89.16	
1.M	1700 - 1815	Sh	T.Misc.168	62.02	28.35	–	–	–	9.42	0.07	90.37	Wet gas from 1735-60' oilsand. 0.18 sol. in conc. H_2SO_4. Unsaturated nil.
1.M	1700 - 1955	Sh	T.Misc.167	85.05	5.61	–	–	–	9.26	0.07	90.66	Gas leaked up from below plug at 1955'.
1.C	1584 - 1586	Sh	T.Misc.159A	87.2	6.4	–	–	–	5.9	0.1	93.6	Send from Sn to Sh cf. No.5 0.3 sol. in conc. H_2SO_4. Unsaturated nil.
1.C	1582 - 1632	Eg.	Prof. Egerton	91.0	2.0	0	0	0	Tr.	Tr.	93.0	Communicated by Mr. A.H. Taitt.

TABLE 2 - CONTD.

WELL	DEPTH FT.	ANALYSIS	LAB. REF. NO.	METHANE	ETHANE	PROPANE	BUTANE	PENTANE	NITROGEN	CARBON DIOXIDE	PER CENT PARAFFINS	REMARKS
1.C.	1720 - 1734	Sn	A.P.S. 55 (A)	98.0	1.0		0.7		0.32	-	99.7	These do not compare well.
1.C.	1720 - 1734	Sh	T.Misc. 163	87.8	5.6	-	-	-	5.6	1.0	93.4	Very similar data.
1.C.	1759 - 1806	Sh	T.Misc. 164	88.5	5.7	-	-	-	4.7	1.03	94.2	These do not compare well.
1.C.	1759 - 1806	Sn	A.P.S. 55 (B)	94.0	2.9	0.3		0.3	2.59	-	97.5	
1.C.	2094 - 2122	Sn	A.P.S. 56	87.9	3.85	1.05	0.55	0.1	6.55	-	93.45	These analyses compare fairly well. a slightly "wet" gas
1.C.	2094 - 2122	Sh	T.Misc. 169	84.1	7.75	-	-	-	7.9	0.24	91.9	
1.M.	2050 - 2204	Sh	T.Misc. 175	79.63	9.94	-	-	-	10.16	0.17	89.6	Probably slightly "wet" gas. 0.10 sol. in conc. H_2SO_4. Unsaturated nil.
1.M.	2050 - 2090	Sh	T.Misc. 177	87.4	3.4	-	-	-	9.05	0.15	90.8	
1.M.	1997 - 2009	Sh	T.Misc. 178 *	86.43	4.22	-	-	-	8.85	0.5	90.7	Agrees fairly well with No.9 of previous note.

* T. Misc. 178. This sample as received at Sheffield was labelled :- taken on September 14th: source 2088 ft. Mr. Chapman of the A.A.O.C. on 4.1.39 states that this label was incorrect and should read :- September 21st, 1997 - 2009 ft. as the sample was taken through perforations in the 7" casing over that range of depth.

G. W. L.

APPENDIX D - OIL ANALYSES

COUSLAND NO. 1

DEPTH 831 - 853

CONCLUSIONS:

The material extracted from the powdered core by solvents is highly waxy in nature, and amounts to 0.86% by weight of the sand.

HISTORY:

D'Arcy Exploration Co. Ltd. write as follows with regard to the condition of this sample :-

"Although the core is waxed up on the surface owing to evaporation of the lighter fractions, the oil inside should be in its original condition. The core has never been above 55°F. which cannot be many degrees above its temperature in situ."

EXPERIMENTAL:

The dample as received consisted of several large lumps of core each weighing about 1 kilogram. One of these pieces was ground to a fine powder, and was extracted with carbon tetrachloride, the solvent being afterwards removed.

The yield so obtained was 0.86% by weight.

The characteristics of the CCl_4 extracted material, which had the appearance of a dark brown wax, were as follows :-

Specific Gravity at 60°F.		0.875
Melting Point	°F.	102
Sulphur	%	0.13
Hard Ashphalt		Trace
Soft Asphalt	%	8.0
Total Wax at 60°F.	%	26.4
Melting Point	°F.	109
Hard Wax at 32 °F.	%	23.2
Melting Point	°F.	118

CORES

CONCLUSIONS:

The oils obtained from all these cores have similar characteristics, being highly asphaltic and waxy. The quantity present varies from 1.5% to 4.8% be weight. The sulphur content averages about 0.1%. Porosity determinations carried out on two samples of core gave results of 18.1%, 23.0%.

EXPERIMENTAL:

Portions of all samples of core were ground to pass 40 mesh sieves and extracted with hot benzene and the solvent removed dfrom the dissolved oil and asphalt by distillation.

