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STATOIL

31/2 - 6.

EPORT

IC AND INDUSTRIAL
ITUTE OF TECHNOLOGY

Denne rapport tilhører STATOIL

LTEK DOK.SENTER

L. NR. 30284110008

KODE Well 31/2-6 Nr-39

RETURNERES ETTER BRUK

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AUTHORS Lars Kyrre Olsen / Olav Selle	PROJECT SUPERVISOR
SECTION Division of Petroleum Engineering	PROJECT NO. 280156.04

PROJECT CLIENT/SPONSOR A/S Norske Shell	CLIENT'S REF. Håkon Sletvold

ABSTRACT

The present report presents the results of a room condition oil and waterflooding test on a core sample from well no. 31/2-6.

LNR: 3028111-0008		STATOIL
MOTT: 14.3.84		GR:
		ARKIV: RES
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O.PR:		
MED.ID:		
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INDEXING TERMS: NORWEGIAN	ENGLISH
Reservoarteknikk	Reservoir Engineering
Endepunktmetninger	Endpoint saturations
Olje/vann fortrengning	Oil/water displacement

31/2-6. [illegible]

SINTEF REPORT

THE FOUNDATION OF SCIENTIFIC AND INDUSTRIAL
RESEARCH AT THE NORWEGIAN INSTITUTE OF TECHNOLOGY

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SINTEF SPECIAL CORE ANALYSIS

WELL : 6
FIELD : 31/2
COMPANY : A/S Norske Shell

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FIELD : 31/2
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INTRODUCTION

The present report presents the results of a room condition oil and water flooding test on a core sample from well no. 31/2-6.

The results are presented at saturations after displacement of gas with oil and saturations after breakthrough, one, two and three pore volumes of brine injected.

Figure 1 shows produced gas as fraction of pore volume vs. pore volumes of oil injected. Figure 2 shows produced gas and oil as a fraction of pore volumes vs. pore volumes of water injected.

Injection rate: 7.2 cc/hour
Viscosity rate: 2.53

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Table 1. Formation water analysis

Na^+	15700	mg/l
Ca^{++}	12000	"
Mg^{++}	370	"
Sr^+	520	"
Ba^{++}	35	"
Fe^{++}	60	"
Cl^-	47000	"

Total dissolved salts: 75685 mg/l
Resistivity at $59^{o}F$: 0.116 Ωm
Specific gravity at $59^{o}F$: 1.056
PH : 3.9

Water viscosity at reservoir conditions : 0.5 mPas cP

Remarks

The above formation water is the same as the syntethic formation water used in the experiment, except that Fe^{++} was excluded, due to precipitation problems.

SINTEF SPECIAL CORE ANALYSIS

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EXPERIMENTAL VALUES *Pluggdyp ?*

1, Rock Properties

Porosity		36.8 %	0,368
Permeability to brine (K_{abs})	KW =	2030 mD	
Diameter		3.89 cm	0,0389
Length		8.00 cm	0,080

2. Initial Conditions

Irredusible water saturation (S_{wi})	10 %	✓
Gas saturation (S_g)	90 %	÷

3. Saturations after oil displacement of gas

RESGAS-O/

Irredusible water saturation (S_{wi})	✓	10 %	/SWI
Oil saturation (S_o)		66 %	
Residual gas saturation ($S_{gr(1)}$)	✓	24 %	/SGR

/ KO(SGR) } se neste side

4. Saturations after brine displacement of oil and gas.

4.1 Saturation at break through:

Water saturation ($S_{wi}+S_w$)	51 %	
Residual oil saturation (S_{or})	27 %	
Residual gas saturation ($S_{gr(2)}$)	22 %	

} $\frac{0}{0}$

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4.2 Saturations at 1 pore volume brine injected:

Water saturation ($S_{wi}+S_w$)	52 %	$\frac{o}{0}$
Residual oil saturation (S_{or})	26 %	
Residual gas saturation ($S_{gr(2)}$)	22 %	

4.3 Saturations at 2 pore volumes of brine injected:

Water saturation ($S_{wi}+S_w$)	54 %	$\frac{o}{0}$
Residual oil saturation (S_{or})	24 %	
Residual gas saturation ($S_{gr(2)}$)	22 %	

4.4 Final saturations at 3 pore volumes of brine injected:

Water saturation ($S_{wi}+S_w$)	55 %	$\frac{6}{0}$
Residual oil saturation (S_{or})	23 %	
Residual gas saturation ($S_{gr(2)}$)	22 %	

