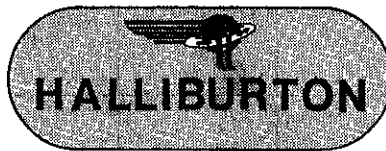


WA. 7/11-07.7(12)

CORING ANALYSIS (JURASSIC SANDST

8 1983

HALLIBURTON



APPENDIX 17

Halliburton Overseas Limited (Norway)  
UTENLANDSK AKSJESELSKAP

**STAVANGER OFFICE:**  
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5363 AGOTNES, NORWAY  
TEL. BERGEN (05) 33 40 00 EXT.  
TELEX: CCB N 42835

August 17, 1983  
IMP - 83 - 132

Mr. G.E. Hicks  
Field Exploration and Development  
Phillips Petroleum Co. Norway  
P.O. Box 220

4056 TANANGER

Dear Mr. Hicks,

Re: Cod 7/11-7 Jurassic Sandstone.

Please find enclosed laboratory report T12-A090-83 detailing results of test performed on core samples from the above well.

Stimulation recommendations for this formation will be based on this report, our experience in the area and local operational considerations.

I hope that the information contained within this report will assist you in your well planning and that you will not hesitate to call should you require further information.

Yours sincerely,

I. McPherson

cc: F.W. Mannes  
P.C. Jennings  
S.K. Karnes

## CHEMICAL RESEARCH AND DEVELOPMENT DEPARTMENT

HALLIBURTON SERVICES  
DUNCAN, OKLAHOMALABORATORY REPORT

No. T12-A090-83

To Mr. Ian McPherson  
Halliburton Overseas Limited  
4056 Tananger, NorwayDate August 5, 1983

This report is the property of Halliburton Services and neither it nor any part thereof nor a copy thereof is to be published or disclosed without first securing the express written approval of laboratory management; it may however, be used in the course of regular business operation by any person or concern and employees thereof receiving such report from Halliburton Services.

We give below results of our examination of 3 cores.Submitted by for Phillips Petroleum Company, NorwayMarked Well: Cod 7/11 ~~5/6~~ -7?  
Location: North Sea  
Formation: Jurassic Sandstone  
Depth: 14,927; 14,931.5; and 14,942 ft  
Received: 7-19-83PURPOSE

This report contains the results of the requested analyses.

RECOMMENDATIONS

VERSAGEL HT would be a suitable fluid to use for fracturing the Cod 7-11 A-6. At this depth, a delayed crosslink, as experienced with CL-18, will reduce friction going down the tubing, and lower pump hydraulic horsepower. Proper selection of the base gel weight will depend on your pumping time. With 350°F BHT, I suggest a major portion of the job be run with VERSAGEL HT 1700 with 5% methanol and 20 lbs GEL-STA per 1000 gallons (no HT breaker during this stage), then complete the final stage with VERSAGEL HT 1600. The idea should be to try and obtain a uniform gel break after completing the job. This procedure is used domestically quite often. Another idea is to use a large pad (which you will probably need due to fluid loss at 4 md) of HYGEL-566 to cool the formation. The base fluid for VERSAGEL should be 2% KCl, 2 1/2 lbs HYG-3, and 10 lbs K-34 per 1000 gallons. CLA-STA II can be used at 1 gallon per 1000 in the pre-pad stage.

Fracture flow capacity testing indicates that 20/40 mesh INTERPROP™ develops flow capacity comparable to SUPER PROP® even at 10,000 psi closure pressure. INTERPROPS are 13% lighter so are easier to suspend. A few trial runs of the Prop computer program should give you a good idea of the transport and settling characteristics to expect.

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DATACore Description

Three samples were received; core plugs from 14,927 and 14,942 ft depth, and a 5 1/2 inch section of 4 inch diameter core from 14,931.5 ft. All three are visually alike: medium grained, micaceous, oily, brown quartz sandstones. They are massive, lacking any sedimentary structures.

Qualitative X-ray Diffraction and Acid Solubility Analyses

**Purpose:** To identify the types and relative quantities of minerals in the formation sample.

**Procedure:** A pulverized 1 gram sample is placed in an x-ray beam and rotated through an arc. The x-ray beam is diffracted by the sample and the diffraction patterns are recorded.

**Results:** The diffraction patterns are used to identify the types of minerals present and their relative quantities. The relative quantities for the submitted samples are as follows:

| Sample No.        | 1      | 2        | 3      |
|-------------------|--------|----------|--------|
| Depth (Feet)      | 14,927 | 14,931.5 | 14,942 |
| HCl Solubility %* | 2.8    | 2.8      | 10.6   |
| HF Solubility %** | 33.7   | 36.3     | 46.9   |
| Iron Content %*** | 0.4    | 0.3      | 1.0    |
| Quartz            | 50-65% | 50-65%   | 40-50% |
| Feldspar          | 15-20% | 25-30%   | 20-30% |
| Calcite           | 0.5-2% | 0.5-2%   | 0.5-2% |
| Dolomite          | 2-5%   | 2-5%     | 5-10%  |
| Illite            | 2-5%   | 2-5%     | 5-10%  |
| Mixed Layer Clay  | 2-5%   | 5-10%    | 5-10%  |
| Chlorite          | 2-5%   | 0.5-2%   | 2-5%   |
| Pyrite            | 2-5%   | 0.5-2%   | 0.5-2% |

\* 1 gram of sample is added to 0.5N HCl. After reaction, the excess acid is titrated with 0.2N NaOH. The results are calculated and reported as calcium carbonate. (Note: a pure dolomite will be reported as 108%.)

\*\* This is solubility by actual weight loss after reaction with an excess amount of 3% HF-12% HCl at 150°F for 30 minutes.

\*\*\* 1 gram of sample is added to concentrated HCl. After reaction, the dissolved iron is titrated with Potassium Dichromate and reported as % by weight.

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DATA (Cont'd)Permeability and Porosity Analyses

Purpose: To measure the permeability and porosity of a porous media.

Procedure: A test plug 1 inch in diameter by 1.187 inches long is obtained from the submitted core sample so that the longitudinal axis of the plug is normal to the depth. The plug is then oven dried and allowed to cool to room temperature.

Permeability is determined by placing the plug securely in a Hassler Sleeve of the Permeameter. Dry air is then flowed through the plug. Measurements of flow rate and pressure drop across the plug are then obtained.

Porosity is determined by placing the plug securely in a Hassler Sleeve of the Porosimeter. The system is purged with helium gas. The meter has a known storage volume in which the helium gas is allowed to reach equilibrium and a reference point is set on the gauge and a reading taken. The valve to the plug chamber is opened allowing the helium gas to expand into all the void spaces of the plug. A gauge reading is taken in cubic centimeters. The plug is removed and a nonporous plug is placed in the holder and the gas volume is measured in the same manner as with the sample plug. The difference in the volumes is the pore volume of the test plug. The bulk volume is calculated from measuring the plug with calipers.

Results: Permeability is calculated by the following:

$$K = \frac{CQL}{0.7845 (D)(D)}$$

K is permeability in millidarcys (md)

C is the value reading taken from the charts on the Permeameter

Q is the flow rate in cubic centimeters per second (cc/sec)

L is the plug's longitudinal length in centimeters (cm)

D is the diameter of the plug in centimeters (cm)

Porosity is calculated by the following:

$$P = \frac{P.V.}{B.V.} \times 100$$

P is the effective porosity expressed in percent (%)

P.V. is the pore volume measured in cubic centimeters (cc)

B.V. is the bulk volume measured in cubic centimeters (cc)

| <u>Sample No.</u> | <u>Depth (feet)</u> | <u>Porosity (%)</u> | <u>Air Permeability (md)</u> |
|-------------------|---------------------|---------------------|------------------------------|
| 1                 | 14,927              | 16.37               | 5.59                         |
| 3                 | 14,942              | 13.06               | 0.45                         |

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DATA (Cont'd)Rock Properties

**Purpose:** To measure the elastic deformation and strength of rock materials.

**Procedure:** A 15/16 inch diameter by 2 inch plug is drilled horizontally from a core and placed in the test load cell. An axial stress is applied to the plug and the resulting deformation is measured by displacement transducers. Two transducers are mounted to detect axial strain and one transducer to detect lateral strain. The axial stress is applied to the test plug until full scale (120,000 pounds) is reached or failure occurs.

**Results:** This data is recorded as Young's Modulus, which is the ratio of stress to strain for values of stress not exceeding the elastic limit of the test plug. Poisson's Ratio is the ratio of lateral strain to axial strain within the elastic limit of the test plug.

| <u>Sample No.</u> | <u>Depth (feet)</u> | <u>Young's Modulus (psi)</u> | <u>Poisson's Ratio</u> |
|-------------------|---------------------|------------------------------|------------------------|
| 1                 | 14,927              | 1.8E6                        | 0.27                   |
| 3                 | 14,942              | 1.8E6                        | 0.32                   |

Immersion Test

**Purpose:** To observe the effect of various base fluids on core chips from selected representative cores.

**Procedure:** Freshly broken chips from cores are immersed in test fluids; one chip per fluid in a 30 ml beaker. The samples are then placed in a vacuum for one hour. After that time, an observation is made to evaluate the effect of the fluid on the core chip.

**Results:** Released fines from a core chip may indicate formation sensitivity to the test fluid.

Effects of immersion under vacuum at 180°F (test temp.) for one hour in the following:

| <u>Sample No.</u> | <u>Depth (feet)</u> | <u>Sea Water</u> | <u>Fresh Water</u> | <u>2% KCl</u> | <u>2% KCl*</u> | <u>7½% MCA</u> | <u>6% HF</u> | <u>Kero-sene</u> |
|-------------------|---------------------|------------------|--------------------|---------------|----------------|----------------|--------------|------------------|
| 2                 | 14,931.5            | N                | N                  | V             | N              | N              | N            | N                |

N = No fines released.

V = Very small amount fines.

S = Small amount fines.

M = Moderate amount fines.

L = Large amount fines.

P = Partially disintegrated.

CD = Completely disintegrated.

GR = Gelatinous residue formed.

PD = Partially dissolved.

C = Completely dissolved.

\* 0.5 gallon CLA-STA II compound per 1000 gallons.

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DATA (Cont'd)Fluid Loss Tests

**Purpose:** To describe the leakoff properties of a particular fluid on a formation rock sample.

**Procedure:** The sides of a test plug (15/16 inches in diameter by 1 inch in length) taken horizontally from a core are sealed with an epoxy so that the test fluid flows linearly through the test plug. A 1000 psi differential pressure is applied to the test fluid. The fluid volume through the test plug is recorded as a function of time for 36 minutes as per API Test procedures.

**Results:** The results of these timed volume readings are plotted as a function of volume versus the square root of time. The slope of the line obtained when the data is plotted on regular graph paper will give the  $C_w$  values and spurt volume.

| <u>Sample No.</u> | <u>Depth (feet)</u> | <u>Perm. Gas (md)</u> | <u>Gelled Fluid</u> | <u>C<sub>w</sub> (feet/sq. rt. min)</u> | <u>Spurt Loss (gal./sq. foot)</u> |
|-------------------|---------------------|-----------------------|---------------------|---|-----------------------------------|
| 2A                | 14931.5             | 4.10                  | VERSAGEL HT 1600    | 0.00287                                 | 0.0                               |

Gelled Fluids Description

VERSAGEL HT 1600: 60.0 lbs WG-11  
 10.0 lbs K-34  
 2.5 lbs HYG-3  
 2.5 lbs SP Breaker  
 1.8 gal CL-18  
 All per 1000 gal 2% KCl water

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DATA (Cont'd)Regained Permeability Tests (N<sub>2</sub> Gas)

| <u>Sample No.</u> | <u>Depth (feet)</u> | <u>Test Pressure (psig)</u> |
|-------------------|---------------------|-----------------------------|
| 2A                | 14,931.5            | 150                         |
| 2B                | 14,931.5            | 150                         |

Purpose: To measure the effect of fluids on the permeability of samples.

Procedure: The core test plugs (15/16 inches in diameter by 1 inch in length) are oven dried and the sides are sealed with epoxy to insure linear flow through the test plugs. Initial nitrogen permeability measurements are then obtained in one direction. The core plugs are then saturated and a measured volume of fluid is flowed through the core plug in the opposite direction. Fluid flow temperature was 180°F. Some of the plugs are then subjected to a standard 36-minute fluid loss test on gelled fluids at 180°F and a test pressure of 1000 psig. The plugs remained in the gelled fluids for 24 hours at 180°F to obtain a gel break prior to regained nitrogen flow. Regained permeability measurements are obtained in the original direction. Gas flow measurements are at 73°F.

Results: The data are reported as a percent of the initial permeability recovered.

| <u>No.</u> | <u>Sample (md)</u> | <u>Saturation Gelled Fluid*</u> |
|------------|--------------------|---------------------------------|
| 2A         | 2% KCl             |                                 |
| 2B         | 2% KCl             | VERSAGEL HT 1600                |

\* Fluid descriptions are under the Fluid Loss Tests section.

| <u>Sample No.</u> | <u>Time (hrs)</u> | <u>%</u> |
|-------------------|-------------------|----------|
| 2A                | 24                | 17       |
| 2B                | 24                | 96       |

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DATA (Cont'd)Fracture Flow Capacity

**Purpose:** To measure the conductivity of a created proppant pack under closure pressure.

**Procedure:** The core sample is cut into wafers, with a set of two wafers used to make a test. The test is conducted with one set of wafers with a proppant pack between. A perforated stem is placed down through a hole in the middle of the wafer set. Air is flowed through the stem, out of the perforations and radially through the proppant pack. The upstream pressure is measured and compared to the known downstream pressure to obtain a differential pressure. Pressure readings are made under various closure pressures.

**Results:** The data is presented as liquid conductivity in units of md-ft.

Core Depth: 14,931.5 ft

Proppant Type: (1) 20/40 SUPER PROP®  
(2) 20/40 INTERPROP™

| Proppant<br>Concentration<br>(lb/sq ft) | Closure<br>Pressure<br>(psi) | Fracture Flow Capacity (md-ft) |            |
|---|------------------------------|--------------------------------|------------|
|   |                              | Prop No. 1                     | Prop No. 2 |
| 1.0                                     | 5,000                        | 1522                           | 1847       |
|   | 7,000                        | 1364                           | 1446       |
|   | 9,000                        | 1065                           | 1032       |
|   | 10,000                       | 962                            | 836        |
| 2.0                                     | 5,000                        | 2865                           | 4242       |
|   | 7,000                        | 2557                           | 3242       |
|   | 9,000                        | 1992                           | 2269       |
|   | 10,000                       | 1848                           | 1831       |

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DATA (Cont'd)Scanning Electron Microscope (SEM) Examination  
and Petrographic AnalysisFor SEM:

**Purpose:** To provide a greatly magnified view of a core sample. Minerals present in the sample can be identified and their location observed.

**Procedure:** A core chip with a freshly broken surface is required for this examination. The sample is coated with a gold palladium alloy and placed in the vacuum chamber of the SEM. The core chip is viewed at a high magnification and a photomicrograph is taken. An associated energy dispersive x-ray (EDX) is used to help identify the mineral content of the sample.

**Results:** The framework grains can be identified and their size approximated. The location of the clay minerals within the sample can be observed. The SEM can produce, in effect, a pseudo three dimensional view of formation pore spaces. The area of the sample viewed is very small and may not clearly characterize the entire formation.

For Petrographic:

**Purpose:** To describe the framework grains, the matrix or the cementing material, and the pore spaces.

**Procedure:** Core chips are glued to glass slides and then ground to a thin section through which light can be transmitted. The slide is placed under a microscope and viewed using polarized light at high magnification.

**Results:** The result of this examination is descriptive and systematic classification of the rock and materials present in the sample. This analysis is a visual observation, thus is somewhat subjective.

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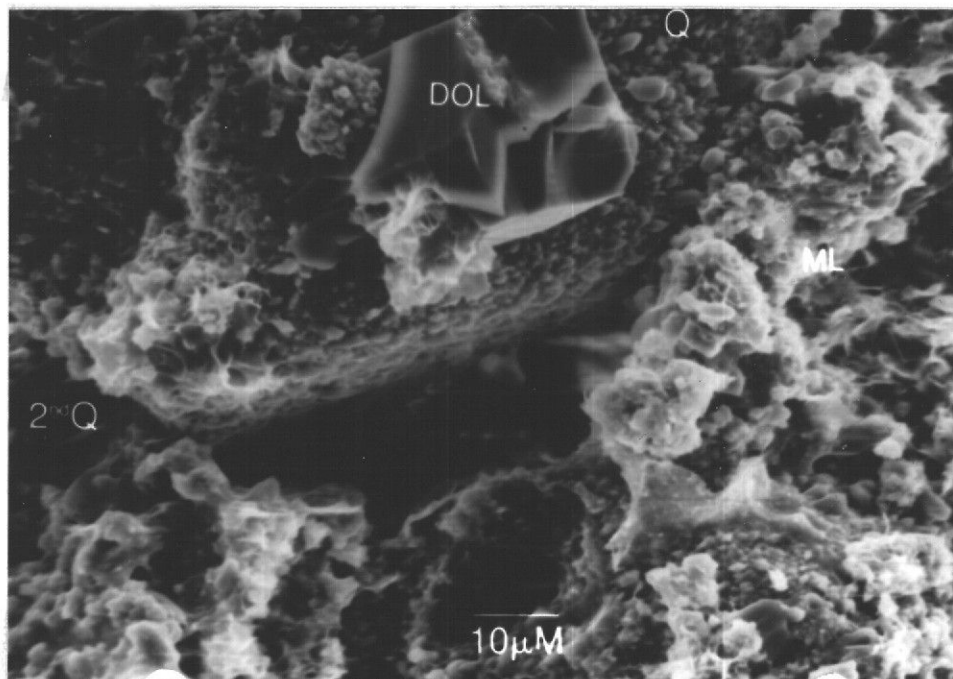
DATA (Cont'd)Scanning Electron Microscope (SEM) Examination

Figure No. 1; Negative: 21821-1713; Sample No. 1; Depth: 14,927 feet; Magnification 1000X.

A framework of fine to very fine quartz grains covered with mixed layer (ML) clay, secondary quartz ( $\partial$  and Q) and debris. Scattered dolomite (DOL) crystals observed. Fair to good apparent porosity.

Petrographic

PEBBLY SANDSTONE - Framework of poorly sorted, subangular to round, pebbly to fine sand size grains of quartz, feldspar, with mica and rock fragments. Intergrain pores coated with mixture of illite, mixed layer and chlorite clays. Fair to good visible porosity.

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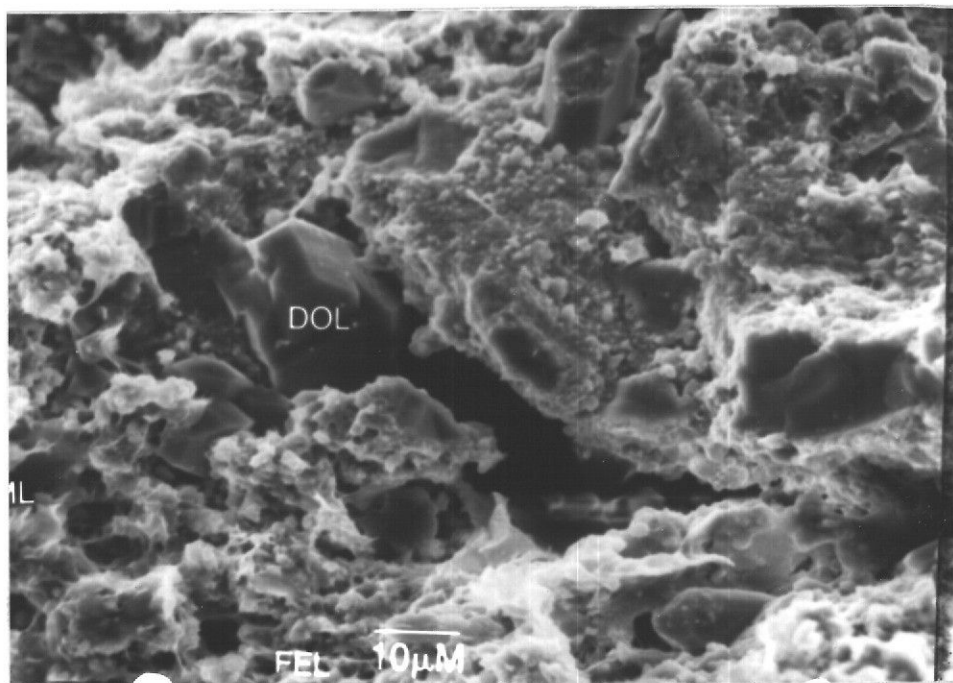
DATA (Cont'd)Scanning Electron Microscope (SEM) Examination (Cont'd)

Figure No. 2; Negative No. 21821-1712; Sample No. 2; Depth: 14,931.5 ft; Magnification 1000X.

This sample has a framework of very fine quartz and feldspar (FEL) sand grains covered with mixed layer clay and quartz debris. Scattered dolomite crystals. Fair apparent porosity.

Petrographic

CALCAREOUS SANDSTONE - Framework of poor to moderately sorted, medium to fine quartz and feldspar grains with mica and rock fragments. Intergrain pores are lined by illite and mixed layer clays, and contain dolomite crystals. Poor visible porosity.

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PAGE NO.

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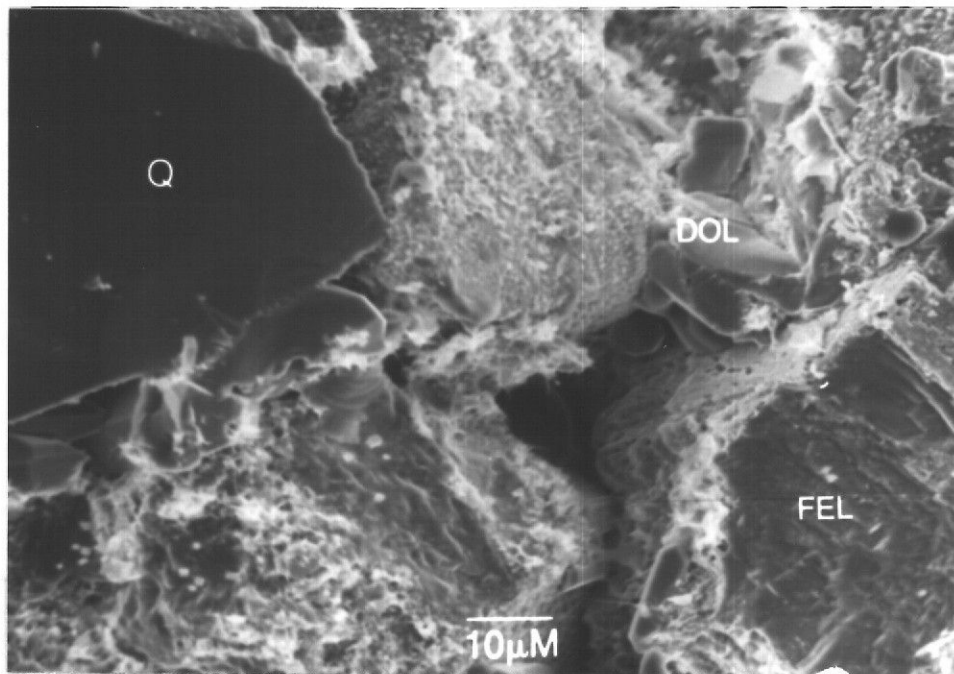
HALLIBURTON CHEMICAL LABORATORY REPORT NO. T12-A090-83DATA (Cont'd)Scanning Electron Microscope (SEM) Examination (Cont'd)

Figure No. 3; Negative No. 21821-1714; Sample No. 3; Depth: 14,942 ft;  
Magnification 1000X.

A framework of fine to very fine quartz and feldspar sand grains.  
Small amounts of mixed layer clay and dolomite crystals cover the  
grains. Fair apparent porosity.

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REMARKS

The data in this report were telexed to Mr. McPherson on August 1, 1983.

CORE SAMPLE DISPOSITION

The core samples will be held in storage for 60 days following mailing of the report. At the end of this time, we will select representative core pieces for storage in the Core Library and discard the remainder unless we are requested to ship the cores to another location.

The selected core pieces will be in the Core Library for two years and will be considered the property of the customer. These core pieces will not be released without the permission of the customer, the originating Halliburton Engineer, or a Stimulation Technical Support Section Supervisor. After two years, the selected core pieces will be kept for another eight years, during this time the pieces may be used for a variety of projects.

DATA BOOK REFERENCES

The data presented in this report are recorded in Stimulation Technical Support Book No. 5177, pages 52, 54; Stimulation Technical Support Book No. 5192, page 59; Stimulation Technical Support Book No. 5211, pages 18-25; Stimulation Engineering Research Book No. 5154, page 68; Analytical Book No. 5202, page 45; Analytical Book No. 5207, pages 21, 24; Analytical Book No. 5199, page 34; Analytical Book No. 5130, page 21; and Analytical Book No. 5218, page 6.

cc: Mr. F. M. Blakeslee  
 Mr. R. D. Padgham  
 Mr. P. C. Jennings  
 Mr. F. W. Mannes  
 Mr. S. K. Karnes  
 Mr. R. M. Lasater  
 Mr. A. B. Waters  
 Dr. L. E. Harris

Respectfully submitted,

Laboratory Analyst

~~Phelps-Brinegar-Blanton-Loghry-Graham~~  
~~Meadows-Anderson-Simon-Stewart-Halterman~~

HALLIBURTON SERVICES

*Martin Halterman*

jd

Martin Halterman

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