GEOPRESSURED - GEOTHERMAL DRILLING AND TESTING PLAN

VOLUME I DRILLING & COMPLETION

DOW CHEMICAL CO. - DEPT. OF ENERGY

**DOW-DOE SWEETZ NO. 1 WELL
VERMILLION PARISH, LOUISIANA**

NOVEMBER 1980

**U.S. DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
DOW CHEMICAL COMPANY**

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NOVEMBER 1980

**PREPARED BY THE GEOTHERMAL BRANCH
ENERGY APPLICATIONS DIVISION
DOE/NEVADA OPERATIONS OFFICE**

**U.S. DEPARTMENT OF ENERGY
NEVADA OPERATIONS OFFICE
DOW CHEMICAL COMPANY**

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I. INTRODUCTION

A. Background

In 1975, the U.S. Energy Research and Development Administration (now a part of the U.S. Department of Energy) initiated a research, development, and demonstration program to stimulate commercial development of the geopressed resources underlying the Gulf Coast region of the United States. Several investigators (see References 1, 2, 3, and 4, Section XI) had recognized the energy potential and suggested that studies be conducted to assess the energy resource.

In March 1979, the Dow Chemical Company (Dow) submitted an unsolicited proposal to drill a well into a small geopressed water reservoir and perform an exhaustive study to evaluate geopressed reservoirs as a source of energy. The specific advantages of this proposed program may be summarized as follows:

1. The reservoir is small and thus data to completely define the production life and production characteristics of a geopressed water reservoir can be obtained in a nine-month production period.
2. The geology of the reservoir is known through well logs and seismic profiles already completed. These data define the size of the sand body and indicate that it is a sealed reservoir in a well-defined fault block.
3. The permeability and porosity of the sand is known to be adequate to support production of up to 25,000 barrels of water per day through the proposed 5 1/2-inch production tubing.
4. No previous production has occurred in this reservoir, but the same sand has produced gas in other fault blocks.
5. An exploration well was drilled and abandoned on the proposed site in 1974. Logs and drilling experience from this well increase the probability of success in the proposed drilling program.
6. Extensive geological data has been compiled and evaluated, eliminating the need for further preliminary work. Drilling can begin as soon as the availability of certain long-term delivery items can be assured and a drilling rig can be made available.

In order to conduct these studies, DOE executed a contract with Dow of Houston, Texas, to conduct the drilling, completion, and testing of one geopressed-geothermal well (i.e., Dow-DOE Sweezy No. 1) and one disposal well in Vermilion Parish, Louisiana. A schedule for the two-year drilling and testing program is given in Section X.

Volume I of this drilling and testing plan addresses only the drilling and completion of the wells. Volume II will contain all production testing information.

B. Program Objectives

The primary objective of this program is to determine the production characteristics of a definable and known geopressed water reservoir. Secondary objectives include observation of the changes in the nature of fluids as production proceeds, evaluation of procedures relative to the mechanisms of producing the fluids, and accumulation of data to evaluate the economics of energy production from the resource.

The reservoir production characteristics which the program is designed to determine include:

1. Maximum attainable production rate under the conditions of the well and the reservoir.
2. Ultimate producibility of the reservoir over its practical productive life.
3. Reservoir pressure change as production proceeds and estimation of formation changes which occur.
4. Accumulation of baseline data for determination of parameters useful for calculations involving three-dimensional geopressed reservoir modeling.
5. Determination of possible contribution of shale water influx on reservoir productivity.

Produced fluids will be carefully measured and analyzed to determine:

1. Composition of the fluids, both liquid and gaseous.
2. Initial gas/water ratio and changes in this ratio as pressure declines.
3. Nature of the reservoir fluids prior to production through recombination studies under simulated reservoir conditions.
4. Presence of shale dewatering through salinity changes, trace element occurrence, and reservoir behavior.

C. Location

North Parcperdue field is located in Vermilion and Lafayette Parishes, approximately eight miles south of the city of Lafayette, just off Highway 339. This area of south Louisiana is on a Pleistocene terrace of the Gulf Coastal Plain. Surface elevation is approximately 20 feet and drainage is good. The Sweezy lease is 37.5 acres and is comprised of pasture land. The proposed well location is 1,800 feet from the south line and 1,350 feet from the east line of Section 26, Township 11 south, Range 4 east. Good paved roads access the lease area. Figure 1, state of Louisiana map, shows the general location plus the location of El Tigre Lagoon, the site of the No. 1 Edna Delcambre geopressed-geothermal

STATE OF LOUISIANA MAP

Scale: 1" = Approximately 40 Miles

FIGURE 1

test, approximately 30 miles south of Parcperdue. Figure 2 shows the location of the North Parcperdue field on the parish highway map and Figure 3 shows the location of the well site. Figures 4, 5, and 6 show the *Cibicides jeffersonensis* (Cib jeff.) sand and the location of the Dow-DOE Sweezy No. 1 well.

The test well is located in an exceptionally well-defined fault block. Fault cuts in wells, plus extensive seismic data, indicate 19 points of control on the fault boundaries. The high definition of reservoir geometry offers a unique opportunity to study reservoir behavior with a degree of accuracy not available to any other proposed test location. To fully utilize this potential, reservoir testing will be as extensive and thorough as is practically feasible.

Location Map
Louisiana Gulf Coast Area
Showing Well Location

FIGURE 3

FIGURE 4
Cib. jeff. Sand
INDUCTION SPHERICALLY FOCUSED LOG

1-8

FIGURE 5

SCALE

0 2000'

DOW CHEMICAL U.S.A.
OIL & GAS DIVISION

EASTERN REGION

N. PARCPERDUE AREA
LAFAYETTE & VERMILION PHS.

STRUCTURE MAP

TOP OF CIB. JEFF. SAND

Interpreted by R. Turner

C.I. 1" = 100'
SCALE 1" = 2000'

SEISMIC LINE

FIGURE 6

PLAIN BASE M.B. 5A

DOW CHEMICAL U.S.A.
OIL & GAS DIVISION

EASTERN REGION

N. PARCERDUE AREA
LAFAYETTE & VERMILION PHS.

NET SAND ISOPACH

CIB. JEFF. SAND
Interpreted by J. Hamilton

— FAULT BOUNDARY
— LINE OF CROSS-SECTION

C.I. 10'
SCALE 1" = 2000'
FILE

1-9

II. PROGRAM MANAGEMENT

A. General

This section identifies the organizations and principal personnel participating in the well drilling and testing program and describes basic authorities and responsibilities.

B. Organizations and Personnel

1. Department of Energy, Division of Geothermal Energy, Washington, D.C.

Geopressure Program Manager--Mr. Robert Holliday
2. Department of Energy, Nevada Operations Office, Las Vegas, Nevada
 - a. Director, Energy Applications Division--J. Cotter
 - b. Chief, Geothermal Branch--R. Stearns
 - c. Project Manager Drilling--D. Steinnerd
 - d. Director, Geopressure Projects Office, Houston--K. Westhusing
 - e. Project Manager Testing--F. Goldsberry
3. Dow Chemical Company, Houston, Texas
 - a. Contractor Program Manager--J. S. Wilson
 - b. Business Manager--J. G. Stanley
 - c. Drilling Manager--J. C. Hammer
 - d. Geologist--J. R. Hamilton
4. Louisiana Geological Survey/Louisiana State University
 - a. Program Manager, Geological--Dr. D. Bebout
 - b. Program Manager, Environmental--Dr. C. Groat
5. University of Southwestern Louisiana

Principal Investigator--G. L. Kinsland

C. Authorities and Responsibilities

Responsibilities of the participating organizations are summarized as follows:

1. Division of Geothermal Energy

Identify overall program objectives, provide funding and authorization, and designate a Geopressure Program Manager with the following authorities and responsibilities:

- a. Approve any major changes to the approved well drilling and testing plan.
- b. Provide an approved Environmental Impact Assessment for the drilling and testing activities.
- c. Approve any proposed contract modifications which result in increased funding levels.
- d. Maintain continual cognizance of the well drilling and testing activities.

2. Nevada Operations Office

a. Geothermal Branch, Las Vegas, Nevada

- (1) Approve the Dow Chemical Company geopressure well drilling and testing plan.
- (2) Provide a Project Manager Drilling to maintain technical and administrative management of the project through receipt of oral and written reports and by on-site monitoring of critical project phases.
- (3) Provide formal direction to the Contractor to assure compliance with contract provisions.
- (4) Report project status to the Geopressure Program Manager.

b. Geopressure Project Office, Houston

- (1) Review and evaluate the well drilling and testing progress and make recommendations to the Project Manager Drilling.
- (2) Provide the day-to-day interface with industry, states, and educational institutions to maintain effective channels of communications regarding the development of the geopressure energy resource.
- (3) Provide a Project Manager Testing to maintain technical and administrative management of the project through the testing phase.
- (4) Assist in the coordination between the well drilling and testing contractor, the Louisiana Geological Survey/Louisiana State University scientific studies groups, and the University of Southwestern Louisiana.

(5) Prepare and coordinate press releases.

3. Dow Chemical Company

- a. Prepare a detailed geopressure well drilling and testing plan for approval.
- b. Conduct the well drilling and testing activities in accordance with the approved plan and the provisions of the Contract.
- c. Coordinate drilling and testing activities with the Louisiana Geological Survey through the Nevada Operations Office.
- d. Provide logistical and other support to the Louisiana Geological Survey and other participating research institutions, with approval of the Nevada Operations Office.
- e. Prepare and submit reports as specified in Section IX of this plan and maintain a daily project cost status.
- f. Inform NV of any proposed deviation from the approved drilling and testing plan, before the deviation if not an emergency, and immediately afterwards if an emergency.

4. Louisiana Geological Survey/Louisiana State University

Provide geological analysis and environmental monitoring as specified in Section VII of this plan.

5. University of Southwestern Louisiana

Obtain and interpret high resolution seismic data before and after production of geopressured fluids.