5. Endpoint relative permeabilities

Relative permeability to oil	0.266	✓ *
Relative permeability to brine	0.187	$\frac{o}{o}$

$^*K_{oe} = k_{ro} \cdot 2030$

/KOSGR = 0.266 × 2030

= 539,98 mD

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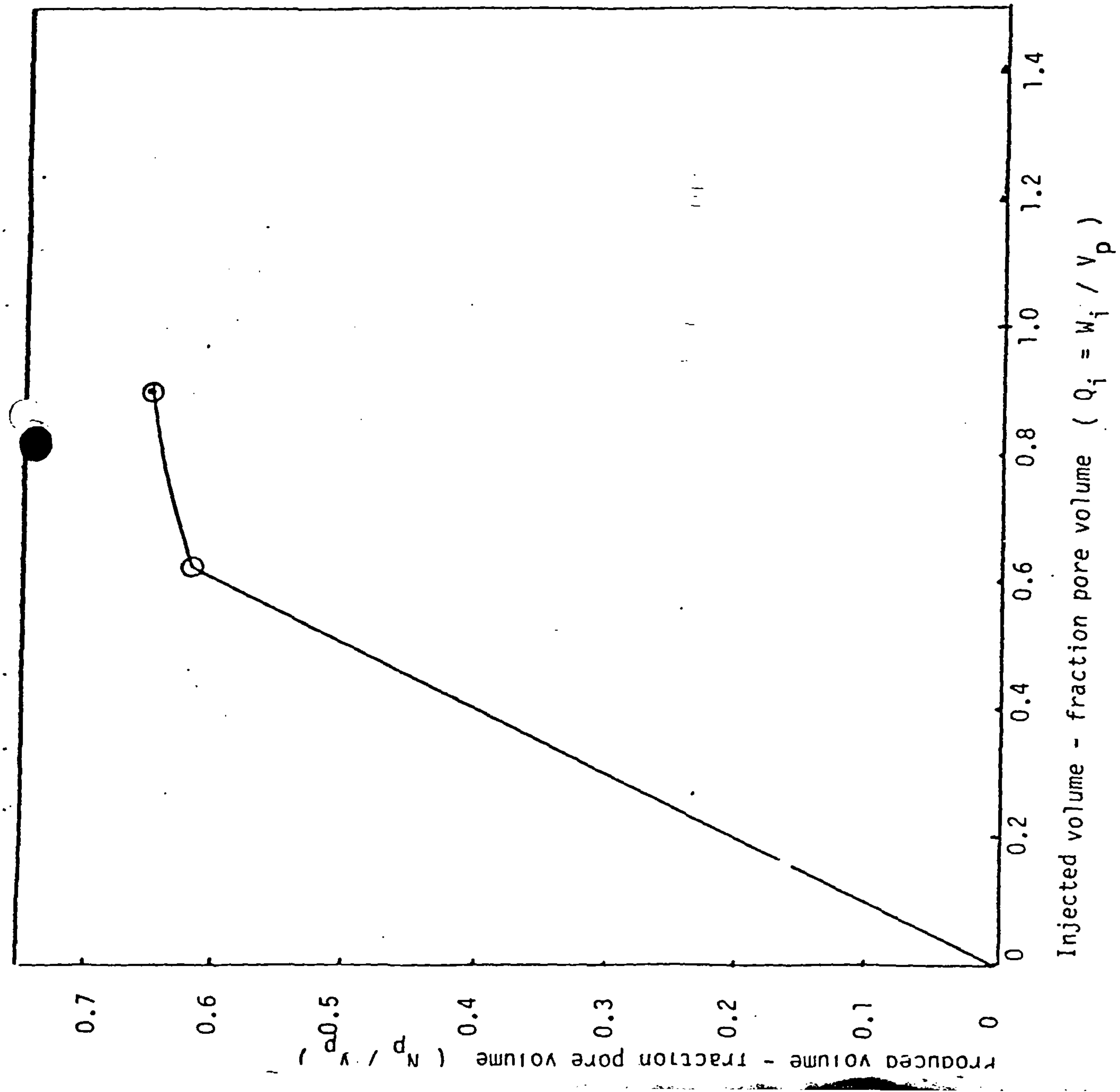

Fig. 1 . Produced gas volume (fraction of pore volume) vs. injected oil volume (fraction of pore volume)

