TECHNICAL REPORT

FOR

SHELL NORWAY

ON

CORE ANALYSIS OF PRODUCING FORMATION SANDSTONE SAMPLE FROM TROLL FIELD WELL NO. 31/2-9

AND ON

WELLBORE FLUID DESIGN TO MINIMISE FORMATION DAMAGE

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MAY, 1983

1.0 INTRODUCTION

In the Troll Field, the oil reservoir is a very high permeability, unconsolidated sand. Completion procedures to be performed are either:-

(a) Drill in 12¼" hole. Completion to be an in-casing gravel pack.

or (b) Drill in 8½" hole. Underream to 18". External gravel pack to be placed.

The reservoir is relatively shallow, with a low BHT of 154°F. The reservoir pressure requires a wellbore fluid density of 1.18.

A frozen core sample from Well 31/2-9 (1594.76 - 1595 M) was received, plus details of connate water analyses.

This report details the results of laboratory examinations on the nature of the core sample, and proposes wellbore fluids designed to minimise formation impairment and operational problems.

1.1 FULL CORE IDENTIFICATION

The sample was labelled:-

SHELL 31/2-9 Core No. 4 (Box 4 of 19) Depth 1594.76 - 1595 M (7½") Box 5.

2.0 NATURE OF THE CORE SAMPLE

2.1 Description

Light grey, extremely friable sandstone. Medium/coarse sub-angular grains. Moderately sorted. Evident high porosity.

2.2 Pore Size

Because of sample friability, capillary pressure methods were not possible. Pore sizes were assessed using an optical microscope.

Pore Size (Microns)	Frequency Assessment
More than 200	Occasional
100 - 200	Typical
Less than 100	Frequent

2.3 Grain Size

For possible utility in gravel pack design, screen analysis results of grain size distribution are given below.

Grain Size (Microns)	Percent by Weight
More than 1676	0.2
1003 - 1676	4.0
500 - 1003	34.9
152 - 500	55.7
Less than 152	5.2

2.4 Retort Analysis

A known weight of as received core was retorted. Assuming 100% liquid saturation, the oil and water saturations were as follows:-

Oil Saturation	13%
Water Saturation	87%

Assuming now a grain density of 2.7, the porosity was calculated.

Porosity	31%

2.5 Permeability

A core plug was cut under liquid nitrogen, and encased in epoxy resin containing Idcarb 150 to prevent resin invasion. Fluid flow was established through many 1/16" holes drilled at each end through the epoxy to just penetrate the friable sand.

Result:-

Effective permeability to Kerosene (at irreducible water saturation)

= 8,000 millidarcys

An average reservoir permeability of 10 - 15 Darcys is reported.

2.6 Mineralogy and Dispersible Fine Clay Content

A sample of the core was cut from immediately alongside the sample used for permeability testing. The sample was taken from at least one inch away from the rounded mud contacted edge produced during coring.

The material was placed in distilled water containing a deflocculant at pH 10, the mixture gently stirred, and ultrasonic energy introduced via an ultrasonic probe (Soniprobe - Dawe Instruments) for a period of four minutes.

The mixture was allowed to sediment and the smaller than 5 microns particles removed by repeated decantation.

This procedure is designed to separate the more loosely held clay minerals without significant comminution of the coarser particles. The dispersible fine mineral content has been found to correlate with the water sensitivity of sandstones.

The mineralogical analyses of two fractions : less than 5 microns and whole core, were determined by X-Ray Diffraction. The results are shown in Table 1.

TABLE 1 - MINERALOGY AND PARTICLE SIZE RESULTS

Particle Size Fraction	Less than 5 Microns	Whole Core
% W/W in Fraction	2.6	100

X-Ray Diffraction Analysis

Minerals found % w/w of whole core

Quartz	0.08	63
Felspar	0.05	14
Kaolinite	0.94*	2
Mica	0.10	3
Montmorillonite	-	-
Pyrites/Haematite	0.05	2
Calcite	0.03	1
Barytes	0.08	-

* Kaolinite plus Chlorite
\- No mineral detected

Discussion of Results

The fine particle (less than 5 microns) content of the core is 2.6%. This represents a moderately clean sand and by normal criteria no more than moderately water sensitive. The very high permeability and pore size, however, suggests that the water sensitivity is low. This is because any mobilised fine particle clays are probably well able to move through the pore network without significant plugging effects.

The predominant fine particle mineral is Kaolinite. No swelling clays such as Montmorillonite were found.

Barytes, found only in the fine particle fraction, may well have been present from coring fluid invasion of the very open pored core sample.

3.0 FORMATION WATER ANALYSIS

Two analyses of connate water from the Troll Field have been made available.

Ion Concentration (mg/l)	No. 1	No. 2
Na+	16,600	15,900
Ca2+	1,870	2,400
Mg2+	320	320
Sr2+	295	270
Ba2+	23	-
Fe	20	-
Cl-	29,780	29,500
HCO3-	615	800

3.0 FORMATION WATER ANALYSIS (Cont'd)

On contact with Calcium Chloride based filtrates on the alkaline side of neutral, precipitation of Calcium Carbonate (ca. 1 g/l depending on mixture ratio) is likely to occur.