See Figure 7 for relationship of primary organizations.

GEOPRESSURE WELL

DRILLING & TESTING PROGRAM ORGANIZATION CHART

Figure 7

III. GENERAL SITE ACTIVITIES

A. Site Preparation

1. General

Existing drainage ditch to be filled and compacted, particularly in area of rig substructure.

A surface location of approximately 490 x 670 feet will be required for the following:

a. Dow-DOE Sweezy No. 1, Test Well

Drilling rig and associated equipment.

b. Dow-DOE Sweezy No. 2, Saltwater Disposal Well

Drilling rig and associated equipment.

c. Reserve Mud and Salt Water Storage Pits

d. Production Test Facilities

(1) Gas recovery and measurement.

(2) Gas sales.

(3) Saltwater disposal.

e. Living Area

During drilling, completion, and testing, the number of house trailers for quarters, offices, and laboratories could vary between four and seven.

f. Security Officer's Shack

To be located at entrance to the well location.

A diagram of the site layout is shown in Figure 8.

2. Pad Area

a. Approximately 152,000 square feet.

b. Pad to be constructed as follows (location is dry and well drained):

(1) Drainage ditch traversing location to be temporarily rerouted outside proposed ring levees. Existing drainage

DRILL SITE LAYOUT
DOW-DOE SWEETZ NO. 1
FIGURE 8

REVISED 3-14-80 CAB

THE DOW CHEMICAL CO.
PARCERDUE PROJECT
REVISED SITE LAYOUT
2-19-80 CAB

ditch to be filled and compacted, particularly in area of rig substructure.

- (2) Location to be graded and sloped to drain to ring levee ditches.
- (3) Drive piling as required for rig loading.
- (4) A two-ply hardwood board matting on entire pad.
- (5) Six to eight inches of coarse graded limestone over boards.
- (6) Two to three inches fine limestone topping.
- (7) After rig selection, an additional two-ply hardwood board matting to be placed under rig substructure and major equipment.
- (8) Heavy-duty cattle guard to be installed at exit from parish road.
- (9) Existing shell road to be improved to entrance of location.

3. Reserve Mud and Salt Water Storage Pits

- a. The reserve pit will be approximately 200 x 350 x 6 feet and the saltwater storage pit will be approximately 100 x 200 x 6 feet.
- b. Pits will be located for use while drilling two wells.
 - (1) Test Well Dow-DOE Sweezy No. 1.
 - (2) Saltwater Disposal Well Dow-DOE Sweezy No. 2.
- c. Pits will be lined to prevent leakage.
- d. Levees will be graded and compacted to prevent surface leakage.
- e. Material for levees will be removed from immediately inside levees. Center area of pit will remain at natural ground level to reduce restoration cost.
- f. Entire pit area will be inside outer ring levee.
- g. Reserve pit will have "duck's nest" section with downcomer to main pit area.

4. Ring Levee

- a. Ring levee to enclose entire location.
- b. Ring levee to be ditched inside and outside.
 - (1) Inside ditches to collect in two easily accessible sumps.

(2) Outside ditches to enter natural drainage systems.

5. Water Well

- a. Will be used for drill water and nonpotable site water.
- b. Will be drilled prior to rig move-in.
- c. Will utilize a 400-barrel tank as holding pit.

6. Security

- a. Entire location and entrance road will be fenced.
- b. Single entrance to location with:
 - (1) A checkpoint and guard station to be located at exit from parish road.
 - (2) A 24-hour security guard.

B. Trailers

Trailers on site will be provided by their respective organizations and will be present only for the period of their involvement. During the drilling phase, trailers on the site will include at least (1) the tool pusher's trailer, (2) the mud logger's trailer, (3) the mud engineer's trailer, (4) the Dow analytical trailer, and (5) the Dow on-site manager's trailer. Trailers on site for the longer period of well testing and production are estimated to be one testing contractor (well operator) trailer plus the two Dow trailers.

The only additional building will be a small guard shack located at the entrance to the property. This will be a portable building approximately 8 x 10 feet, serving to house a man to check incoming and departing traffic for property security.

C. Communications

Two telephone lines will be installed to the Dow manager's trailer, with one line having extensions in the Dow analytical trailer, the tool pusher's trailer, and the guard shack.

D. Power

The location will be serviced by lines from the local power company, SLEMCO, with 120- and 240-volt power.

E. Drilling Rig Engines

Drill rig engines will be placed on the east side of the rig substructure to mitigate noise.

F. Water Supply

A freshwater well will be drilled and completed. A pumping system will be installed to supply water to all points of need on the site. Only bottled water will be used for human consumption.

G. Sanitation

Two 500-gallon septic tanks will be installed on the west side of the site and connected to the flush toilets in the trailers with PVC pipe.

H. Site Cleanup and Restoration

The entire site area will be returned to its original condition unless other written agreement is made with the surface owner.

1. Wells will be plugged and abandoned as per Louisiana Conservation Commission rules and Section V.A.5.g.
2. Remove production test and water disposal facilities.
3. Remove pad area.
 - a. Limestone
 - b. Board matting
4. Empty and restore reserve mud and saltwater storage pits.
5. Remove septic system.
6. Level surface to original contours and plant a ground cover to prevent erosion.
7. Return drainage ditch to original location.

IV. OCCUPATIONAL HEALTH AND SAFETY

A. General

All drilling operations and other site activities will be conducted in accordance with standards of the Occupational Safety and Health Act of 1970 (OSHA).

All participating organizations are responsible for the health and safety of their own personnel and for conducting all activities in accordance with procedures that assure:

1. A safe and healthful environment for the employees.
2. Control and minimization of hazards to the public and to personnel of other participants.
3. Minimization of accidental damage or loss of equipment, materials, and property.

No unauthorized personnel will be permitted on location. Dow Oil and Gas Division safety rules will apply, a copy of which will be available at the drill rig.

B. Site Access

Because of the hazardous nature of geopressured-geothermal well drilling and testing operations, Dow will control access to the test site and will arrange all visits of nonproject personnel.

C. Fire Protection

1. Hand-operated fire extinguishers for the drill rig and other surface equipment will be provided. Extinguishers will be available for control of Class A, B, and C fires.
2. "No Smoking" signs will be placed 100 feet from the drill rig and production facilities.
3. A wind sock will be installed which is visible from all points on the site.

D. Industrial Hygiene

Potable water and chemical or standard toilets will be provided at all areas where personnel are stationed on a full-time basis. The chemical toilets will be serviced on a regular basis. Solid wastes will be disposed of in accordance with local regulations.

E. Safety Hazards

1. Hydrogen Sulfide

None expected. Normal precautions will be taken by placing H₂S detectors in the drilling fluid pit areas and monitoring same with the mud logging unit.

2. Blowouts

- a. Refer to Section V.A.4.b. for equipment.
- b. Should a severe "well kick" develop, the Hydril will be closed and the choke line opened. Circulation will continue while slowly increasing the weight of the drilling fluid. After sufficient weight material (barite) has been added, the Hydril will be opened. Circulation will continue for a length of time necessary to completely stabilize the mud at the new weight. The pump will be shut down and the well observed for flow. If the drilling fluid is stable, normal operations will be continued.

During the course of the well-killing procedure with the Hydril closed, the drill pipe will periodically be moved to lessen the chance of the drill pipe becoming stuck in the hole. Should the Hydril fail, the upper preventer will be closed and circulation continued with the drill pipe in place.

V. DRILLING OPERATIONS

A. Test Well

1. General

The site will be prepared as specified in Section III.

A 30-inch conductor casing will be driven to ± 150 feet. A 20-inch hole will be drilled to 5,000 feet and a 16-inch casing will be set and cemented to the surface. A 13 3/4-inch hole will be drilled to $\pm 12,600$ feet. A 10 3/4-inch casing will be set and cemented to 5,000 feet. A 9 5/8-inch hole will be drilled to $\pm 13,600$ feet. An 8 5/8- to 7 5/8-inch tapered casing string will be set and cemented to 7,500 feet.

The casing will be perforated with 12 shots per foot and gravel packed using Dowell H-W IV fluid to avoid sand damage. A schematic diagram of the well design is shown in Figure 9.

See Appendix C for the logs and drilling highlights for the offset well, Sweezy "A" No. 1.

2. Drilling Procedure

The Proposed Drilling Curve for the test well is shown in Figure 10. The drilling procedure for the test well will be as follows:

- a. Stake location, obtain permits, prepare location, move in and rig up, and drive 30-inch conductor to ± 150 feet.
- b. Drill 20-inch hole to 5,000 feet, condition hole, run multishot survey. Run and cement 16-inch surface casing to surface.
- c. Install and test 16-inch, 5,000 psi wellhead. Nipple up and test 16 3/4-inch, 5,000 psi BOP stack and choke manifold. Pressure test casing to 1,000 psi for 30 minutes. Pressure test casing shoe to 14.8 ppg equivalent mud weight.
- d. Install computerized mud logging unit at approximately 5,000 feet.
- e. Drill 13 3/4-inch hole to $\pm 12,600$ feet. Condition hole and log. Run multishot survey.
- f. Run 10 3/4-inch intermediate casing to 12,600 feet and cement to 5,000 feet.
- g. Nipple up and test 11-inch, 10,000 psi BOP stack and choke manifold. Pressure test 10 3/4-inch casing to 3,000 psi. Pressure test casing shoe to 17.7 ppg equivalent mud weight.