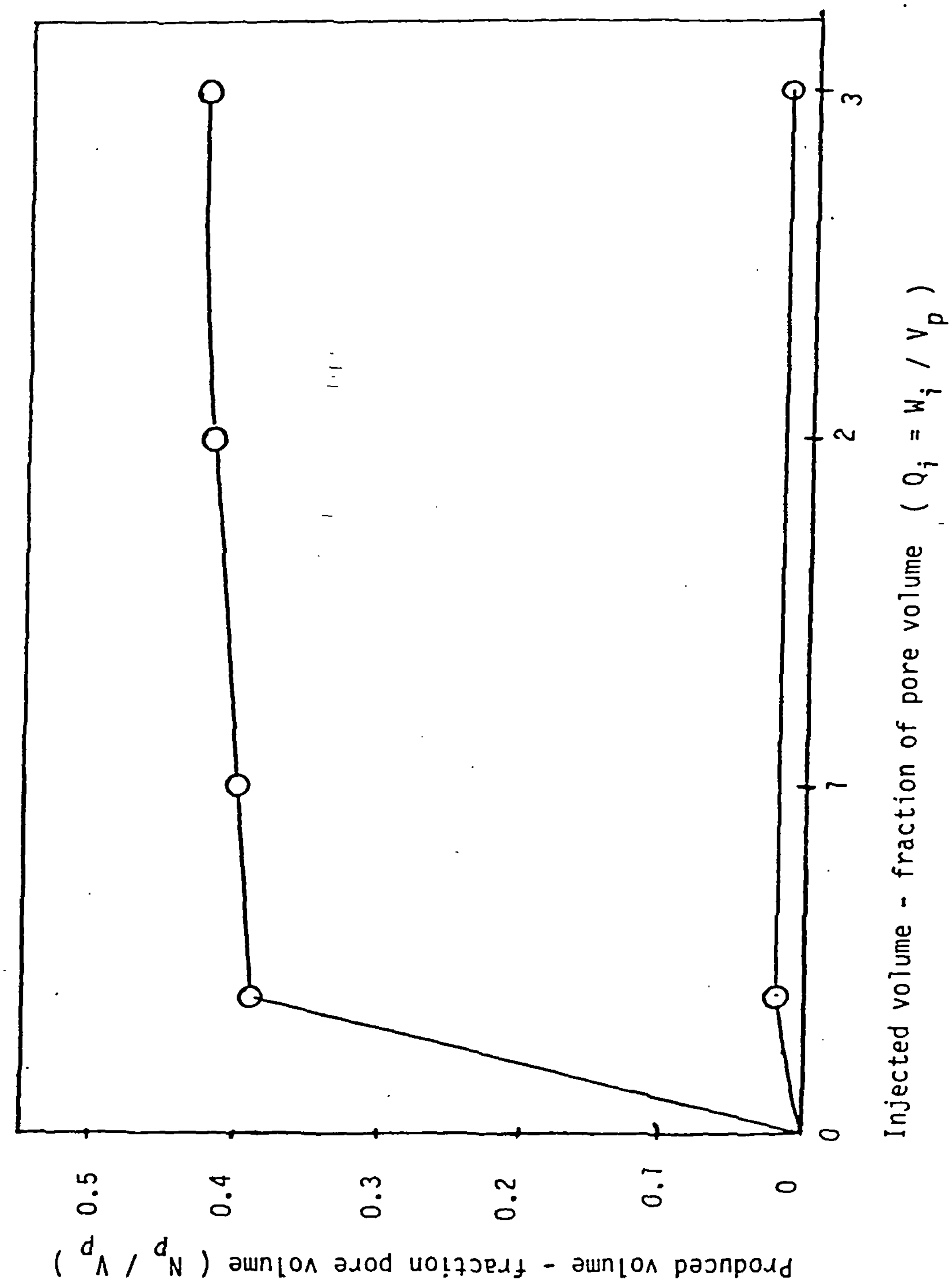

Fig. 2 . Produced gas and oil as a fraction of pore volume vs. injected water (fraction of pore volume)

DISCUSSION

Accuracy of experimental procedure and results.

The process of establishing irredusible water saturation (Swi) caused some problems. Shortly, the process which is a drainage process, can be described asmethane displacement of brine followed by a diffusion process where the brine diffuse into the hot methane. At the outlet the hot methane is cooled and the vapour condenses into traps in series where the volume or weight is measured. This part of the process demands very efficient cooling. The efficiency of the cooling process may be estimated by the amount of liquid condensed in the first part of the systems compared to the amount in the latter part. In the actual experiment most of the vapour condensed into the first trap and nothing in the last one. The cooling process was therefore assumed to be sufficient. In addition the methane used in the experiment was shecked for vapour content. No vapour condensed at the actual experimental conditions.