The Strontium and (particularly) Barium concentrations are sufficiently low that little sulphate scale is likely to occur with seawater based wellbore fluids.

4.0 ASPECTS OF WELLBORE FLUID DESIGN

4.1 Bridging Solids

For both drill-in and under-reaming fluids, the most critical feature required here is an adequate concentration of bridging solids. This will minimise the depth and degree of solids invasion of this very open-pored sand.

The presence of bridging solids also allows the laying down of a tight filter cake on the surface of the exposed sand. The differential pressure between the wellbore fluid and the formation is thus concentrated essentially across the filter cake. This will support unconsolidated sand and prevent sloughing and washouts. Near-gauge hole will allow good perforation penetration of the formation through the casing and thin cement bond.

Bridging Solid Particle Size

From the microscope examination given in 2.2, the typical pore size is estimated at 150 microns. In SPE Paper No. 5713, Albert Abrams (Shell Development Co.) recomments:-

"(i) The median particle size of the bridging additive should be equal to or slightly greater than one third of the median pore size of the formation. (ii) The concentration of the bridging size solids must be at least five percent by volume of the solids in the final mud mix."

Therefore, for this formation, at least five percent of the solids in the fluid should be of 50 microns diameter or greater.

Suitable bridging solids are :-

(i) Idcarb 150 - a high purity acid soluble calcite containing (typically) 30% of particles greater than 50 microns (See Appended Product Data).

(ii) Idbridge 'L' - an aqueous dispersion of oil-soluble resin particles, of which 45% (typically) are greater than 50 microns diameter (See Appended Product Data).

4.2 Nature of the Aqueous Phase

The choice of the brine in which the wellbore fluid is built is governed by the following factors:-

i) Fluid density required
ii) Water sensitivity of the formation
iii) Compatibility with formation water
iv) Performance of polymeric suspending agents.

4.2 Nature of the Aqueous Phase (Cont'd)

The density required is 1.18. For brines unweighted with Idcarb, this is about the limit for KCl brine. Solely from the aspect of density, for fluids further weighted with Idcarb it is immaterial whether KCl, NaCl or CaCl2 brine is used as a basis.

The water sensitivity of the formation is probably low. However CaCl2 and KCl brines are far better than NaCl brine for stabilising such clays as are present. NaCl brine converts clays by ion exchange to the sodium form, which on clean-up of the well can disaggregate on contact with lower salinity formation water.

From the aspect of compatibility with formation water, Calcium Chloride brine, used at slightly alkaline pH, would cause precipitation of some CaCO3 on contact with the formation wayter containing 600 - 800 mg/l Bicarbonate anion.

For suspension of relatively coarse bridging solids, the use of a biopolymer (Xanthan Gum) suspending agent is necessary. HEC lacks the necessary progressive gel strnegth for adequate suspension.

Biopolymers such as XC Polymer or DF-Vis, however, exhibit problematical performance in Calcium Chloride brine. Their performance (yielding characteristics) is extremely dependent on pH.

At lower pH (6 - 7), especially with prehydration, XC Polymer can provide satisfactory yield points in Calcium Chloride brines. However, the progressive gel strength (suspending ability) is much reduced. More importantly, if the pH approaches 8.0 and above, the Xanthan Polymer can (at least partially) precipitate as evidenced by lower pseudoplastic properties and (often) very low API filtrate loss.

The pH of commercial Calcium Chloride solutions can vary due to varying unreacted brine contents. Also mud systems containing CaCO3 ultimately buffer the pH on the alkaline side of neutral (pH 7.5 - 8.0).

For these reasons, and because of erratic behaviour under field conditions, IDF does not recommend the use of either XC Polymer or DF-Vis in Calcium Halide brines.

Recommended Brine Phase

The recommended choice is between the cheaper Sodium Chloride type or the more expensive but clay stabilising Potassium Chloride brine, thus avoiding any scale or polymer performance problems. If an under-reaming fluid based on viscosified brine plus Idbridge L were adopted, the density limit of 9.8 ppg (1.176 density) for KCl brine may not allow enough flexibility for kick control.

In this instance, a more flexible and cheaper system exists in a mixed NaCl/KCl brine. This can attain a density of 1.234 (higher than either pure NaCl or pure KCl when the NaCl:KCl ratio is between about 2:1 and 3:1.

For example, 0.869 bbls of water, plus 96 bbls of NaCl plus 32 lbs of KCl gives one barrel of brine with a density of 1.234, a crystallisation temperature of 32°F.

5.0 RECOMMENDED FLUID DESIGN

The fluids used will depend on the completion operations performed.

5.1 Drill-In Fluid

For drilling in the production sand prior to either casing/perforation or under-reaming, solubility or removability of the filter cake is not an important factor.

However, the fluid must contain bridging solids to prevent deep skin damage and sloughing, and must exhibit a thin impermeable filter cake to minimise any tendency to differential sticking.

Such a fluid is provided by the following composition per finished barrel:-

Drill Water	0.872	bbls
KCl (or NaCl)	50	lbs
DF-Vis	2	lbs
Idflo	4	lbs
Idcarb 150	70	lbs
NaOH	To pH 10.0	

Typical Properties:-

S.G.	AV	PV	YP	GELS	FILTRATE LOSS API	FILTRATE LOSS HTHP*
1.18	36	20	32	6/10	3.0	9

* At 500 psi and 250°F.