Proposed Well Bore and Completion Schematic Dow Chemical U.S.A. Parcperdue Project Geopressure Geothermal Test Well No. 1

NOTE:

All depths used are
correlative to the Phillips
Sweezy "A" No. 1 Well

Packer Fluid

17.2 ppg ZnBr₂ completion
fluid

Production Tubing

5 1/2", 23#, S-95, LT&C
w/ Atlas Bradford

8 5/8" casing

7 5/8" casing. Radioactive
collars @ ± 13,000' and
13,200' for correlation

88' X .012 gauge screen
Top of screen @ 13,364'
Bottom of screen @ 13,452'

Lower Tattle-tail screen

Dowell Model 18 Packer

TD @ 13,600'

* NOT TO SCALE

30" @ ± 150'

16", @ ± 5000' cemented
to surface

8 5/8" X 6.5" ID X 10' long
polished bore receptical (PBR)

8 5/8"; X-over

10 3/4", @ ± 12,600'
Cemented to 5000'

gravel packing packer

Annulus gravel packed w/
20-40 resieved Ottawa sand

Proposed Perforations in
Cib Jeff Sand

BHP bomb latching nipple

PBSD @ ± 13,560'
7 5/8" @ 13,600'

FIGURE 9

FIGURE 10 PROPOSED DRILLING CURVE

- h. Drill 9 5/8-inch hole to $\pm$ 13,350 feet and core from just above, through, and below the Cib. jeff sand.
- i. Drill 9 5/8-inch hole to $\pm$ 13,600 feet, condition hole and log.
- j. Run 8 5/8- to 7 5/8-inch tapered casing string to $\pm$ 13,600 feet and cement to 7,500 feet.
- k. Clean out hole. Circulate and condition mud to 17.2 ppg. Run Gyro survey.
- l. Run GR/CBL-VDL from plug back TD. Block squeeze as necessary and test.
- m. Run production log suite. Clean up hole.
- n. ~~Displace 17.2 ppg mud with 36 barrels of 17.2 ppg Dowell Spacer 1001 followed by 11.5 ppg CaCl₂ brine. Circulate and filter CaCl₂ brine until returns are clean.~~
- o. ~~Displace CaCl₂ with 36 barrels of 17.2 ppg Dowell Spacer 1001 followed by 17.2 ppg Dowell H-W IV (zinc bromide/calcium bromide). H-W IV will be constantly filtered and reweighed during remainder of completion.~~
- p. Rig up wire line. Perforate with 12 shots per foot (correlative to Phillips Sweezy "A" #1) 13,441 to 13,447 feet (6 feet); 13,417 to 13,434 feet (17 feet); 13,389 to 13,412 feet (23 feet); 13,369 to 13,389 feet (20 feet). See Figure 11 for correlative ISF log. Wash perforations with filtered H-W IV and prepack using Dowell WATER-PACK method. Set Dowell Model 18 permanent packer with punch-out at 13,465 feet. Rig down wire line.
- q. Run in 4-inch screen and liner, and gravel-pack assembly. Perform gravel pack using 3 1/2-inch drill pipe. Clean up and pull out of hole.
- r. Inspect 5 1/2-inch coated tubing using Amolog IV system. Go in hole with locator seal assembly, landing nipple, and latching assembly for securing Hewlett-Packard gauge. Tubing connections to be made using AMF Tuboscope "Torque and Proper Engagement Control Service" (TAPE). Hang off 5 1/2-inch tubing and test seals to 3,000 psi. Install back-pressure valve.

3. Completion Procedure

a. General

In the proposed formation, the sand is expected to be unconsolidated and therefore subject to possible displacement under high-velocity production. The relatively small thickness of sand which can be opened for production is further curtailed by

3300

C13 Jeff
Sand

13400

13500

Proposed Perforations

13,369'-13,412' (43')

13,417'-13,434' (17')

13,441'-13,447' (6')

Correlative Depths "Only"

Based on Sweezy "A" #1

FROM:

Figure 11
PROPOSED PERFORATIONS
DOW CHEMICAL USA
PARCERDUE PROJECT
PHILLIPS SWEETZ "A" #1
ISF LOG SECTION
RUN 3 DATED 12/13/73

the presence of shale stringers in the sand. Thus, high-volume production from this reservoir necessitates high flow rates at the well bore.

The production well will be completed using a perforation and gravel-pack technique unless well conditions otherwise dictate.

b. Summary of Procedure

- (1) Clean up mud in hole with light brine. When returns are clean, run spacer followed by H-W IV. Filtering and reweighing of H-W will be a constant process.
- (2) Run in Dowell Model 18 permanent (drillable) production packer and set at 13,445 feet. (Used as lower sump packer in gravel pack accommodates screen assembly.)
- (3) Perforate with 12 shots per foot. Wash perforations to clean out debris and create cavity for placement of gravel.
- (4) Prepack perforations to ensure proper emplacement of gravel in tunnels using Dowell Model 14 squeeze packer. Clean out gravel fill.
- (5) Clean out hole to Model 18 packer. Run in Model 16 packer with screen assembly and set.
- (6) Perform inside gravel pack, fill around screen assembly, and clean up.
- (7) Run production assembly using inhibited H-W IV as packer fluid.

4. Surface Equipment and Services

a. Wellhead

The wellhead will be rated at 10,000 psi working pressure with a stainless steel valve and specifications as shown in Figure 12.

b. Blowout Prevention Equipment

The blowout prevention equipment will conform to or exceed the description given below:

(1) Minimum Configuration Blowout Preventers

(a) Surface Casing (16-inch)

3 ea - 16 3/4-inch 5,000 psi ram-type preventer

1 ea - 16 3/4-inch 5,000 psi bag-type preventer

5-1/2", 10,000 Flanged Tree top
w/needle valve & 10,000 psi gauge

5-1/2", 10,000 stainless steel
trimmed gate valve (manual).

5-1/8", 10,000 Special "Y" Tee.

6" SCH. SSS long radius
90° turn.

5-1/8", 10,000 Stainless
Steel Gate Valve (manual).

5-1/8", 10,000 Stainless Steel
Gate Valve (w.operator)

5-1/8", 10,000 Stainless Steel
Gate Valve (manual)

9", 10,000 x 5-1/8", 10,000 spool

9" x 5-1/2" FBB tubing Hanger

1 13/16" 10,000 tapped flange w/
tapped bull plug, needle valve &
gauge

11", 10,000 x 9", 10,000
Tubing Spool w/2-2" flanged
outlets

1 13/16" 10,000 psi Flanged Gate Valve

11" x 8-5/8" slip-type
hanger

1 13/16" 10,000 Tapped Flange w/Tapped bull
plug, needle valve & gauge

16", 5000 x 11" 10,000 Casing
Spool w/2-2" Flanged Outlets

1 13/16", 10,000 Flanged Gate Valve

16", 5000 SO Casing Head

16" x 10-3/4" Slip Type Hanger

2", 5000 Gate Valve

16" Surface Casing

10-3/4" Intermediate Casing

8-5/8" Production Casing

5-1/2" Production Tubing

PROPOSED WELLHEAD AND X-MAS TREE
DOW CHEMICAL USA
PARCERDUE PROJECT
GEOPRESSURE GEOTHERMAL NO. 1

Figure 12
5-7

- 1 ea - Remote control HCR-type valve on choke line
- 1 ea - Drilling spool oriented on surface casing
- 1 ea - Full opening safety valve to fit drill pipe and drill collars
- 1 ea - Inside blowout preventer to fit drill pipe and drill collars

(b) Intermediate Casing (10 3/4-inch)

- 3 ea - 11-inch, 10,000 psi ram-type preventer
- 1 ea - 10-inch, 5,000 psi bag-type preventer
- 1 ea - Remote control HCR-type valve on choke line
- 1 ea - Drilling spool oriented on intermediate casing
- 2 ea - Full opening safety valve to fit drill pipe and drill collars
- 1 ea - Inside blowout preventer to fit drill pipe and drill collars

(c) Completion (8 5/8-inch)

- 3 ea - 11-inch, 10,000 psi ram-type preventer
- 1 ea - 10-inch, 5,000 psi bag-type preventer
- 1 ea - Remote control HCR-type valve on choke line
- 1 ea - Drilling spool oriented on production casing
- 2 ea - Full opening safety valve to fit drill pipe and drill collars
- 1 ea - Inside blowout preventer to fit drill pipe and drill collars

(2) Choke and Manifold

- (a) A remote-control, hydraulic choke is to be installed at rig up on 16-inch casing.
- (b) Minimum pressure rating of 10,000 psi for the choke and 5,000 psi for the manifold.

(3) Preventer Testing Pressures and Procedures

(a) Testing Pressures

- 1) Rams are to be tested to their working pressures.
- 2) Bag preventers are to be tested to 70 percent of their working pressures.
- 3) The choke and manifold are to be tested to their working pressures.
- 4) All equipment is to be tested once each week (as a minimum).

(b) Tighten the bolts on the preventer each week.

(c) Work the ram preventers on each trip.

(d) Flush all lines on each trip.

c. Drill Rig

The rig will have a traveling block and hook, swivel, and rotary rated at 1,000,000 pounds. The mast must be capable of a 1,000,000-pound A.P.I. static hook load and the substructure must have a 1,600,000-pound capacity.

d. Auxiliary Equipment and Services

The following equipment and services will be employed at the indicated depth intervals:

<u>Equipment</u>	<u>Interval</u>
Desilter	Spud-TD
Desander	Spud-TD
Atmospheric Degasser	Spud-TD
Pit Level Monitor	5,000-TD
Flow Monitor	5,000-TD
Gas Detector	5,000-TD
Dual Screen Shaker	5,000-TD
Remote Hydraulic Choke	5,000-TD
Vacuum Degasser	10,000-TD
Stabilizers	0-TD
Drill Pipe Protectors	5,000-TD
Depth Recorder	0-TD
16 3/4-inch BOPs	5,000-12,600 feet
11-inch BOPs	12,600-completion
Wear Bushing	5,000-TD
Full Opening Valve	5,000-completion
Inside BOP (Drill Pipe)	5,000-completion
Test Unit	TD
Mud Scrubber	5,000-TD
Bulk Barite Tank	5,000-TD

5. Downhole Equipment and Services

a. Drilling Fluids Program

The following mud program will be used:

<u>Depth (Feet)</u>	<u>Mud Weight (ppg)</u>	<u>Viscosity (Sec./Qt.)</u>	<u>API Fluid Loss (cc/30 min)</u>	<u>HTHP Fluid Loss (cc/30 min)</u>	<u>Comments</u>
0-5,000'	8.8-9.4	36-38	N.C.	N.C.	Gel-Caustic System Desanded
5,000- 8,000'	9.2	36-38	N.C.-10	-	Gel-Caustic System Desilted, Desanded
8,000- 10,500'	9.5	36-38	10-8	-	Lignite- Lignosulfonate Mud Scrubber
10,500- 12,600'	9.5-13.0	38-42	8-5	20	Lignite- Lignosulfonate Mud Scrubber
12,600- 13,600'	13.0-17.2	42-50	3-2	10	Lignite Lignosulfonate Mud Scrubber Centrifuge

The drilling fluid solids content data is given in Figure 13 and the expected pressure gradients are given in Figure 14.

- (1) HTHP fluid loss test to be run at 300°F and 500 psi differential pressure.
- (2) Solids content of the mud to be maintained below the levels shown in Figure 13 for mud in good condition.
- (3) Rheology values to correspond to values shown in Table 1.
- (4) Solids control equipment should include a desilter, desander, centrifuge, and combination cyclone-screen unit (mud scrubber).

b. Mud Logging Program

A mud logging system, including a computerized logging unit, will be installed and operational at approximately the 5,000-foot depth. This will include drilling rates, lithology interpretation and description, total gas content of the drilling fluid—

FIGURE 14

TABLE 1
RECOMMENDED MUD PROPERTIES

WT. <u>lbs./Gal.</u>	SOLIDS <u>% VOLUME</u>	PLASTIC <u>VISCOSITY</u>	YIELD <u>POINT</u>
10.0	10.0-12.0	13.0-17.5	X-5.5
10.5	12.0-14.0	15.0-19.5	X-8.0
11.0	13.5-15.5	17.0-21.5	X-11.0
11.5	15.0-17.0	19.0-23.5	X-12.5
12.0	17.0-19.0	21.0-25.0	4.5-14.0
12.5	20.0-22.0	23.0-28.0	6.5-15.0
13.0	22.0-24.0	25.0-30.0	8.0-16.5
13.5	24.0-26.0	27.5-33.0	9.5-17.5
14.0	25.5-27.5	30.9-35.0	10.5-18.0
14.5	27.0-29.0	32.0-38.0	11.5-19.0
15.0	28.5-30.5	34.5-41.0	12.0-19.0
15.5	30.0-32.0	37.0-44.0	13.0-19.5
16.0	31.5-33.0	40.0-47.5	13.5-20.0
16.5	32.5-34.0	42.5-51.0	14.0-20.0
17.0	34.0-35.5	46.0-55.5	14.0-20.0
17.5	35.0-36.5	49.5-60.0	14.5-20.0
18.0	36.0-37.5	53.0-66.0	14.5-20.0

continuously recorded, dual-column chromatograph, trip gas notation, connection gas notation, pump strokes monitored, drilling mud properties, and pit volume and flow rate monitored.

The computerized logging unit will monitor formation porosity, formation pore pressure, rate of penetration, weight on bit, rotary rpm, accumulative drilling hours, and bearing condition of drill bit. Calculations of equivalent circulating density, fracture gradient, corrected "d" exponent, swab-surge pressures, and a hydraulics analysis will be furnished by the logging unit personnel.

c. Logging Program

Logging will follow the "Standard Well Logging Program" described in Appendix A. The logs listed as desirable but not essential will be employed only if agreement has been made with DOE/NV and funds have been allocated for them. The section titled "Research Needs in Logging Geopressured-Geothermal Reservoirs" is provided as information for cooperative assistance by the operator where possible. Many of the research efforts described are being accomplished by the University of Texas at Austin and the Institute of Gas Technology. Accordingly, data useful to their respective research studies should be provided when possible. Operator coordination with participating research institutions, including providing of useful data collected during the course of drilling and completion operations, is a required and vital part of the design well program.

d. Coring Program

During the drilling of the well, two standard 60-foot core barrels will be taken just above, through, and below the Cib. jeff. sand, the expected production interval. The zone to be cored includes the design well stratigraphic equivalent to the upper transitional shale above the Cib. jeff. zone starting at about 13,350 feet in the Phillips Petroleum Sweezy "A" No. 1 and running for 60 feet, approximately 40 feet into the Cib. jeff. sand. The second 60-foot core will be a continuation of the equivalent stratigraphic interval from 13,410 feet to 13,470 feet providing some 30 feet of shale that underlies the production interval. Other zones of interest or where core may be missed during conventional coring will be cored by wire line sidewall coring (SWC) methods.

Core handling procedures will follow the "Guidelines for Core Handling Procedures and Rock Mechanics Laboratory Testing" in Appendix B. Rock properties derived from core studies will be cross-referenced with values derived from logging operations to determine the most efficient means of formation evaluation and for sizing the gravel pack. Accordingly, it is important that core handling and distribution be expedited to assure accomplishment of rock mechanics in a timely manner.

e. Casing Program

The casing program will be as follows:

(1) Conductor

Proposed Setting Depth: 175 feet (150-foot penetration).

- (a) 30-inch Grade B line pipe with a wall thickness of 1.50 inches (at top) approximately 150-foot penetration with a D-62 Diesel Hammer. Drive to 300 BPF for a bearing capacity of $\pm 1,300$ tons.
- (b) A drive shoe is to be used to prevent crimping. A sub-sea-type hanger ring to be run at ± 100 feet of penetration.
- (c) Each joint is to be welded together.
- (d) Rig up diverter and mud return lines on 30-inch conductor pipe.

(2) 16-Inch Casing

<u>Size and Thread</u>	<u>Interval</u>	<u>Weight Grade</u>	<u>Makeup Torque</u>	<u>Maximum Running Rate</u>
16" BTRC	0-5,000'	109# K-55	To Mark	90 ft./min.

- (a) Float shoe to be thread locked to bottom of first joint.
- (b) Float collar to be thread locked at top of first joint. (Coupling to be removed and float collar to be double female type.)
- (c) Centralizers and Scratchers as required.
- (d) All couplings to be cleaned and doped with an API modified thread compound.
- (e) Reciprocate casing with 15-foot stroke while circulating one casing volume. Continue reciprocating casing while mixing and displacing cement until second plug bumps. Land casing on hanger ring. (Buoyed weight = 488,000 pounds, including 20,000 pounds for the weight of the block assuming 9.4 ppg mud.)
- (f) Maximum pull of the 16-inch casing is 1,237,000 pounds. (This is 70 percent of the minimum yield and includes 20,000 pounds for the weight of the block.)

(3) 10 3/4-Inch Casing

<u>Size and Thread</u>	<u>Interval</u>	<u>Weight Grade</u>	<u>Makeup Torque</u>	<u>Maximum Running Rate</u>
10 3/4" BTRC	0-5,500'	55.5# S-95	To Mark	40 ft./min.
10 3/4" BTRC	5,500-8,400'	55.5# P-110	To Mark	40 ft./min.
10 3/4" BTRC	8,400-12,600'	55.5# S-95	To Mark	40 ft./min.

- (a) Float shoe to be thread locked to bottom of first joint.
- (b) Float collar to be thread locked at top of first joint. Float collar to have double floats. (Float collar to be male by female.)
- (c) Centralizers and Scratchers as required.
- (d) All connections to be cleaned and doped with an API modified thread compound.
- (e) Install cementing head, break circulation, and reciprocate casing with 15-foot strokes while circulating at least one casing volume (1,162 barrels) to clean hole. Continue reciprocating while mixing and displacing cement until second plug bumps. (Buoyed weight = 583,000 pounds, including 20,000 pounds for the weight of the block assuming 13.0 ppg mud.)
- (f) Maximum allowable pull on the 10 3/4-inch casing is 1,004,000 pounds. This is 65 percent of the body yield strength (55.5#, S-95, BTRC) plus 20,000 pounds for the weight of the block.

(4) 8 5/8- to 7 5/8-Inch Tapered Casing

<u>Size and Thread</u>	<u>Depth</u>	<u>Weight Grade</u>	<u>Makeup Torque</u>	<u>Maximum Running Rate</u>
8 5/8" FL4S	0-11,000'	44# P-110	8,500 ft.-lbs.	15 ft./min.
7 5/8" LT&C	11,000-13,600'	39# P-110	10,600 ft.-lbs.	45 ft./min.

NOTE 1: Run 8 5/8" x 6.5" TC x 10' long polished bore receptacle at $\pm$ 10,800 feet.

NOTE 2: Use 8 5/8" 44# P-110 FL4S box x 7 5/8" 39# P-110 8RD LT&C pin combination crossover joint, 4 feet long.

- (a) Float shoe to be thread locked to bottom of first joint.
- (b) Float collar to be thread locked at top of first joint. Float collar to have double floats.

- (c) Centralizers and scratchers as required.
- (d) All connections to be cleaned and doped with an API modified thread compound.
- (e) Install cementing head, break circulation, and reciprocate casing with 15-foot strokes while circulating hole clean (at least one casing volume). Continue reciprocating while mixing and displacing cement until second plug bumps. Hang casing in full tension. (Buoyed weight = 454,000 pounds, including 20,000 pounds for the weight of the block assuming 17.2 ppg mud.)
- (f) Maximum allowable pull on the 8 5/8-inch casing is 694,000 pounds. This is 65 percent of joint strength (44#, P-110, FL4S) plus 20,000 pounds for the weight of the blocks.

(5) 5 1/2-Inch Tubing

<u>Size and Thread</u>	<u>Depth</u>	<u>Weight Grade</u>	<u>Makeup Torque</u>
5 1/2-inch LT&C w/seal rings	± 10,800 feet	23# S-95	5,700 ft.-lbs.

- (a) Go in hole with polished bore receptacle (PBR) locator seal assembly with ± 25 feet of 6.50-inch O.D. seals and mule shoe guide, landing nipple, and 5 1/2-inch tubing.
- (b) Test 5 1/2-inch tubing to 9,000 psi (connection only) while going in hole.

NOTE 1: Dope pin ends only and wipe off excess.

NOTE 2: Clean all connections and use API modified thread dope only.

- (c) Locate in PBR at ± 10,800 feet. Test seals to 3,000 psi.
- (d) Space out tubing with locator 6 feet above the top of the packer. Install hanger to land tubing in 9-inch, 10,000 psi head.
- (e) Pull seals out of packer, close Hydril, and displace annulus with 370 barrels H-W IV treated with 1 percent Corban 333.
- (f) Land and hang off 5 1/2-inch tubing in 9-inch, 10,000 psi head. Test seals to 3,000 psi.

- (g) Set Dowell 5 1/2-inch retrievable bridge plug at 400 feet in tubing. Test bridge plug to 3,000 psi. Install back-pressure valve.
- (h) Nipple down blowout preventers and nipple up 5 1/8-inch, 10,000 psi X-mas tree. Test tree to 10,000 psi.
- (i) Rig up coil tubing unit. Go in hole unloading 17.2 ppg H-W IV with N₂ until the well begins to flow. Recover H-W IV until returns become contaminated with well fluids.

f. Cementing Program

(1) 16-Inch Casing

	<u>Lead</u>	<u>Tail</u>
Type:	Dowell Lightweight	UniBase H + .2% D-46
Sacks:	5,200	400
Slurry Yield:	1.54 cu.ft./sx	1.09 cu.ft./sx
Slurry Volume:	8,008 cu.ft. (1425 bbls)	436 cu.ft. (78 bbls)
Mix Weight:	12.5 ppg	16.2 ppg
Water Requirement:	8.24 gal/sx	4.53 gal/sx
Thickening Time:	6.0 hrs.	4.0 hrs.

Pipe displacement to the float collar (4,960 feet) is 1,039 barrels. Total time to mix and displace the slurry is 4.2 hours at 10 BPM. Calculated fill-up is to the surface, assuming a 23 3/4-inch average hole size (100 percent excess).

- (a) Use top and bottom plugs displacement method.
- (b) Preflush with 30 barrels of 10.0 ppg Dowell CW-100.
- (c) If cement does not circulate to the surface, top out to the surface with Class H + 2 percent CaCl₂ placed in the 30- x 16-inch annulus through 1 1/4-inch tubing.
- (d) Install 5,000 psi weld-on casing head and seal 30- x 16-inch annulus. Test head to 2,000 psi (80 percent of 16-inch collapse).
- (e) Nipple up 16 3/4-inch blowout preventer and choke manifold (three ram type and one bag type with drilling spool). Test BOPs and choke manifold.
- (f) Displace 16-inch casing to 100 feet with water and test casing to 1,000 psi for 30 minutes (Louisiana Conservation Commission requirement).

- (g) Drill out the 16-inch shoe and 10 feet of formation with a 13 3/4-inch bit. Test the shoe and formation by pressuring up slowly until leak-off occurs. Estimated fracture gradient at the 16-inch shoe is 14.8 ppg. Retest the shoe after drilling an additional 100 feet of formation. Drilling design requires a minimum fracture gradient of 14.8 ppg equivalent. Surface pressure required for a 14.8 ppg equivalent with a 9.4 ppg mud in hole is estimated at 1,404 psi. Circulate and condition mud to a uniform weight before leak-off test.

If shoe fails to test 14.8 ppg equivalent, cement squeeze and retest until desired pressures are achieved.

(2) 10 3/4-Inch Casing

	<u>Lead</u>	<u>Tail</u>
Type:	Dowell Lightweight + .2% D-13 + .2% D-46	Unibase H + .2% D-13 + .2% D-46
Sacks:	3,580	1,000
Slurry Yield:	1.24 cu.ft./sx	1.09 cu.ft./sx
Slurry Volume:	4,439 cu. ft. (790 bbls)	1,090 cu.ft. (194 bbls)
Mix Weight:	13.5 ppg	16.2 ppg
Water Requirement:	6.02 gal/sx	4.53 gal/sx
Thickening Time:	7.0 hrs.	4.0 hrs.

Pipe displacement to the float collar (12,560 feet) is 1,162 barrels. Total time to mix and displace the slurry is 4.0 hours at 10 BPM. Calculated fill-up is to 5,000 feet, assuming a 15 3/4-inch average hole size (100 percent excess).

- (a) Use top and bottom plug displacement method.
- (b) Preflush with 30 barrels of 13.5 ppg Dowell Spacer 1000.
- (c) Do not bump plug with over 750 psi. Displace with cementing pump units. Slow pump rate to 4 BPM at 25 barrels before calculated displacement.
- (d) Hang 10 3/4-inch casing in 16-inch, 5,000 psi casing head. Hang in full tension plus 150,000 pounds overpull to compensate for thermal expansion. Nipple down BOPs. Run temperature survey and recalculate overpull required.
- (e) Install 16-inch, 5,000 psi x 11-inch, 10,000 psi casing spool. Test packoff to 3,400 psi (80 percent of 10 3/4-inch collapse).

- (f) Nipple up and test 11-inch, 10,000 psi blowout preventers and 10,000 psi choke manifold with remote-controlled hydraulic choke (three ram type and one bag type with drilling spool).
- (g) Displace 10 3/4-inch casing to 100 feet with water and test casing to 3,000 psi for 30 minutes (Louisiana Conservation Commission requirement).
- (h) Drill out the 10 3/4-inch shoe and $\pm$ 10 feet of formation with a 9 5/8-inch bit. Test the shoe and formation by pressuring up slowly until leak-off occurs. Estimated fracture gradient at the 10 3/4-inch shoe is 17.7 ppg. If shoe fails to test to 17.7 ppg equivalent, retest after drilling an additional 100 feet of formation. Circulate and condition mud to a uniform weight before leak-off tests.

(3) 8 5/8- to 7 5/8-Inch Tapered Casing

Type:	Unibase H + 35% D-30 + 19.27#/sx D-18 + 1.5% D-65 + .42 gal/sx D-108 + .2% D-46 + D-13
Sacks:	725
Slurry Yield:	1.419 cu.ft./sx
Slurry Volume:	1,029 cu.ft. (183 barrels)
Mix Weight:	17.7 ppg
Water Requirement:	4.16 gal H ₂ O/sx
Thickening Time:	4.5 hrs.

Pipe displacement to the float collar (13,560 feet) is 729 barrels. Total time to mix and displace the slurry is 2.5 hours at 6 BPM. Calculated fill-up is to 7,500 feet, assuming a 10 1/2-inch average hole size.

- (a) Use top and bottom plug displacement method. A special 7 5/8-inch Flex plug is required.
- (b) Preflush with 70 barrels of 17.5 ppg Dowell Spacer 1000.
- (c) Do not bump plug with over 750 psi. Displace with cementing pump units. Slow pump rate to 4 BPM at 20 barrels before calculated displacement.
- (d) Pick up 11-inch, 10,000 psi blowout preventers. Hang 8 5/8-inch casing in 11-inch, 10,000 psi casing spool. Hang in full tension plus 100,000 pounds overpull to compensate for thermal expansion. Nipple down BOPs. Run temperature survey and recalculate overpull.

- (e) Install 11-inch, 10,000 psi x 9-inch, 10,000 psi tubing spool. Test packoff to 6,500 psi (80 percent of 8 5/8-inch collapse).
- (f) Nipple up 11-inch, 10,000 psi blowout preventers (three ram type and one bag type with drilling spool). Install 10,000 psi choke manifold with remote-control hydraulic choke. Test rams and choke manifold to rated working pressure and bag type to 70 percent of rated working pressure.

NOTE: Install a second flow line from bell nipple (to be located below normal mud return line) with shutoff valve. This flow line will be utilized to return completion fluid to a separate system.

- (g) Displace top 100 feet of hole with fresh water. Close blind rams and test 8 5/8-inch casing to 5,000 psi for 30 minutes.
- (h) Go in hole with 6 1/2-inch bit and clean out to PBTD. Circulate and condition mud to 17.2 ppg.

g. Plugging and Abandonment Plan

The general plug and abandon plan is as follows:

- (1) Rig up electric wire line unit. Set GO, or equivalent, tubing bridge plug in 4 1/2-inch blank liner (3.920-inch I.D.) at $\pm$ 13,250 feet. Test plug.
- (2) Perforate four 3/4-inch-diameter holes in 5 1/2-inch tubing two joints above landing nipple.
- (3) Install adjustable choke on casing annulus. Pump down 5 1/2-inch tubing with 18.0 ppg mud to displace 17.2 ppg Dowell HEVI-WATER IV (H-W IV) packer fluid and well fluids out of well.
- (4) Rig up heavy workover rig. Nipple down tree and nipple up blowout preventers. Pull out of hole and lay down 5 1/2-inch tubing.
- (5) Pick up and go in hole with work string. Set cement retainer at $\pm$ 13,100 feet. Spot cement plug 13,100 to 12,700 feet. Test plug.
- (6) Set second cement retainer or CIBP $\pm$ 10,000 feet. Spot 200-foot cement plug above. Test plug.
- (7) Spot surface plug from 250 to 50 feet.

(8) Cut casing strings 3 feet below ground level and weld 1/2-inch steel plate over 13 3/8-inch casing.

(9) Rig down.

B. Disposal Well

1. General

The disposal well should have the capacity to dispose of >20,000 bpd for a period of more than one year. It is not anticipated that a second well will be required for the program and it will not be drilled unless absolutely necessary.

Disposal aquifers are abundant and of excellent quality in Parcperdue field. Sands are massive throughout the entire Miocene section and comprise more than 50 percent of the interval, which roughly ranges from near surface to approximately 10,000 feet.

The well will be drilled to a total depth of 5,000 feet. The log of the adjacent well (Texaco, Inc., F. Bacque No. 1--see Figure 15) indicates two thick sands available with disposal potential. The well will be initially completed in the lower sand. The next higher sand will be used should the back-pressure buildup be too high. The proposed initial and alternate injection zones should correlate to 4,725-4,850 feet and 4,515-4,635 feet, respectively, with Texaco's F. Bacque No. 1 well.

2. Drilling Procedure

The schematic well design is shown in Figure 16.

The drilling procedure will be as follows:

- a. Location will be staked, permits obtained, and necessary forms filed.
- b. Site will be prepared.
- c. Rig will be moved in.
- d. A 16-inch conductor casing will be driven to $\pm$ 120 feet. A 13 1/2-inch hole will be drilled to 2,700 feet, with a 10 3/4-inch surface casing set and cemented to the surface. The surface casing will protect all possible freshwater sands. A cement bond log will be run to verify good cementing.
- e. A 9 7/8-inch hole will be drilled to 5,000 feet TD with one 60-foot core taken in each of the stratigraphic equivalent injection intervals shown in Figure 15.

Electrical Log Section
from Texaco, Inc.
~~P. Bacque #1 S-27-115-4E~~
Vermilion Parish, Louisiana

DOW/DOE L.R. Survey no. I

Salt Water Disposal Well #1
Proposed Injection Zone
Parcperdue Project

PROPOSED COMPLETION SCHEMATIC
Dow Chemical U.S.A.
Parcperdue Project SWD Well #1

NOT TO SCALE

FIGURE 16

- f. A 7 5/8-inch casing string will be set at 5,000 feet and cemented to the surface. The disposal zone will be perforated.
- g. Nipple down BOPs, nipple up 6-inch injection tree.
- h. Rig down and move out.
- i. Flow to pit, clean up hole and acidize.
- j. Install downhole pressure recorder. Perform injection test at ± 15 bpm.
- k. Hook up injection well to surface facilities.

VI. PRODUCTION TESTING

Volume II of the drilling and testing plan will contain all production testing information.

VII. ENVIRONMENTAL MONITORING PLAN:

PARCERDUE TEST WELL NO. 1

A. Introduction

The Louisiana Geological Survey/Louisiana State University (LSU) will undertake management of environmental baseline and monitoring studies for geopressured test well activities in the North Parcerdue oil and gas field near Lafayette, Louisiana.

The drilling and testing operations associated with the Parcerdue geopressured well will be conducted within the scope of an Environmental Impact Assessment (EIA) which was prepared by the Oak Ridge National Laboratory. In this EIA, the environmental implication of geopressured resource testing at Parcerdue was evaluated for activities beginning with well site preparation and continuing through the site restoration after completion of testing.

B. Environmental Baseline and Monitoring Studies

The purpose of collecting environmental baseline data is to provide a description of selected physical, chemical, and biological conditions against which later environmental monitoring data can be compared. This comparison will provide a basis for determining the net environmental change attributable to test well operations at any subsequent time.

The following data shall be collected to establish the baseline of ambient conditions prior to fluid production:

Air Quality

- existing air quality conditions
- local meteorological characteristics

Water Quality (surface and subsurface)

- existing water quality conditions
- water resource usage
- hydrologic patterns, surface, and groundwater levels

Subsidence

- subsidence history
- leveling surveys

Seismicity

- microseismic surveys

Ecosystem Quality

-- biological surveys

In order to avoid duplication, information presented in the DOE/Oak Ridge Environmental Impact Assessment for the Parcperdue well test shall be incorporated where possible in the LSU environmental baseline evaluation. For example, very little additional work may be required to establish existing ecosystem quality.

An environmental monitoring program designed to provide comparative data during drilling and production phases will include the studies listed below. The asterisk indicates the studies that are contingent upon the occurrence of environmental changes (e.g., changes in air quality and/or standards violation in the case of air quality) and are not considered in the base scope of work.

Air Quality

- air quality monitoring
- pollutant dispersion modeling*
- continuous wind speed, wind direction, temperature, and precipitation

Water Quality (surface and subsurface)

- water quality monitoring
- water level monitoring

Subsidence

- repeated leveling surveys

Seismicity

- continuous microseismic surveys

Ecosystem Quality

- biological surveys*
- bioassays*

Monitoring studies may be increased if environmental conditions, either natural or as a result of test well activities, and geopressure fluid analysis require such adjustment. However, LSU will be obligated to demonstrate the inadequacy of the existing data collection program to DOE when seeking approval for additional studies.

The combined scope of environmental baseline and monitoring studies which are planned during the first year include the air quality, water quality, subsidence, seismic, and ecological studies described below.

1. Air Quality

Air quality baseline studies will be performed to: (1) determine ambient air quality prior to possible disturbance from test well activities; (2) identify any substance potentially derived from the geopressed fluid that may have an adverse effect on the environment, and establish baseline concentrations for these substances; (3) collect locally available meteorological data necessary for understanding dispersion and conversion patterns; and (4) provide baseline data compatible with later measurements needed to assure compliance with state and federal air quality standards.

Air quality monitoring will be performed to determine changes in air quality which may be related to well testing activities. Sampling and analysis for hazardous substances will be from a fixed automated monitoring unit located approximately one mile northwest of the test site (prevailing winds are from the southeast). Analyses will include continuous measurement of sulfur dioxide, hydrogen sulfide, total hydrocarbons, and methane. Meteorological data from continuous recorders shall include wind speed, wind direction, temperature, and precipitation. In the event of significant atmospheric pollutant emissions, dispersion characteristics will be determined.

Analytical procedures for air quality monitoring will be consistent with designated Reference or Equivalent Methods published by the U.S. Environmental Protection Agency, Monitoring and Research Laboratory, Research Triangle Park, North Carolina, November 3, 1978. Analyzer performance shall conform to specifications for automated methods as described in 40 CFR, Parts 50 and 53.

2. Water Quality

Water quality baseline studies will be conducted to determine: (1) ambient water quality conditions in local bayous and canals and in shallow groundwater prior to possible disturbance from test well activities; (2) baseline conditions for substances potentially present in the geopressed fluids; and (3) water resource usage and baseline concentrations for substances and physical properties for which state standards have been established.

Water quality monitoring studies will be performed so that changes in chemical and physical properties of surface and groundwater can be determined. Surface water samples will be collected monthly; surface water levels will be recorded at the time of sample collection. Laboratory analyses to be conducted for each sample will include Na, K, NH_3 , SO_4 , Cd, Mn, Ca, Cl, Ba, Pb, As, B, Hg, total hardness (calculated), and total organic carbon. Field measurements shall include pH, specific conductance, turbidity, temperature, and dissolved oxygen.

Two observation wells will be drilled approximately 200 feet into the zone of fresh groundwater. Groundwater samples will be collected

each month. Field and laboratory analyses to be performed on ground-water samples will be the same as for surface waters. Water level in the observation wells will be reported monthly.

Ground and surface water sample collection, handling, preservation, and analysis will be consistent with methods published by the U.S. Environmental Protection Agency, "Manual of Methods for Chemical Analyzers of Water and Wastes" (1974), and the U.S. Geological Survey, "Recommended Methods for Water Data Acquisition" (1977).

3. Subsidence

Subsidence baseline studies will include an initial leveling survey to establish relative surface elevations, and an examination of historic leveling data and topographic maps to determine subsidence history in the vicinity of the test well.

The initial leveling survey shall consist of approximately 16.5 miles of First-Order precise leveling. Leveling profiles will be tied to National Oceanic and Atmospheric Administration (NOAA) elevation benchmarks which are located beyond the area of potential subsidence impact. Procedures to be used in establishing benchmarks in the vicinity of the test well will be in accordance with guidelines provided in the NOAA publication, "Specifications to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys" (1978).

Subsidence monitoring will consist of first-order releveing surveys which will be conducted at 12-month intervals during production to document the occurrence of land-surface subsidence, if any, near the well site or of differential surface movement along reactivated faults. First-order releveing is planned during the second-year environmental monitoring program, and is not considered in the base scope of work for this proposal.

4. Seismicity

Microseismic surveys will be performed to (1) determine background microseismic activity prior to disturbance from fluid production, and (2) monitor microseismic activity during fluid production. Baseline microseismic studies will include an initial reconnaissance survey to determine sources and levels of background microseismic activity. Data from this survey will be used to identify locations for permanent monitoring installations which will be least influenced by natural and cultural background noise.

Continuous microseismic monitoring will be performed using seismometers emplaced in sealed boreholes at approximately four feet below ground surface. Microseismic monitoring studies will provide the origin time of local seismic events, their estimated locations, and their relative magnitudes. The microseismic monitoring net will be operative approximately six months prior to fluid production.

5. Ecosystem Quality

Baseline ecological studies will rely on existing published and unpublished data to establish ranges and populations of plant and animal species in the vicinity of the test well. Additional biological surveys will be conducted in the event of significant impact to plant or animal life, but are not considered part of the base scope of work.

C. Environmental Program Management

The environmental monitoring program will be managed by Dr. Charles G. Groat, Director of the Louisiana Geological Survey and Professor of Geology, Louisiana State University. The management of environmental monitoring will include ensuring that data collected is compiled, analyzed, and reported to DOE on a quarterly basis, or more frequently if necessary. LSU will provide for contractual arrangements with firms for performance of selected field and laboratory studies. Overall data interpretation and impact assessment will be performed by LSU investigators. LSU will also be responsible for determining if federal, state, and local environmental quality standards are being met and will inform DOE in the event of noncompliance. LSU investigators will also inform DOE when an increase or decrease in baseline monitoring studies are required, justifying such changes in scope as they occur.

This Environmental Monitoring Plan outlines a one-year program of combined environmental monitoring and baseline studies. LSU will prepare quarterly status reports, including data summaries, and an annual report summarizing the results obtained during the first year. Based on the analysis of the data; the development of the test well; and federal, state, and local regulations, LSU will propose a second-year plan for continuing air quality, water quality, subsidence, and microseismic monitoring studies. In preparing this plan, LSU will determine whether or not it can be accomplished at a reduced level in any of the monitoring programs (e.g., increasing the interval between water samples, reducing the number of ions analyzed, increased level of air quality monitoring, etc.).

VIII. PERMITS

The attached permit and report forms are applicable to the drilling of Dow-DOE Sweezy No. 1 and the saltwater disposal well in the state of Louisiana.

1. Work Permit (Figure 17)
2. Application for Permit to Drill (Figure 18)
3. Weekly Progress or Drill Reports (Figure 19)
4. Permit Plat--Well No. 1 (Figure 20)
5. Permit Plat--Well No. 2 (Figure 21)
6. Well History and Work Resume Report (Figure 22)
7. Well Completion or Recompletion Report (Figure 23)
8. Affidavit of Test of Casing in Well (Figure 24)
9. Plug and Abandon Report (Figure 25)

Well Name & No. _____ Sec. _____ T _____ R _____
Field _____ Parish _____
Permit Serial No. _____ Work Permit No. _____
Description of Work _____

Sand & Reservoir To Be Tested _____ T D _____
Operator _____
Address _____
City, State & Zip _____
Permit Requested By _____ Date _____
Permit Authorized By _____ District _____ Date _____

Form DM-4R Rev.

TYPE ONLY

APPLICATION FOR PERMIT TO DRILL (OR RENEW) FOR MINERALS

FORM MD-10-R

8-2

STATE OF LOUISIANA
OFFICE OF CONSERVATION

This Report is to be filed WEEKLY, by the Operator, for all new wells from the time a Permit to Drill is issued until the well is either Completed or Plugged and Abandoned, whichever comes first. Show present condition and all significant activities during the previous seven days. Mail Report to District Office each Monday.

Operator: _____

PARISH	FIELD	WELL NAME & NO.	CONDITION OF WELL, ACTIVITY AND DEPTH

Phone _____

[illegible]

R 4 E

23

I, Ellis L. Jones, hereby certify that the loc'n. of
The Dow Chem. Co. - D.O.E. Lee Roy Sweezy No. 1
is as follows: 1800' NORTH and 1350' EAST from
the Southwest corner of Sec. 26, T11S-R4E,
Vermilion Parish, Louisiana

Ellis L. Jones
REGISTERED LAND SURVEYOR NO. 354 Figure 20
STATE OF LOUISIANA
JOHN E. CHANCE & ASSOCIATES, INC.

LOUISIANA DEPT. OF CONSERVATION

THE DOW CHEMICAL CO. - D.O.E.

PERMIT PLAT

VERMILION PARISH, LOUISIANA

SCALE: 1" = 1000'

JAN 23, 1980

R 4 E

23

I, Ellis L. Jones, hereby certify that the loc'n. of The Dow Chem. Co. - D.O.E. Lee Roy Sweezy No. 2 (S.W.D.) is as follows: NORTH 1840' and EAST 1160' from the Southwest corner of Sec 26, T11S-R4E, Vermilion Parish, Louisiana

LOUISIANA DEPT. OF CONSERVATION

THE DOW CHEMICAL CO. - D.O.E.

PERMIT PLAT

Ellis L. Jones
REGISTERED LAND SURVEYOR NO. 354
STATE OF LOUISIANA
JOHN E CHANCE & ASSOCIATES, INC.

Figure 21

VERMILION PARISH, LOUISIANA

8-5

SCALE: 1" = 1000'

MAR. 6, 1980

OFFICE OF CONSERVATION WELL HISTORY AND WORK RESUME REPORT		FIELD _____ SERIAL NO _____ PRODUCING INTERVAL _____ RESERVOIR (COMPANY SAND IDENTIFICATION) _____								
Three typewritten copies of this report must be filed with the District Office of the Office of Conservation in which the well is located within twenty (20) days of the date of completion. NOTE: If not properly completed and signed this report will be returned.										
LEASE AND WELL DATA										
CHECK APPROPRIATE BOXES ☐ NEW WELL ☐ RECOMPLETION ☐ P S A		☐ 31 INACTIVE DRY HOLE FUT. UTIL. ☐ 32 INACTIVE DRY HOLE NO FUT. UTIL. ☐ 36 INACTIVE WAITING ON PIPELINE ☐ 37 INACTIVE WAITING ON MARKET								
PRODUCT ☐ OIL ☐ GAS ☐ OTHER		IF RECOMPLETION ☐ SAME RESERVOIR ☐ DIFFERENT RESERVOIR								
DATE COMP. RECOMP. OR P S A M D Y										
OPERATOR		CODE	ADDRESS							
WELL NAME		WELL NO								
PARISH	SEC.	TWP.	RGE.							
DATE SHUDD		DATE PERMIT ISSUED								
DATE READY TO PRODUCE*		PSTD								
GROUND ELEVATION		CASING HEAD FLANGE ELEVATION								
DATE WELL TURNED INTO TANKS		DISTANCE FROM RKB TO CHP								
SINGLE, DUAL OR TRIPLE COMPLETION?		NOTE: IF THIS IS A MULTIPLE COMPLETION, FURNISH A SEPARATE REPORT FOR EACH COMPLETION								
WAS WELL DIRECTIONALLY DRILLED?	WAS DIRECTIONAL SURVEY MADE?	WERE 3 COPIES FILED WITH THE OFFICE OF CONSERVATION?	DATE FILED							
TYPE OF ELECTRICAL OR OTHER LOGS RUN (CIRCLE LOGS FILED WITH OFFICE OF CONSERVATION)			DATE FILED							
CASING, LINER AND TUBING RECORD										
C	CASING SIZE	HOLE SIZE	CASING WEIGHT	DEPTH SET		SACKS CEMENT	TEST PRESSURE	HOURS UNDER PRESSURE	DATE TESTED (MMDDYY)	NAME OF TEST WITNESS - STATE IF CONSERVATION AGENT OR OFFSET OPERATOR
				FROM	TO					
101										
102										
103										
104										
105										
TUBING SIZE:		DEPTH OF TUBING		DEPTH OF PACKER(S)						
INITIAL COMPLETION OR RE-COMPLETION DATA										
INITIAL PRODUCTION		GAS VOLUME		GOR		CHOKE SIZE		PRODUCING METHOD		
BOPD		MCF/DAY		CF/BDL		/64"				
FLOWING TUBING PRESSURE		SHUT-IN TUBING PRESSURE		CASING PRESSURE		WATER PRODUCTION		BPS&W		
PSIG		PSIG				BPD				
GRAVITY		BHP (SHUT-IN)		COMPANY REPRESENTATIVE		DATE GAUGED				
API 60° F		PSIG								
PLUG AND ABANDON (P S A) DATA										
CASING SIZE	AMOUNT PULLED	CEMENT PLUGS				DATE WORK PERFORMED	NAME OF TEST WITNESS - STATE IF CONSERVATION AGENT OR OFFSET OPERATOR			
		FROM	TO	SACKS	HOW PLACED					
CERTIFICATE: I, the undersigned, state: That I am employed by _____ and that I am authorized to make this report, and that this report was prepared under my supervision and direction and that all facts stated herein are true, correct and complete to the best of my knowledge.										
Signature: _____				Title: _____						

*Date well is equipped to produce, but due to no available market, no pipe line connection, etc., the well has been shut-in.

Figure 22

STATE OF LOUISIANA
OFFICE OF CONSERVATION

AFFIDAVIT OF TEST OF CASING IN WELL

DATE WORK DONE _____ WELL SERIAL NO. _____

_____ DISTRICT
(One copy to be filed with District Office)

NOTE: This Report Will Be Returned If Not Properly Completed and Signed

Field _____ Parish _____ Sec. _____ Twp. _____ Rge. _____

Operator _____ Well Name _____ Well No. _____

Size of casing _____ Weight _____ Make _____

No. of threads per in. _____ Grade _____ Seamless _____ New ☐ 2nd ☐

If second hand, was pipe tested _____ Describe _____

Depth casing shoe landed below derrick floor _____ Ft. _____ Sacks of cement _____

Size of hole _____ Ins. _____ Amount of cement left in pipe _____

Method of cementing _____. Cement set in _____ hrs., under _____ psig.

Total depth _____. Total time set _____ hrs.

DETAIL OF PRESSURE TEST BEFORE DRILLING PLUG

Date of test _____. Gauge pressure of casing _____ psig.

Pressure at end of 30 minutes _____ Pressure drop _____ psig.

Test fluid: Water Mud Weight _____ Viscosity _____

Remarks: _____

This work was done according to the Rules and Regulations of the Department of Conservation.

WITNESS

OPERATOR

(SIGNED) _____

Figure 24 REPRESENTATIVE
8-8

DEPARTMENT OF CONSERVATION
STATE OF LOUISIANA

PLUG AND ABANDON REPORT

DATE WORK DONE _____

WELL SERIAL NO. _____

WORK PERMIT NO. _____

_____ DISTRICT
(Three Copies to be Filed with the District Office)

NOTE: This Report Will be Returned if Not Properly Completed And Signed.

Field _____ Parish _____ Sec. _____ Twp. _____ Rge. _____

Company _____ Lease _____ Well No. _____

Total Depth _____ Condition of Well _____

1. Surface Casing Size _____ Depth _____ Amount Pulled _____

2. Protection Casing Size _____ Depth _____ Amount Pulled _____

3. Production Casing Size _____ Depth _____ Amount Pulled _____

CEMENT PLUGS

1. Depth _____ To _____ No. of Sacks _____ How Placed _____

2. Depth _____ To _____ No. of Sacks _____ How Placed _____

3. Depth _____ To _____ No. of Sacks _____ How Placed _____

Mud Record: Weight _____ Viscosity _____

Remarks: _____

This work was done according to the Rules and Regulations of the Department of Conservation.

WITNESS

COMPANY

(Signed)

REPRESENTATIVE

Figure 25
8-9

IX. REPORTING

All reports (except daily and monthly) will be submitted to DOE/NV by the Contractor for review prior to publication in accordance with the Uniform Contractor Reporting System (UCRS) guidelines. The UCRS guidelines include format, number of copies, and submittal schedules. In summary, the reports will consist of the following:

A. Management Plan

The Contractor's plan to manage the effort described in the statement of work. It will contain management methodologies, control systems, and procedures it will use to perform the effort identified in the Contract. It will include milestones and other planning schedules, organizational identifications and descriptions, and special and critical plans, such as test plans and plans for the handling of Government-owned property. Work breakdown structures, key personnel identification, and methods for monitoring progress toward objectives will be required.

B. Milestone Plan and Management Report

The Contractor's milestone schedule for all work breakdown structure items, line items, or deliverables specified in the Contract. To be updated periodically (usually monthly) to show status, progress toward total contract completion, and percent completion of each line item.

C. Contract Management Summary Report

A single-page graphic presentation of integrated cost, major milestones, and manpower for rapid visual analysis and trend forecasting.

D. Major Milestone Status Plot

A periodic graphic presentation of events, deliverables, or major milestones and associated dates plotted in an expected performance envelope for rapid visual analysis and trend forecasting.

E. Cost Management Report

A periodic report of the status of costs compared to the Cost Plan. Data will be used to report actual and project accrued costs, evaluate performance against plan, identify actual and potential problem areas, construct cost experience for projects and budgeting efforts, and to verify the reasonableness of Contractor's invoices.

F. Technical Progress Report

1. Daily Drilling Report

An informal activity report submitted daily throughout the drilling and testing phase. The daily report will be phoned or telecopied

directly to the Nevada Operations Office and the Geopressure Projects Office. The report will include the cumulative mud cost and the cumulative total drilling cost.

2. Technical Progress Report

A monthly technical report describing accomplishments made during the month, the present status, and the planned work schedule for the succeeding month. The total cumulative cost (invoices paid by Dow) through the end of the month should also be included. Problems that have occurred will be discussed along with the method of solution. Test measurement results and analytical data will be presented.

The monthly "Technical Progress Report" must be received by the Nevada Operations Office by no later than the eighth day after the end of each month.

G. Final Reports

These written reports will correlate findings of flow tests and analyses and will include a summarization of the operational aspects of well activities. The reports will also include the evaluation of the completion technique and production strategy; the result of sand stability investigations, including the maximum and reasonable rates at which the well and the reservoir will safely operate; the determinations concerning corrosion and scaling properties of the produced fluid and any treating methods that can be used to control corrosion or scaling problems; evaluation of the reservoir deliverability and depletion, including appropriate material-energy balance equations of use; determination of reservoir size as indicated from test data; reservoir fluid characteristics, including salinity, formation compaction related to any detected surface subsidence, and discussion of the heterogeneity of the reservoir if detected.

1. Yearly Technical Report

A technical report will be submitted in draft form upon completion of each contract year. It will describe operational procedures followed, drilling completion and testing methods employed, and it will provide measurement and test information with all necessary illustrations, graphs, and tabulations required to show significant results. Descriptive text will be used to explain all illustrations.

2. Final Technical Report

A report will be submitted at the conclusion of the program presenting a summary of overall program results. It will be a complete report on all significant data obtained and will be a composite of work performed by all investigators directly related to the drilling and testing of the production well, drilling and utilization of the disposal well(s), and operation of the surface facility.

X ~~---~~ SCHEDULE PARCPERDUE RESERVOIR STUDY DOW — D.O.E. L.R. SWEETZ NO.1

1-01

FIGURE 26

XI. REFERENCES

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APPENDIX A

STANDARD WELL LOGGING PROGRAM FOR GEOTHERMAL-GEOPRESSURED WELLS

I. INTRODUCTION

This "Standard Well Logging Program" was developed at a DOE workshop held July 21, 1980, at the Bureau of Economic Geology in Austin, Texas, and in subsequent discussion and correspondence between participants. The Department of Energy, Bureau of Economic Geology, Petroleum Engineering Department of the University of Texas, and well logging companies were represented at the workshop. This program represents the consensus of the group and was designed taking into account the special needs of the DOE in carrying on their geothermal-geopressured (hereafter abbreviated as geo²) program. Similar workshops have been held to develop standard programs for chemical analyses of formation waters, and for coring and rock mechanics for the geo² program. These standard programs are currently being prepared and should be available by fall of 1980.

II. WIRE LINE LOGGING REQUIREMENTS

A. General Logging Requirements

1. Provide the original film plus 15 copies of all field prints and 15 copies of all finished prints.
2. Provide at least two maximum recording thermometers on each logging run. The use of maximum recording thermometers on each logging run is a must and it is the responsibility of the operator and the logging service company to assure that it is done.
3. A gamma log should be obtained on every run into the well to obtain positive depth correlation between runs.
4. All formation evaluation logs must be digitally recorded, and tapes should be available for copying if desired.

B. Open-Hole Logging Requirements

1. From the bottom of the conductor pipe to the surface casing point.

Essential Logs: (1) Self-potential, (2) dual induction resistivity, (3) caliper with hole volume.

2. Hydropressure Zone--From the bottom of the surface casing to the drilled total depth at the intermediate casing point.

a. Essential Logs: (1) Self-potential, (2) gamma ray, (3) dual induction resistivity, (4) borehole compensated sonic with R_{wa} calculation, (5) compensated neutron, (6) density, (7) caliper with hole volume.

b. Desirable but Not Essential Logs: (1) Long spaced sonic log, (2) flushed zone resistivity log (R_{xo}), (3) dipmeter with drift calculation included.

3. Geopressure Zone

a. Essential Logs: Same seven logs as for hydropressure zone plus: (8) computer calculation through potential producing and injection zones, including a depth listing of data and calculated results, initial cross plots used in the calculations, etc.; (9) for wells in Louisiana, where sand production is one of the possible problems, an elastic constant calculation made over all potential producing zones. Hopefully this can be done using actual shear velocity data from the conventional sonic or long spaced sonic (if run) rather than using an empirical shale correlation to get shear modulus.

b. Desirable but Not Essential Logs: Those three desirable but not essential logs listed for hydropressure zone plus: (4) gamma ray spectral log.

4. Other Open-Hole Wire Line Services

a. Sidewall cores will be needed in potential producing and injection zones, in the shales adjacent to the potential producing zones, in the zone of transition from hydropressure to geopressure, and possibly in other zones of interest. Zones to be sidewall cored would be selected after logging, considering particularly, data from the gamma ray spectral log if run.

b. Repeat formation tests may be desired in several sands to investigate in situ mud filtrate properties (see Addendum I).

C. Cased Hole Logging and Perforating Requirements

1. Essential Logs: (1) Temperature log when cement is not brought to the surface and when pipe is to be stretched; (2) cement bond log over all cemented intervals without casing pressure; (3) if bond log without pressure does not show good bonding, run another log with 1,500 psi applied to the casing; (4) if microannulus is still indicated on cement

bond log at 1,500 psi surface pressure, rerun at a higher pressure as selected by drilling and logging personnel; (5) production logs run soon after completion (flow rate, temperature, pressure, radioactive logs). These logs may be repeated one or more times after significant production has occurred.

2. Desirable but Not Essential Logs: (1) Dual detector pulsed neutron log, run as soon as possible after perforations cleanup as shown by production log data. This log may be repeated one or more times during the producing life, to monitor possible gas buildup around the well bore leading to permeability reduction. This log is considered highly desirable (see discussion in Addendum I). (2) Noise log and temperature log to monitor possible leaks behind pipe.

3. Perforating

Twelve jet shots/foot with 1/2-inch entrance holes are recommended, using a negative differential pressure of 500 psi. Casing collar--perforating log is recommended for depth control.

III. LOGGING PROCEDURES

A. Open Hole

1. Accurate calibration is essential and should be carried out using approved service company procedures with the data attached to the logs.
2. At least 200 feet of log should be overlapped on each run if possible.
3. Comparison of log data being obtained should be made relative to the log data available from the control well, which is usually close by (100 to 200 yards), to check for gross differences in calibration, depth accuracy, etc.
4. Mud and filtrate resistivity, density, etc., data should be obtained on good mud samples, carefully measured. Multiple (two) mud samples and measurements would be desirable. A quart of mud should be labeled and saved. The mud logger setup should include provision for continuous measurement of mud resistivity and temperature. A sample (quart or more) of the mud in the system while drilling or coring each potential producing zone should be obtained by the drilling engineer while the zone is being drilled and delivered to the appropriate institution's field representative for measurement when well is logged and for later analysis.

B. Cased Hole

If the pulsed neutron log is run, six repeat runs should be made over the producing interval to establish repeatability for reference to later runs of this tool.

IV. INTERPRETATION TECHNIQUES AND REQUIREMENTS

A. Open Hole

1. Compaction

If it is desired to measure compaction, a monitor well should be used, which is not produced.

2. Bottom-Hole Pressure

The primary pressure instrument will be the Hewlett-Packard gauge. This should be calibrated before and after each run into the well with a dead weight tester, being particularly careful that the gauge reaches temperature equilibrium when calibrating.

3. Salinity

Use applicable cross plots as well as SP and R_{wa} methods to get salinity. Make temperature corrections on formation factor in calculating R_{wa} . Use appropriate temperature versus resistivity corrections for the mud employed (see Addendum I).

4. Determine porosity from cross plots of all three porosity logs as well as from individual logs. Use sidewall cores for grain density determination. Control drilling variables to maintain good hole size while drilling potential production and injection zones.

5. