

7

7/1/83

EUROPEAN REGION TECHNICAL CENTRE**REPORT No** CS-83-38

CORE ANALYSIS

JURASSIC

CLIENT- PHILLIPS, NORWAY
DATE- 14 July 1983
D.S. CONTACT- R COOPER

AUTHOR(S)

COLIN SIM

MANAGER- C. KEARY

Proprietary Rights:

This report is based on confidential information and neither this report nor any part may be disclosed directly or indirectly to any third party without the prior written authorisation of Dowell Schlumberger.

This report is presented in good faith, but no warranty is given and any user of this report agrees to absolve and hold Dowell Schlumberger harmless against any consequences resulting from the use thereof.

CONTENTS

- 1 INFORMATION REQUESTED
- 2 SAMPLES TESTED
- 3 SUMMARY OF RESULTS
- 4 PHYSICAL CHARACTERISTICS
 - Porosity
 - Permeability
 - Hardness
- 5 CHEMICAL CHARACTERISTICS
 - Acid Solubility
 - Iron Content
 - Water Sensitivity
 - Acid Response
- 6 PETROGRAPHIC STUDY
 - Scanning Electron Microscope Observation

1 INFORMATION REQUESTED

Core analysis to include permeability, porosity, acid solubility, iron content, water sensitivity, acid response, hardness and Scanning Electron Microscope study with EDAX analysis.

2 SAMPLES TESTED

Three core samples were received in the laboratory from the following depths:-

A	-	14,928 ft
B	-	14,941 ft
C	-	14,948 ft

All chemicals used came from laboratory stock.

3 SUMMARY OF RESULTS

The following table summarises the results given in this report.

CORE

	A	B	C
Porosity	13.37%	12.63%	5.40%
Permeability	3.40 mD	4.77 mD	-*
Hardness	Medium Hard	Medium Hard	Medium Hard
15x Solubility	8.0%	13.0%	4.0%
RMA Solubility	35.0%	33.0%	41.0%
Iron Content	1130 ppm	4510 ppm	1570 ppm
Fresh Water Sensitivity	Not sensitive		
Sea Water Sensitivity	Not sensitive		
Acid Response	Permeability increased from 4.12 mD to 32.06 mD ^{to 96 mD}		
Mineralogy	>99% Quartz + Illite	>95% Quartz + calcite + illite	>99% Quartz + illite

* Permeability below the range of the permeameter.

4 PHYSICAL PROPERTIESPOROSITYi) Procedure

The effective porosity was found by subtracting the absolute volume from the bulk volume of the sample. Clean, dry cores were used, the bulk volume was determined using a mercury pycnometer and the absolute volume by an air compression pycnometer.

ii) Results

<u>SAMPLE</u>	<u>Effective Porosity (%)</u>
A	13.37
B	12.63
C	5.40

PERMEABILITYi) Procedure

Clean, dry one inch diameter core plugs were placed in the permeameter, where nitrogen was flowed through them. The permeabilities were then determined from pressure and gas flow rate measurements using Darcy's Law.

ii) Results

<u>SAMPLE</u>	<u>NITROGEN PERMEABILITY (md)</u>
A	3.40
B	4.77
C	—*

* Below range of permeameter

PHYSICAL PROPERTIES (Continued)FORMATION HARDNESSi) Procedure

These tests were carried out by penetrating a water wet section of core with a 1/16 inch diameter spherical tip. DOWELL uses an arbitrary scale on which hardness is inversely proportional to the depth of penetration. The reported values are an average of a number of readings.

ii) Results

<u>SAMPLE</u>	<u>HARDNESS</u>	<u>MODULUS OF ELASTICITY</u>	<u>POISSONS RATIO</u>
A	Medium Hard	6.5×10^6 psi	0.22
B	Medium Hard	6.5×10^6 psi	0.22
C	Medium Hard	6.5×10^6 psi	0.22

5 CHEMICAL PROPERTIESACID SOLUBILITY1 HYDROCHLORIC ACID SOLUBILITY TESTSi) Procedure

One gram of pulverised formation was placed in 100 mls of 15% hydrochloric acid for one hour at 150°F. The solution was then filtered, then weighed. The amount of hydrochloric acid soluble material was calculated and reported as a percentage by weight.

ii) Results

<u>SAMPLE</u>	<u>PERCENT SOLUBILITY IN 15% HYDROCHLORIC ACID</u>
A	8.0
B	13.0
C	4.0

2 MUD ACID (12% HYDROCHLORIC, 3% HYDROFLUORIC ACID) TESTSi) Procedure

One gram of pulverised formation was placed in 15% hydrochloric acid for one hour at 150°F to remove any carbonates from the sample. This was done since calcium or magnesium fluoride precipitation could occur when hydrofluoric acid reacts with carbonate material.

The hydrochloric acid was then poured off and 100 mls of mud acid was added. After one hour at 150°F the solution was filtered and the residue dried and weighed.

5 CHEMICAL PROPERTIES (Continued)

The amount of mud acid soluble material was calculated and reported as a percent by weight.

ii) Results

<u>SAMPLE NUMBER</u>	<u>PERCENT SOLUBILITY IN 12-3 MUD ACID</u>
A	35.0
B	33.0
C	41.0

IRON CONTENTi) Procedure

The total iron content of the samples were measured using a Perkin-Elmer atomic absorption spectrometer calibrated with standard solutions of known concentration. One gram of pulverised formation was immersed in 100 mls of 15% hydrochloric acid for one hour at 150°F. The solution was then filtered to remove undissolved solids and then aspirated into the spectrophotometer, where the iron content was directly displayed.

ii) Results

<u>SAMPLE NUMBER</u>	<u>IRON CONTENT</u>
A	1130 ppm
B	4510 ppm
C	1570 ppm

5 CHEMICAL PROPERTIES (Continued)ACID RESPONSE TESTS (ARC III)i) Procedure

One inch diameter cylindrical core plugs were placed in the Hassler sleeve holder of the flow test apparatus, a confinement pressure was then applied to the outside of the sleeve to eliminate fluid flow along the core-sleeve interphase.

The tests were run at a chosen temperature during which the core permeability was monitored using measurements of differential pressure and the volume of fluid passed through the core.

The initial permeability to an inert fluid (sea water) was first measured; after treating fluids had been passed through the core this measurement was repeated to assess the success of the acid treatment.

The treatment carried out on the core consisted of a 15x pre-flush & 12-3 Mud Acid main stage.

ii) Results

Core B

Test Temperature = 80°F

<u>FLUID</u>	<u>STABILIZED PERMEABILITY</u>
Sea Water	4.12 mD
15x (216mls)	3.83 mD
12-3 Mud Acid (440 mls)	30.90 mD
Sea Water	32.06 mD

This represents an increase in permeability to sea water of almost 8 fold.

PETROGRAPHIC DESCRIPTION

The cores were all found to be medium grained sandstone, consisting in all cases, of over 95% quartz.

Core A consisted of over 99% quartz with the primary grains being cemented by secondary quartz and the only other mineral detected was illite.

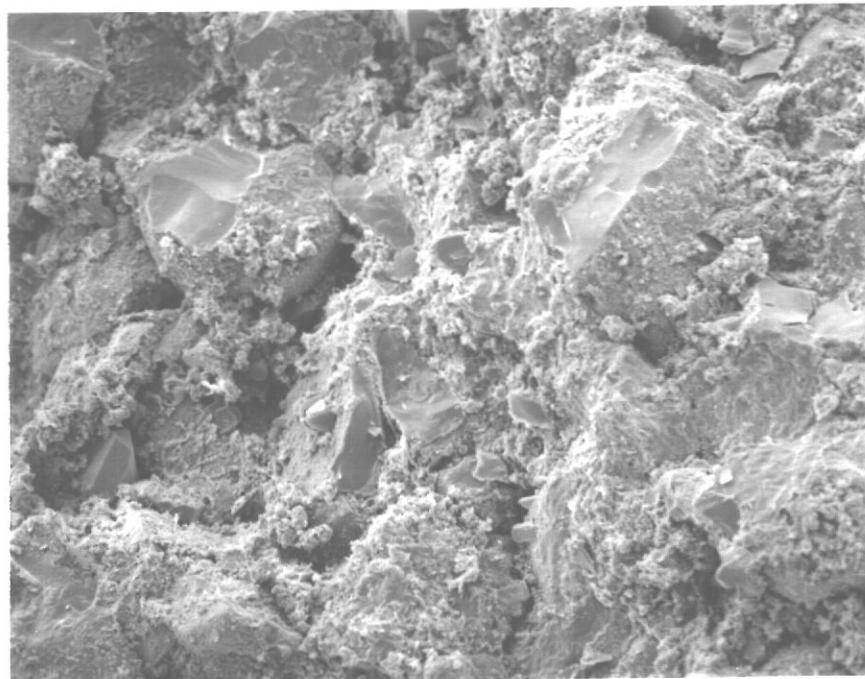
Illite typically occurs as a fibrous coating on the host grains. This structure gives a very large surface area and therefore the presence of illite can cause the formation to hold large amounts of bound water in the micropores. The introduction of fresh water into an illite - rich formation can also cause a certain amount of swelling of the illite which leads to a reduction in permeability.

However, in the sensitivity testing carried out in the lab, no detrimental effects on permeability were noted, when flowing fresh or sea water through the cores, so in this case, the effects of illite are minimal.

Core B was very similar to core A, except that a small amount of calcite was present.

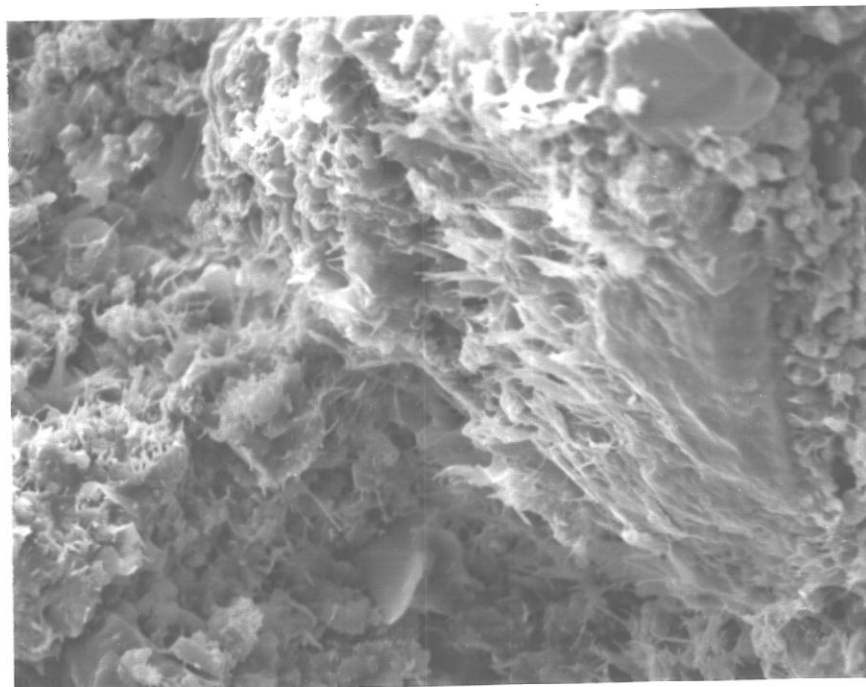
This explains the higher solubility of this core in 15x.

Core C was similar to core A in that it consisted of over 99% quartz plus illite, but the degree of cementing by secondary quartz was much greater with very little pore space remaining, resulting in very low permeability.

S.E.M. OBSERVATIONS

Core A Magnification x 160

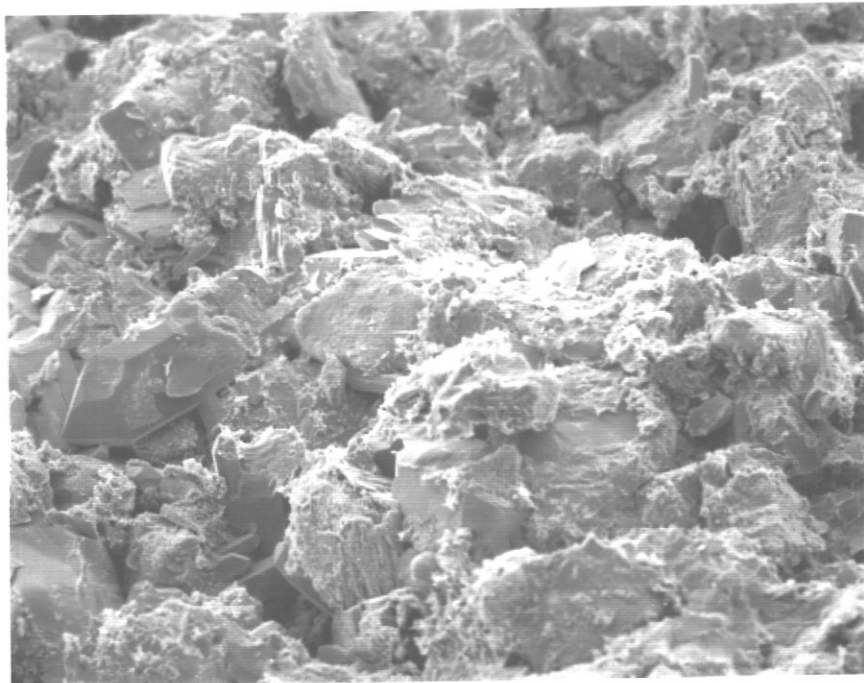
The primary quartz grains with secondary quartz cement
and illite coatings.

S.E.M. OBSERVATIONS (Continued)

Core A Magnification x 1250

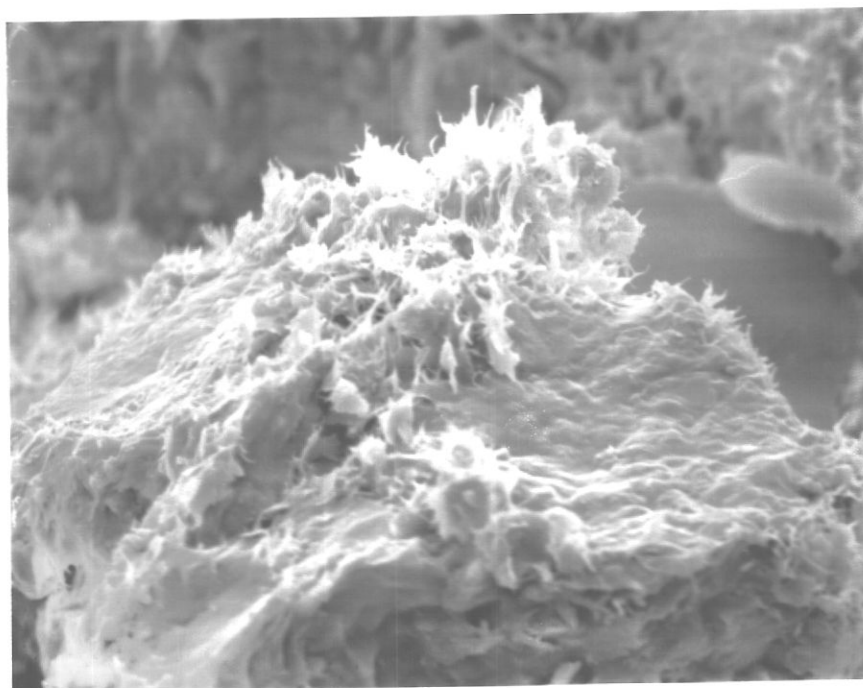
Fibrous illite coating a primary grain.

Photo 2

S.E.M. OBSERVATIONS (Continued)

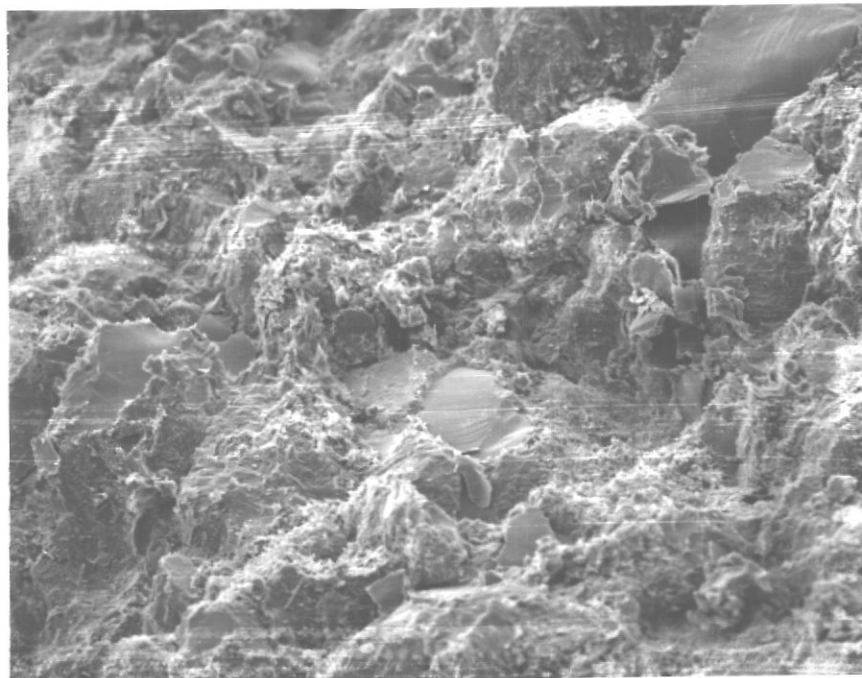
Core B Magnification x 160

Very similar to core A in morphology except that this core contains a small amount of secondary calcite.

S.E.M. OBSERVATIONS (Continued)

Core B Magnification x 1250

Illite

S.E.M. OBSERVATIONS (Continued)

Core C Magnification x 160

The original pore spaces in this core have been almost completely filled by secondary minerals resulting in very low permeability.