Further portions of the broken samples of core were charged to a small retort and subjected to distillations in the presence of steam. A non asphaltic, waxy distillate was then obtained.

It is considered that these two processes of extraction of the oil are necessary as there is no method available which will allow of the recovery of both the lightest and heaviest portions of the oil content in one operation. There having been a show of gas from this drilling (cf. A.P. S/40) it was considered that there might be some very light hydrocarbons associated with the cores.

Since they gave evidence of the presence of light oil, the last two cores were distilled on a much larger scale from a pipe retort without the use of steam and also with adequate precautions for collecting all oil and gas evolved.

TABLES I & II - PAGE 18A- overleaf.

T A B L E I

Lab. No.	5653	5770	5654	5655	5753	5907	5944	5945
Depth Ft.	931/32	938/39	949/50	969/70	1162/65	1192/202	1262	1248/58
Yield by Extraction %	3.17	6.0	2.6	4.8	-	1.4	3.5	1.5
Constants of Oil								
Melt'g Pt. °F.	110	110	105	168	129	102	102	below 70
Sp. Gr. @ 60°F.	.849	.885	.886	.912	.915	.867	.886	.877
Sulphur %	0.10	0.09	0.11	0.07	0.31	0.08	0.09	0.09
I.B.P. °C.	200							
Vol. to 275°C. %	10							
350°C.	30							
Yield by Distillation with steam %	3.8	4.8	3.7	4.7	1.5	2.2	4.7	-
Constants of Oil								
I.B.P. °C.	220	70	130	180	-	-	90	-
Vol. to 250°C. %	-	35	15	10	-	-	20	-
375°C.	45	75	40	50	-	-	55	-
Porosity %							18.1	23.0

The results obtained on the one Kilogramme scale distillation were as follows :-

T A B L E II

Lab. No.	5944	5945
Depth Ft.	1262	1248/58
Yield %	3.68	1.50
Vol. of Gas Litre / kg. core	4.5	6.4
Analysis of Gas (Approx.)		
Air %		10.0
CO_2 %		3.5
H_2 %		35.8
Unsaturateds %		1.8
I.B.P. °C.	65	indef.
Vol. to 150°C. %	8.5	85 indef.
150°C - 275°C. %	18.8	12.5% to 175°C.
275°C - 350°C. %	25.9	11.0% (175°C - 275°C.)
Residue above 350°C. %	46.8	28.0
Sp. Gr. at 60°F. of 1st fraction	.745	48.5
Aniline Point of 1st fraction °C.	48.3	.770
		54.2

DEPTH 1248 - 1275 FT.

CONCLUSIONS:

This oil is of the paraffin base type. Its sulphur content is similar to those of the oils from the cores from the same source reported in AP.S/41. That this sample may be considered to be somewhat weathered is shown by the fact that it is considerably less volatile than either of the samples reported in Table 2 of the above report. It is not therefore strictly fair to compare such data as aniline points of wide cut initial fractions.

In wax content it appears to be lower than the oils described in Table 1 of AP.S/41, which may be due to the fact that wax had been preferentially filtered out of the crude (in flowing from the formation and left as a residue in the formation) in the cases of some of the cores previously handled.

HISTORY:

This sample was obtained, contaminated with mud, during a bailing test of the zones from which the cores have already been examined.

EXPERIMENTAL:

The oil on receipt was in the form of a semi-solid brown emulsion of oil and water. It s smell was pleasant and no hydrogen sulphide was detected. This emulsion was shaken thoroughly and a preliminary examination carried out on a portion of the shaken sample. The following results were thus obtained :-

Water	15.8 % wt.
Sediment (mud)	1.5 % wt.
Oil (by diff.)	82.7 % wt.
Approx. I.B.P.	100 °C.
Vol. to 275°C.	22 %

The fraction boiling from 100 - 275 °C. had a Sp. Gr. @ 60°F. of 0.792, an. aniline point 66.5°C. and a refractive index of 1.4430 @ 60°F.

It was believed at first that this oil might be contaminated with the T.V.O. used for starting the flow of the well, but the above figures on the 100°C. to 275°C. cut show that this is not the case.

Since little volatile material was present the sample was freed from water and sediment by steam distillation at a high temperature, followed by filtration of the residue. The residue and distillate were then blended back in the proper proportions, to give the original crude oil free from adventitious material.

Thus obtained, the crude was a black viscous liquid (red brown in thin films) with a pleasant smell.

The following data have been obtained on the crude oil :-

Sp. Gravity @ 60°F.	0.863
Hard Asphalt	Trace
Sulphur content	0.08%
Viscosity @ 100°F.	111 sec. Red. 1
Pour Point	50°F.

Distillation on 85 gms charge

I.B.P.	111°C.
Vol. to 125°C.	0.5% by volume
150	2.0 " "
175	4.0 " "
200	6.5 " "
225	8.5 " "
250	11.0 " "
275	15.0 " "
Total Dist. to 390°C.	22.0 " "
Residue above 300°C.	77.0% " "
Loss	1.0% " "

Constants on Fractions :-

Fraction	I.B.P. – 300 °C.	250 – 275 °C.	275 – 300 °C.	Residue above 300 °C.
Bp. Gr. at 60°F.	0.799	0.8145	0.8222	0.882
Aniline Point °C.	68.4	–	–	–
Refracting Index 15.5 °C.	1.4432	–	–	–

DISCUSSION:

The value for the sulphur content given above must be accepted with a certain amount of reserve, since it assumes no loss of volatile sulphur compounds during the preliminary steam distillation. Hydrogen sulphide, however, was not present in the original crude, and it is therefore probable that the above sulphur figure is representative.

A consideration of the specific gravities of the fractions 250 – 275°C., and 275 – 300°C., on the lines indicated in "Report No. 3279 of the Investigations of U.S. Bureau of Mines", lead to the conclusions that this crude oil can be classed as paraffinic. The work described in the Report No.3279, however, was based on a Hempel and a vacuum distillation, whereas in the present instance an A.S.T.M. distillation was carried out.

For ANGLO-IRANIAN OIL CO, LTD.

(Sgd.) D.G. SMITH

CHIEF RESEARCH CHEMIST.

(Sgd.) A.K. STARK.

RAL/R.A.L.

REPORT ON SAMPLES OF OIL

Three samples of oil were received :-

(1) Sample dated 16.1.38 – Depth Sandstone 1248 – 1275 feet
(2) " " 27.2.38 – " " 1248 – 1275 "
(3) " " 11.3.38 – " " 1591 – feet

Sample 1 was a dark, viscous oil, sample 2 was dark but solid at room temperatures, both being practically free from water, while sample 3 was obviously contaminated with water and mud and on test showed a water and sediment content of 32%. To separate the water and mud from the oil in the last sample, it was necessary to centrifuge it at a temperature slightly below 150°F. The attached analysis, therefore, refers in the case of sample 3 to the centrifuged oil, while that for samples 1 and 2 refers to the oils as received.

The oil represented by sample 3, taken at a depth of 1591 feet, shows practically the same characteristics as samples 1 and 2, obtained at 1248 – 1275 feet in January and February respectively.

(Sgd.) G. H. SMITH

Chief Chemist.

(Sgd.) W. ROBERT GUY.

Central Laboratory,
Middleton Hall,

16th March, 1938.

	Sample 16.1.38 Depth Sandstone 1248 - 1275 ft.	Sample 27.2.38 Depth Sandstone 1248 - 1275 ft.	Sample 11.3.38 Depth Sandstone 1591 ft.
Sp. Gr. at 60°F.	.863	.857	.859
Setting Point, (rotating therm. method)	56°F.	64°F.	70°F.
Hard Asphalt	Nil	Nil	-
Sulphur	0.12%	0.12%	0.15%
Br. Val.	5	6	4
Iodine value (Wijs 1 hr.)	14	13	-
Water and Sediment	2.0%	2.0%	-
Water	-	-	-
Distillation Test			
I.B.P.	87°C.	104°C.	163°C.
% Dist. at 125°C	1.0	0.25	-
" " " 150 "	3.0	2.5	-
" " " 175 "	4.5	4.0	0.5
" " " 200 "	6.0	7.0	2.5
" " " 225 "	8.0	9.5	6.0
" " " 250 "	12.0	13.5	11.0
" " " 275 "	16.0	18.0	18.5
" " " 300 "	21.0	24.0	24.5
" " " 325 "	29.0	32.0	33.0
" " " 350 "	42.0	42.5	43.0
10% dist. at	237°C.	230°C.	245°C.
20% " "	297 "	281 "	283 "
30% " "	328 "	320 "	318 "
40% " "	348 "	346 "	343 "
Total Distillate	44.5%	44.5%	45.0%
Residue	55.5%	55.5%	55.0%
Sp. Gr. of dist. at 60°F.	.817	.805	.805
Aniline Point of distillate	81.7°C.	83.5°C.	86.4°C.

CORES

(1) 1586 - 1588 feet

(2) 1625 - 1626 feet

CONCLUSIONS:

The quantities of oil present are 0.5% and 2.1% by weight for core samples taken at 1586 - 8 and 1625 - 6 feet respectively.

Porosity determinations carried out on these two samples gave results of 17.0% and 15.4%.

In general the properties of the oils obtained from these cores are not dissimilar to those previously examined in Report No. AP.S/41.

EXPERIMENTAL:

Portions of these cores were ground to 40 mesh and extracted with hot benzene, and the solvent removed from the extracted material by distillation.

Further portions of these cores were coarsely crushed and distilled from a pipe retort both with and without the aid of steam but with adequate precautions for collecting all the water, oil and gas evolved. A non-asphaltic waxy distillate was obtained in each case.

The following results were thus obtained:-

Lab. No.	8223		8224	
Depth in feet	1586-8		1625-6	
	Without Steam	with Steam	without Steam	With Steam
Oil Yield by dist. %	0.3		1.4	2.1
Sp. Gr. at 60°F.				0.882
Pour point °F.				55
Viscosity at 100°F.				23.5 cs = 90 sec.
				Red I.
Sulphur %	0.22		0.26	0.18

	8223 1586-8 without steam		8224 1625-6 without steam	with Steam
I.B.P. °C.	-	-		170
Vol. 175 - 275°C. %				16
" 275 - 350°C. %				25
Residue above 350°C. %				59
Gas Yields Litres/kg. core	1.24		7.2	4.0
Analysis of gas approx. (air free basis)				
CO_2 -				37.3
H_2 -				28.1
Unsaturateds -			26.0	5.0
Saturateds + N_2 (by diff.)				29.6
Oil Yield by extraction %	0.49			2.2
Approximate MP °F.	80			40
Sulphur %				0.12

The water contents and porosities of these cores have been determined with the following results :-

Depth feet	Lab. No.	Water Content %	Porosity %
1586 - 8	8823	2.4	17.0
1625 - 6	8824	2.8	15.4

In both cases the waters contain ammonia but appear to be only slightly saline.

The water from Lab. No. 8823 contains traces of calcium, magnesium, sulphate and chloride and is of pH value 8.

The water from Lab. No. 8824 is very similar, but contains in addition traces of thiosulphate.

DISCUSSION:

Owing to the fact that the container of sample 8223 was badly punctured on arrival, it appears to be quite possible that the data obtained on this sample may not be representative.

The gas yield obtained on dry distillation of sample 8224 was much higher than was expected. The gas evolved showed a high unsaturateds content, indicating that cracking has taken place.

A second distillation was therefore made, using open steam to keep the temperature down. The results of this second distillation only, should be used in making comparisons with previous samples.

For ANGLO-IRANIAN OIL CO. LTD.,

(Sgd.) D.G. SMITH

CHIEF RESEARCH CHEMIST

(Sgd.) A.K. STARK.

RAL/R.A.L.
HCR/H.C.R.

DEPTH 1722 - 1723 FT.

CONCLUSIONS:

The quantity of oil present in this sample of core is 2.03% by extraction and 1.57% by steam distillation, having sulphur contents of 0.12% and 0.08% respectively. The oil is very similar in general characteristics to that from the 1625 - 6 feet core reported in A.P.S/52 of 13.5.38.

HISTORY: Lab. No. 9198.

The sample of core was taken at a depth of 1722 - 23 feet and was received on 25.5.38., the container being badly punctured.

EXPERIMENTAL:

Portions of this core were extracted with benzene, and steam distilled, in the manner described in Report No. AP.S/52 of 13.5.38.

The following results were thus obtained :-

Oil Yield by steam distillation %	1.57
Specific Gravity at 60°F.	0.873
Melting Point °F.	95
Viscosity at 100°F. cs.	21.4
secs. Red. I	90
Sulphur %	0.08
I.B.P. °C.	240
Vol. to 275°C. %	11
" 275 - 350°C. %	33
Residue above 350°C. %	56
Gas Yield litres/kg. core	10.0
Analysis of gas approx. (Air free basis)	
CO_2 %	63.6
H_2 %	19.0
Unsaturateds %	2.2
Saturateds + N_2 (by diff.) %	15.2
Oil Yield by extraction %	2.03
Melting Point °F.	92
Sulphur %	0.12

DISCUSSION:

Owing to the fact that the container of this sample was badly punctured on arrival, it is quite possible that the data obtained on this sample may not be representative.

The general characteristics of the oil obtained from this core are similar to those of the oil obtained from the 1625 - 6 feet core. Differences are the higher melting point and gas yield of the present sample. This latter is partly accounted for by the increased CO_2 content of the gas.

Both in the case of the present sample and the samples reported in AP.S/52, the presence of hydrogen in the gases arising on steam distillation, is probably due to the decomposition of steam by the hot iron retort.

NOTE:

In report APS/52, the viscosity at 100°F. of the oil from the core taken at 1625 - 6 feet was wrongly given as 23.5 cs = 90 cs. Red. I. This should read : - 23.5 cs = 98 secs. Red I.

For ANGLO-IRANIAN OIL CO. LTD.,

(Sgd.)

for CHIEF RESEARCH CHEMIST.

(Sgd.) H.C. Rampton.

RAL/RAL

JH

REPORT ON CORE SAMPLE AT

1724 - 1725 FEET

A portion of the sample was broken up and the oil extracted with pure Benzene.

Oil Content . . . . 4.4 Imperial Gallons per Ton.

The oil obtained was solid at ordinary temperature, and the following constants were determined thereon :-

Sp. Gr. at 60°F.	.8715
Setting Point (Rot. Therm method)	94°F.
Iodine Value (Wij's 1 hr.)	15.4
Bromine Value	Nil
Sulphur	0.28 %

A second portion of the core was broken up and heated in the usual assay tube. The sample was heated to a temperature of 400°C. in approximately one hour and held at this temperature for two hours. Thereafter, heating was continued so that a final temperature of 800°C. was attained in a further 1¾ hours.

Oil content	3.0 Imperial Gallons per Ton
Water	2.5 " " " "
Gas	800 cu. ft. per ton (approx.)

The small quantity of oil got in this way was tested with the following results :-

Sp. Gr. at 60°F.	.867
Setting Point (Rot. Therm method)	86°F.

The oil recovered from this sandstone core was brownish black in colour and of a waxy nature. From the tests shown above, it is evident that the oil is of the same type as that previously obtained from the bore itself.

As mentioned to the Resident Geologist, Cousland, by telephone, the permeability determination on this core will be reported later along with several others now on hand.

(Sgd.) G.H. SMITH
Chief Chemist

(Sgd.) W. ROBERT GUY.

Central Laboratory,
Middleton Hall.

2nd June, 1938.

CORES

(1) 1791 - 1972 FT.

(2) 1804 - 1805 FT.

Portions of both samples were broken up and the oil extracted with pure Benzene.

	Oil Content (% by wt.)
Core from 1791 - 1792 Ft.	0.77
Core from 1804 - 1805 Ft.	0.99

Certain contents were determined in the oil produced with results as indicated below :-

	Core from 1791-92 ft.	Core from 1804-05 ft.
Sp. Gr. at 60°F.	.922	.922
Setting Point (Rot. Therm Method)	51°F. (Approx.)	56°F. (Approx.)
Bromine Value	7	4
Iodine Value (Wij's 1 hr.)	33	4
Sulphur	1.67 %	0.77 %

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DEPTH 2015 - 2017 FT.

CONCLUSIONS:

The quantity of oil present in this sample of core is 1.35% by extraction and 1.20% by steam distillation, having sulphur contents of 0.12% and 0.05%, and melting points of 97° and 95°F. respectively. The oil is very similar in general characteristics to that from the 1722 - 1723 feet core reported in AP.S/54 of 10.6.38. The latter, however, contains slightly more oil than the core herein reported.

HISTORY:

The sample of core was taken at a depth of 2013 - 2017 feet and was received on 16.7.38, the container being in an airtight condition.

EXPERIEMTNAL:

Portions of this core were extracted with benzene and others steam distilled, in the manner described in Report No. AP.S/52 of 13.5.38.

The following results were thus obtained :-

		Lab. No. 159.
Oil Yield by steam distillation	%	1.20
Specific gravity at 60°F.		0.858
Melting Point °F.		93
Viscosity at 100°F. c.s.		11.7
secs. R.I.		57
Sulphur	%	0.05
I.B.P.	°C.	230
Vol. to 275°C.	%	23
275 - 350°C.		34
Residue above 350°C.		43
Gas Yield	litres/kg. core	3.0
Air content of gas	%	90
Analysis of gas approx. (Air free basis)		
CO_2	%	60
H_2	%	20
Unsaturateds	%	Nil
Saturateds + N_2	(by diff.)	20
Oil Yield by extraction	%	1.35
Melting Point	°F.	97
Sulphur	%	0.12

DISCUSSION:

The general characteristics of the oil obtained from this core are very similar to those of the oil obtained from the 1722-23 feet core. Differences are noted in lower viscosity and gas yield in the present instance. This latter is similar to that obtained from the 1625 - 6 feet core.

For ANGLO-IRANIAN OIL CO. LTD.,

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