Because of the high pore size of the sand, Idcarb 150 is recommended as sole bridging/weighting agent. (Normally blends with the finer Idcarb 75 are used).

Such fluids also exhibit very low dynamic fluid loss. Case histories have demonstrated that very low skin factors are attainable with such fluids.

Solids Removal

Because of the need to maintain relatively coarse bridging solids in the fluid, the solids removal system must be considered. Desanders and desilters are capable of removing most of the particles above 50 microns.

Shaker screen sizes down to 100 mesh will remove most of the cuttings whilst allowing the Idcarb 150 to remain in the fluid. Desanders should only be used when essential to reduce the sand content.

An alternative, if available, is to use a mud cleaner where the desilter hydrocyclone discharge is screened. Again, the use of finer screens than 100 mesh will remove some of the bridging size solids.

Some of the bridging solids will show up in the API Sand Content check (More than 75 microns) at about a 1-1.5% by volume level. This serves as a check for the presence of an adequate concentration. Maintenance additions of Idcarb 150 may be necessary.

5.2 Under-reaming Fluid

Whilst fulfilling basically the same function as the drill-in fluid, the main difference is that the filter cake must be removable after the gravel pack is placed.

Idcarb Fluid

Most conveniently, the same Idcarb containing fluid could be used for under-reaming as for drilling-in. In theory, the Idcarb 150 particles are well able to flow through (on clean-up) a gravel pack suitable for this sand. The particle size of the Idcarb 150 is of the order of ten times smaller than the formation sand.

If, in practice, some of the filter cake remains and causes flow restriction, the Idcarb and polymeric components are fully degradable in 15% Hydrochloric Acid.

Idbridge Fluid

An alternative system for under-reaming and drill-in fluids is to use Idbridge 'L' oil soluble bridging agent, thus avoiding the possible use of acid for cake removal.

Such fluids have been used successfully by Brunei Shell Petroleum for under-reaming wells in the Seria Field (Well clean-ups have been rapid indicating no damage). Idbridge is best suited for low temperature applications such as the Troll and Seria Fields.

Because of the low particle density (1.075), the overall fluid density is provided by the base brine. A mixed NaCl/KCl brine is most appropriate for the densities required.

Because the Idbridge particles tend to float in the brine, DF-Vis is recommended to avoid such separation. DF-Vis also provides a much more stable dispersion than Idhec hydroxyethylcellulose should oil contaminate the fluid.

Formulation:-

NaCl/KCl Brine (1.19 Density)	1 bbl
DF-Vis	2 lbs
Idbridge 'L'	7.5 litres * (2 US Gal)
NaOH	To pH 10.0

Typical Properties:-

Density	1.18
AV	26
PV	13
YP	26
Gels	6/9
API Fluid Loss	6 ml
HTHP Fluid Loss (160°F, 500 psi)	9 ml

* Lower doses required than Idcarb 150 because of the lower SG of the particles.

Solids Removal

Because of the coarser size of some of the Idbridge particles, shaker screen sizes finer than about 50 x 50 mesh will remove quantities of Idbridge.

However, because of their low density, Idbridge particles are not removed by desanders and desilters. Hence full use can be made of such equipment.

The API Sand Content check can be used to check the presence of adequate quantities of bridging solids at about 0.5 - 1.0% by volume levels.

5.3 Perforating Fluid

A solids-free, filtered, unviscosified brine of the necessary density should allow clean, open perforations for subsequent gravel packing.

The most economical system allowing flexibility for kick control (Density up to 1.234) is a mixed NaCl/KCl brine. The NaCl/KCl ratio should be between 2:1 and 3:1.

The following data is for brine formations to give one barrel with NaCl/KCl ratios of 2.5:1.

Density at 20°C ppg	g/cc	Drill Water bbls	NaCl lbs	KCl lbs
9.7	1.164	0.901	65	26
9.8	1.176	0.888	70	28
9.9	1.188	0.877	76	30
10.0	1.200	0.868	81	33
10.1	1.212	0.862	86	35
10.2	1.224	0.861	91	36
10.28*	1.234	0.860	94	37

* Saturated at 68°F (20°C)

Loss Control

Assuming overbalance perforation, losses to the highly permeable sand may well be unacceptable. For moderate losses, spotting a viscous brine pill viscosified with about 3 ppb Idhec hydroxyethyl cellulose should provide sufficient control, whilst leaving perforations open. Such a solution, with a yield point of about 100 on surface and about 60 downhole, will not damage such a high permeability reservoir.

The viscous pill could be spotted prior to perforation as a preventative measure.

For heavy losses, the viscous pill can be loaded with either:-

(i) 20 ppb Idcarb Custom plus 20 ppb Idcarb 150

or (ii) 8 ppb Idbridge Custom plus 2 US Gallons (7.5:1)/bbl of Idbridge L.

depending on whether an oil or acid soluble system is desired. The blend of coarse and fine minerals is to allow better bridging and also easier clean up of the filled perforations.