The accuracy of the irredusible water saturation is therefore estimated to be within one percent

To avoid possible sand production form the core sample into the apparatus, a sand filter was placed at the outlet end of the core.

Trapping of displaced fluids in this filter is possible. A small amount of the residual gas left the core after oil displacement was observed to become mobilized during the waterflooding before breakthrough of water. This gas is assumed to be trapped in the filter. If this is correct, the residual gas saturation after oil displacement is reported to be too high, and the oil saturation too low. During the water displacement of oil, a similar trapping of oil is possible. Produced oil volume reported after water breakthrough may be too high, and produced oil volume before breakthrough consequently too low.

In summary it is concluded in this part of the discussion that the residual gas saturation after oil displacement may be reported too high, and consequently oil saturation two percent too low. As a consequence, residual oil saturation after waterflooding may be reported two percent too low and water saturation two percent too high.

A Validyne pressure transduser with a range of ± 1 psi was used for measuring the differential pressures. Accuracy given from the factory is 0.5%.

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NOMENCLATURE LIST

V_p = Pore volume (cc)

N_p = Produced volume (cc)

W_i = Injected volume (cc)

Q_i = Fraction of pore volume

PV = Pore volume

Sw = Water saturation

Swi = Irredusible water saturation

So = Oil saturation

Sor = Redusible oil saturation

Sg = Gas saturation

Sgr = Redusible gas saturation

Kabs = Absolute permeability

Keft = Effective permeability

Krel = $\frac{\text{keft}}{\text{kabs}}$

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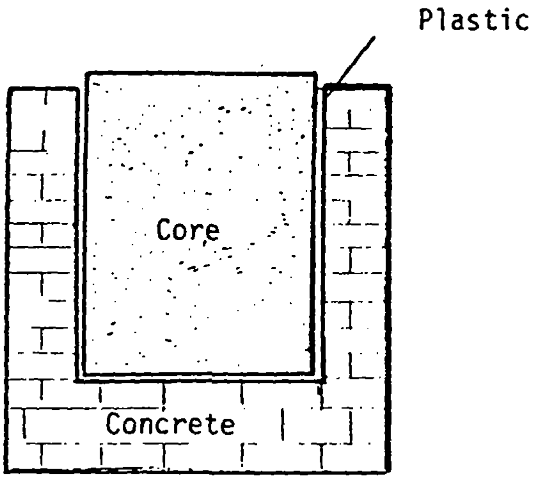
Appendix

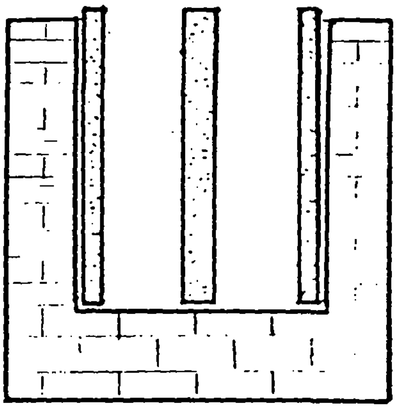
1. EXPERIMENTAL PROCEDURE

1. The received full size core was unpacked. The matrix of the core was very poorly consolidated.

2. The core was wrapped in thin plastic and casted in concrete , see figure.

3. Two plugs of 9 centimeters and 7 centimeters were drilled out using air as cutting fluid.





4. The longest core plug was sealed in a coreholder by melting a tin-bismuth alloy between the plug and the coreholder. The dimensions of the mounted plug were: D =3.89 cm, L=8.00 cm.

5. The plug was cleaned by flushing methanol and touluen, respectively. No sign of oil in the touluen was observed.

6. The plug mounted in the coreholder was dried at 60°C and 40 % relative humidity for 1 week.

7. Porosity was measured by using helium porosimeter and controlled by saturation of formation water.

8. Absolute permeability to formation water at Sw = 100 %.

9. Irreducible water saturation. Swi, was established by injection of hot methane (50°C). Produced brine volume was controlled by weight .

10. Displacement of methane with refined oil. One hydrocarbon volume was injected.

11. Effective permeability to oil was measured.

12. Displacement of refined oil and gas with formation water. 3 pore volumes of brine was injected.

13. Measurement of effective permeability to formation water.