5.4 Gravel Packing Fluid

Filtered brine is recommended viscosified with ca. 2 ppb of Idhec, this will provide good gravel transport whilst the low flat gel strength will allow easy solution flow through the pack and screen.

Typical Properties:-

AV	PV	YP	GELS	FUNNEL VISCOSITY
56	27	58	9/9	100 secs.

It is not considered necessary to use a breaker system for the Idhec because its initial plugging characteristics are very low, and its ultimate degradation assured.

TECHNICAL REPORT

FOR

NORSK HYDRO

ON

CORE ANALYSIS OF PRODUCING FORMATION

SANDSTONE SAMPLE FROM TROLL FIELD

WELL NO. 31/6-1

AND ON

WELLBORE FLUID DESIGN TO MINIMISE FORMATION DAMAGE

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AUGUST, 1983

1.0 INTRODUCTION

In the Troll Field, the oil reservoir is a very high permeability unconsolidated sand. Completion procedures to be performed are either:

i) Drill in 12 1/4" hole. Completion to be an in-casing gravel pack.
ii) Drill in 8 1/2" hole. Underream to 18". External gravel pack to be placed.

The reservoir is relatively shallow, with a low BHT of 154°F. The reservoir pressure requires a wellbore fluid density of 1.18.

Three core samples from Well 31/6-1 (1370m - 1374m) was received.

This report details the results of laboratory examinations on the nature of the core samples, and proposes wellbore fluids designed to minimise formation impairment and operational problems.

1.1 Full Core Identification

The samples was labelled:

a) Hydro 31/6-1 Core No. 4 Depth 1370m

b) Hydro 31/6-1 Core No. 5 Depth 1371m

c) Hydro 31/6-1 Core No. 5 Depth 1374m

2.0 NATURE OF THE CORE SAMPLES

2.1 Description

The cores were light grey in colour, extremely friable sandstones. Medium/coarse sub-angular grains. Moderately sorted. Evident high porosity.

2.2 Pore Size

Because of sample friability, capillary pressure methods were not possible. Pore sizes were assessed using an optical microscope and by scanning electrone microscope on Core No. 5 - depth 1374m.

PORE SIZE (Microns)	FREQUENCY ASSESSMENT
>200	Occasional
100 - 200	More frequent
50 - 100	Typical
>50	Frequent

2.3 Grain Size

For utility in gravel pack design, screen analysis results of grain size distribution are given below.

Grain size in micron	Core No.4 - 1370m	No.5 - 1371m	No.5 - 1374m
>1676 micron	0.05%	0.03%	0.07%
1003 - 1676	0.28%	9.2%	0.14%
500 - 1003	19.9%	46.7%	3.3%
152 - 500	42.4%	28.2%	39.3%
>152 micron	37.4%	15.87%	57.19%

2.4 Retort Analysis

A known weight of sample as received from each core was retorted.

Assuming 100% liquid saturation, the oil and water saturations were as follows:

Depth	Oil % saturation	Water % saturation
1370m	15	85
1374m	22	78

Assuming now a grain density of 2.7, the porosity was calculated to be:

Depth	Porosity
1370m	40%
1374m	36%

2.5 Permeability

No competent cores could be mounted for testing.

2.6 Mineralogy and Dispersible Fine Clay Content

Samples of the cores were examined by X-Ray Diffraction for their mineral composition.

By sedimentation techniques, the quantity of fine minerals of less than 5 microns size was less than 0.5% by weight. There was insufficient of this fraction for XRD analysis.

TABLE 1 - MINORALOGY RESULTS (X-RAY DIFFRACTION ANALYSIS)

Mineral	1370m	1371m	1374m
Kaolinite	5	4	13*
Mica	3	1	5
Quartz	38	44	19
Felspar	14	8	14
Montmorillonite	-	-	-
Pyrites/Haematite	10	25	10

A dash means a mineral was sought but not detected.
* indicates the sample contained chloride.

2.7 Scanning Electron Microscope Micrographs

Micrographs of core No. 5 - 1374 were taken showing:

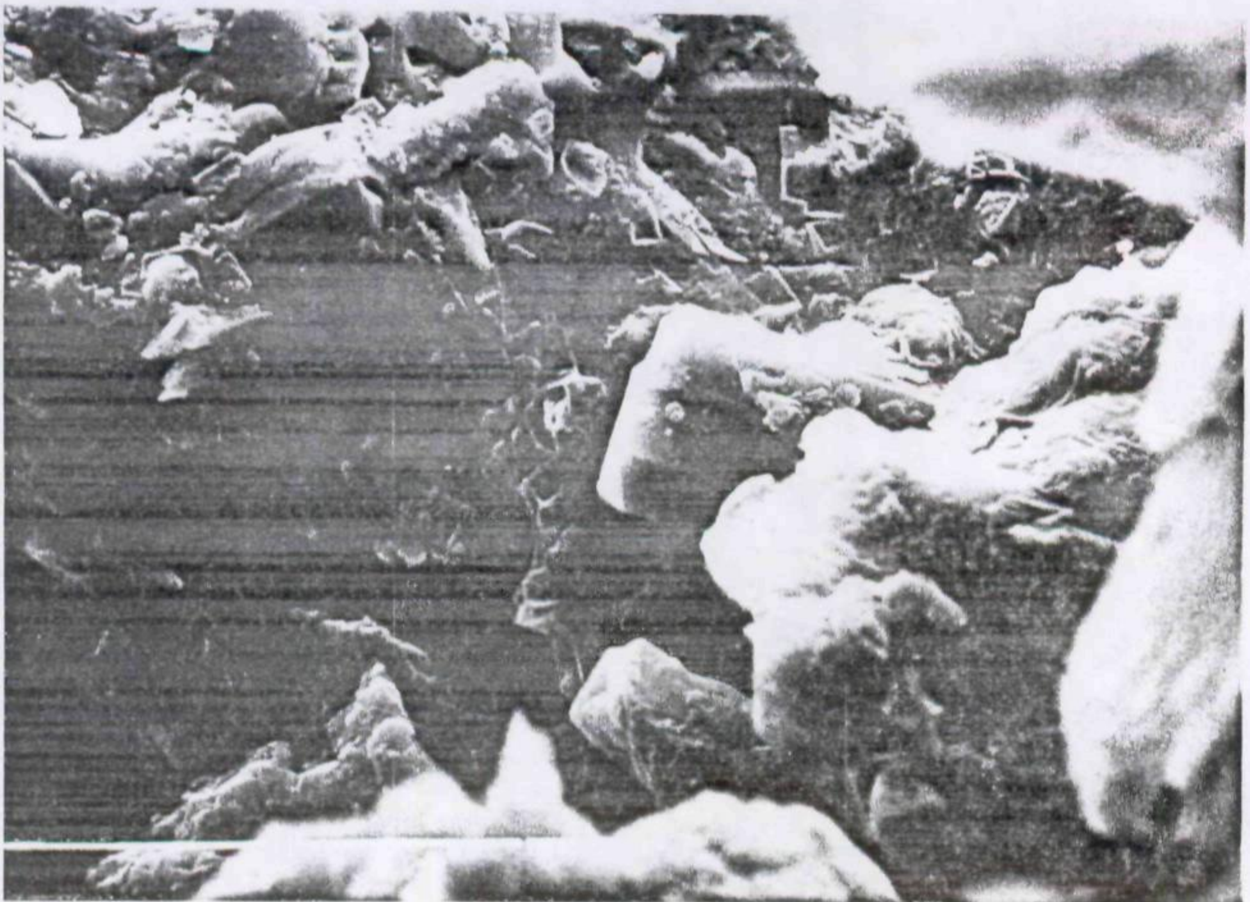
a) General view - giving indication as to pore size.

b) Close-up i.e. higher magnification of the general view. Notice in very centre of micrograph crystal partially hidden by kaolinite/ mica flake. This has been further magnified to provide (c).

c) Close-up of crystal intergrowth. Electron capture analysis suggests this to be an anhydrite crystal.

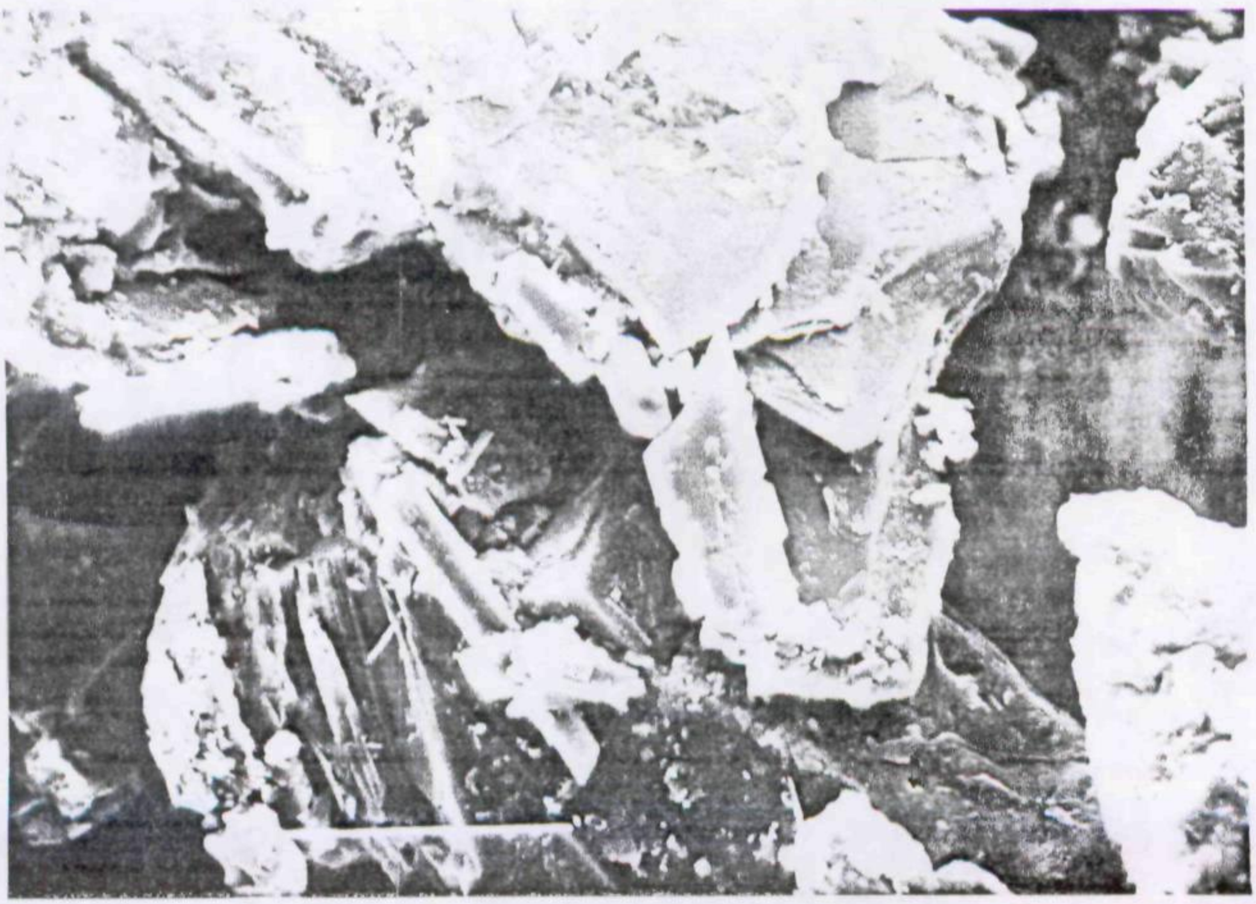
d) Close-up of kaolinite/ mica flakes.

CORE NO. 5 - 1374 m CLOSE OF CRYSTAL INTERGROWTHS

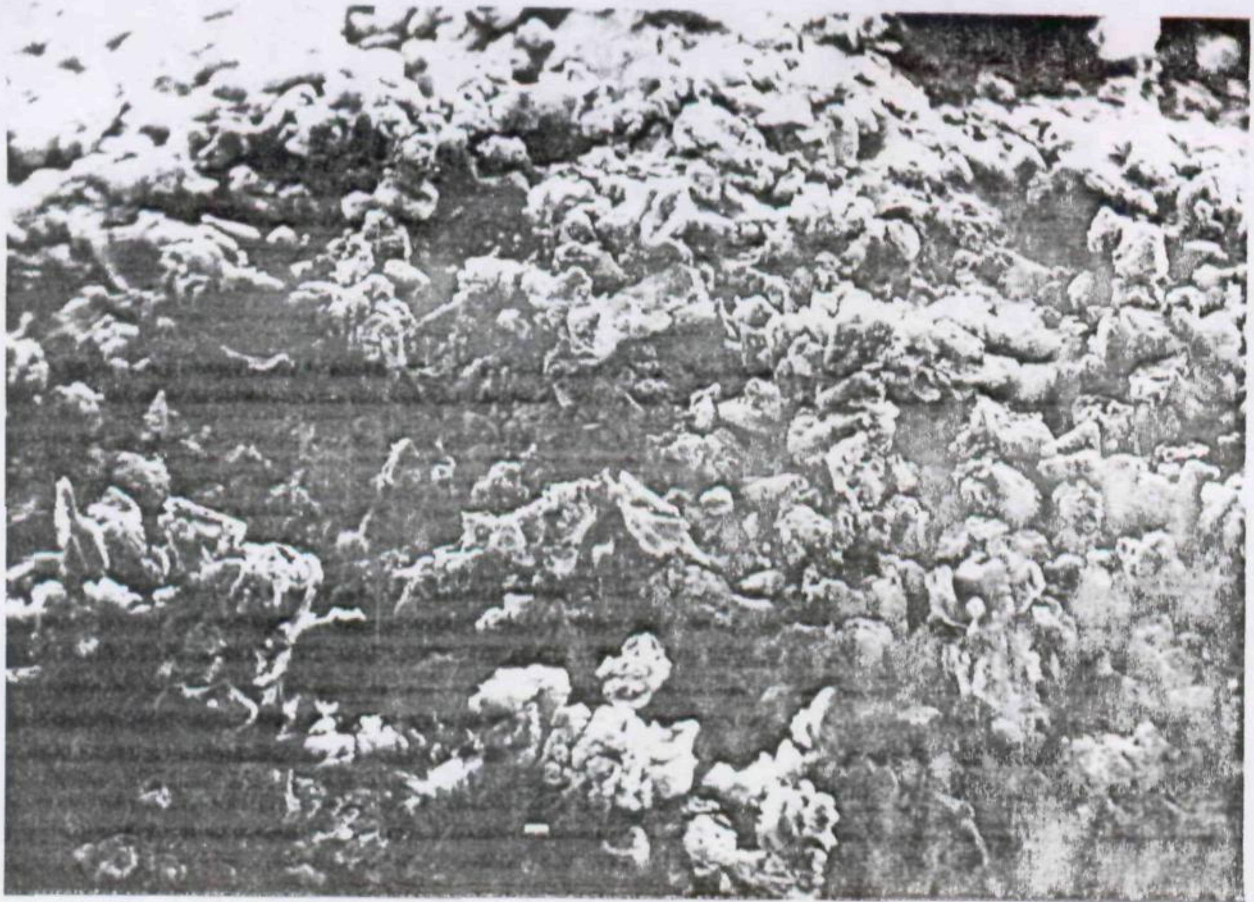


5μ

CORE NO.5 - 1374 m CLOSE UP OF THE KAOLINITE/MICA FLAKES



CORE NO.5 - 1374 m - GENERAL VIEW



CORE NO.5 - 1374 m - CLOSE UP SHOWING KAOLINITE/MICA FLAKES

5μ

DISCUSSION OF RESULTS

The fine particle (>5 micron) content of the core is <0.5%. This represents a clean sand and by normal criteria not water sensitive. The very high permeability and pore size confirm that the water sensitivity is low. This is because any mobilised fine particle clays are well able to move through the pore network without significant plugging effects.

The predominant fine particle mineral is kaolinite. No swelling clays such as montmorillonite were found.

4.0 ASPECTS OF WELLBORE FLUID DESIGN

4.1 Bridging Solids

For both drill-in and underreaming fluids, the most critical feature required here is an adequate concentration of bridging solids. This will minimise the depth and degree of solids invasion of this very open pored sand.

The prescence of bridging solids also allows the laying down of a tight filter cake on the surface of the exposed sand. The differential pressure between the wellbore fluid and the formation is thus concentrated essentially across the filter cake. This will support unconsolidated sand and prevent sloughing and washouts. Neargauge hole will allow good perforation penetration of the formation through the casing and thin cement bond.

Bridging Solid Particle Size

From the microscope examination given in 2.2., the typical pore size is estimated at 75 microns.

In the SPE Paper No. 5713, Albert Abrams (Shell Developement Co.) recommends:

" 1) The median particle size of the bridging additive should be equal to or slightly greater than one third of the median pore size of the formation.

2) The concentration of the bridging size solids must be at least five percent by volume of the solids in the final mud mix."

4.1 Bridging Solids (Cont'd)

Therefore, for this formation, at least five percent of the solids in the fluid should be of 50 microns diameter or greater.

Suitable bridging solids are:-

i) IDCARB 150 - a high purity acid soluble calcite containing (typically) 30% of particles greater than 50 microns. (See Appended Product Data).

ii) IDBRIDGE 'L' - an aqueous dispersion of oil-soluble resin particles, of which 45% (typically) are greater than 50 microns diameter. (See Appended Product Data).

4.2 Nature of the Aqueous Phase

The choice of the brine in which the wellbore fluid is built is governed by the following factors:-

i) Fluid density required.
ii) Water sensitivity of the formation.
iii) Compatibility with formation water.
iv) Performance of polymeric suspending agents.

The density required is 1.29 for the upper section and 1.18 for the lower section. For brines unweighted with IDCARB, this is about the limit for KCl brine. Solely from the aspect of density, for fluids further weighted with IDCARB it is immaterial whether KCl, NaCl or $CaCl_2$ brine is used as a basis.

The water sensitivity of the formation is probably low. However $CaCl_2$ and KCl brines are better than NaCl brine for stabilising such clays as are present. NaCl brine converts clays by ion exchange to the sodium form, which on clean-up of the well can disaggregate on contact with lower salinity formation water.

From the aspect of compatibility with formation water, calcium chloride brine, used at slightly alkaline pH, would cause precipitation of some $CaCo_3$ on contact with the formation water contaning 600-800 mg/l bicarbonate anion.

For suspension of relatively coarse bridging solids, the use of a biopolymer (xanthan gum) suspending agent is necessary. HEC lacks the necessary progressive gel strength for adequate suspension.

4.2 Nature of the Aqueous Phase (Cont'd)

Biopolymers such as XC polymer or IDVIS, however, exhibit problematical performance in Calcium Chloride brine.

Their performance (yielding characteristics) is extremely dependent on pH.

At lower pH (6-7), especially with prehydration, XC polymer can provide satisfactory yield points in calcium chloride brines. However, the progressive gel strength (suspending ability) is much reduced. More importantly, if the pH approaches 8.9 and above, the xanthan polymer can (at least partially) precipitate as evidenced by lower psendoplastic properties and (often) very low API Filtrate Loss.

The pH of commercial calcium chloride solutions can vary due to varying uncreacted lime contents. Also mud systems containing $CaCo_3$ ultimately buffer the pH on the alkaline side of neutral (pH 7.5 - 8.0).

For these reasons, and because of erratic behaviour under field conditions, I.D.F. does not recommend the use of either XC polymer or DF-VIS in calcium halide brines.

Recommended Brine Phase

Two brines are required with a density of 1.18 and 1.29. They should be formulated with calcium chloride.

5.0 RECOMMENDED FLUID DESIGN

The fluids used will depend on the completion operations performed.

5.1 Drill-in Fluid

For drilling in the production sand prior to either casing/ perforation or underreaming, solubility or removability of the filter cake is not an important factor.

5.1 Drill-in Fluid (Cont'd)

However, the fluid must contain bridging solids to prevent deep skin damage and sloughing, and must exhibit a thin impermeable filter cake to minimise any tendenty to differential sticking.

Such a fluid is provided by the following composition per finished barrel:

Drill water	0.872 bbl
KCl (or NaCl)	50 lbs
DF-VIS	2 lbs
IDFLO	4 lbs
IDCARB 150	To required density
NaOH	To pH 10.0

Typical properties for formulation with S.G. 1.18 (70 ppb IDCARB 150).

S.G.	AV	PV	YP	GELS	FILTRATE LOSS API	HTHP*
1.18	36	20	32	6/10	3.0	9

* At 500 psi and 250°F.

Because of the high pore size of the sand, IDCARB 150 is recommended as sole bridging/weighting agent. (Normally blends with the finer IDCARB 75 are used).

Such fluid also exhibit very low dynamic fluid loss. Case histories have demonstrated that very low skin factors are attainable with such fluids.

Solids Removal

Because of the need to maintain relatively coarse bridging solids in the fluid, the solids removal system must be considered. Desanders and desilters are capable of removing most of the particles above 50 microns.

Shaker screen sizes down to 100 mesh will remove most of the cuttings whilst allowing the IDCARB 150 to remain in the fluid. Desanders should only be used when essential reduce the sand content.

5.1 Drill-in Fluid (Cont'd)

An alternative if available, is to use a mud cleaner where the desilter hydrocyclone discharge is screened. Again, the use of finer screens than 100 mesh will remove some of the bridging size solids.

Some of the bridging solids will show up in the API Sand Content check (>75 microns) at about a 1 - 1.5% by volume level. This serves as a check for the prescence of an adequate concentration. Maintainance additions of IDCARB 150 may be necessary.

5.2 Underreaming Fluid

Whilst fulfilling basically the same function as the drill-in fluid, the main difference is that the filter cake must be removable after the gravel pack is placed.

IDCARB FLUID

Most conveniently, the same IDCARB containing fluid could be used for underreaming as for drilling-in. In theory, the IDCARB 150 particles are well able to flow through (on clean-in) a gravel pack suitable for this sand. The particle size of the IDCARB 150 is of the order of ten times smaller than the formation sand.

If in practice some of the filter-cake remains and causes flow restriction, the IDCARB and polymeric components are fully degradeable in 15% hydrochloride acid.

IDBRIDGE FLUID

An alternative system for underreaming and drill-in fluids is the use IDBRIDGE 'L' oil soluble bridging agent, thus avoiding the possible use of acid for cake removal.

Such fluids have been used successfully by Brunei Shell Petroleum for underreaming wells in the Seria Field. Well clean-ups have been rapid to rates indicating no damage. IDBRIDGE is best suited for low temperature application such as the Troll and Seria Fields.

Because of the low particle density (1.075), the overall fluid density is provided by the base brine. A mixed NaCl/KCl brine is most appropriate for the density of 1.18 and calcium chloride for the brine of density 1.29.

5.2 Underreaming Fluid (Cont'd)

Because the IDBRIDGE particles tend to float in the brine, DF-VIS is recommended to avoid such seperation. ID-VIS also provides a much more stable dispersion than IDHEC (hydroxy-ethyl cellulose) should oil contaminate the fluid.

Formulation

NaCl/KCl Brine (1.19 density)	1 bbl
ID-VIS	2 lbs
IDBRIDGE 'L'	7.5 litres* (2. US Gal.)
NaOH	to pH 10

Typical Properties

Density	= 1.18
AV	= 26
PV	= 13
YP	= 26
GELS	= 6/9
API F. LOSS	= 10 mil.
HTHP F. LOSS (160°F, 500 psi)	= 15 mil.

* Lower doses required than IDCARB 150 because of the lower S.G. of the particles.

Solids Removal

Because of the coarser size of some of the IDBRIDGE particles, shaker screen sizes finer than about 50 X 50 mesh will remove quantities of IDBRIDGE:

However, because of their low density IDBRIDGE particles are not removed by desanders and desilters. Hence full use can be made of such equipment.

The API Sand Content check can be used to check the presence of adequate quantities of bridging solids at about 0.5 - 1.0 % by volume levels.

Loss Control

Assuming overbalance perforation losses to the highly permeable sand may well be unacceptable. For moderate losses, spotting a viscous brine pill viscosified with ca. 3 ppb IDHEC (hydroxy-ethyl cellulose) should provide sufficient control, whilst leaving perforations open. Such a solution, with a yield point of ca. 100 on surface and ca. 40 downhole, will not damage such a high permeability reservoir.

5.2 Underreaming Fluid (Cont'd)

The viscous pill could be spotted prior to perforation as a preventative measure.

For heavy losses, the viscous pill can be loaded with either:

i) 20 ppb IDCARB CUSTOM plus 20 ppb IDCARB 150
ii) 8 ppb IDBRIDGE CUSTOM plus 20 US Gallons (7.5 l) bbl of IDBRIDGE 'L'

depending on whether an oil or acid soluble system is desired. The blend of coarse and fine minerals is to allow better bridging and also easier clean up of the filled perforation.

5.3 Gravel Packing Fluid

Filtered brine is recommended viscosified with ca. 2 ppb of IDHEC. This will provide good gravel transport whilst the low flat gel strength will allow easy solution flow through the pack and screen.

Typical Properties

AV	PV	YP	GELS	FUNNEL VIS
56	27	58	9/9	100 secs.

It is not considered necessary to use a breaker system for the IDHEC because its initial plugging characteristics are very low, and its ultimate degradation assured.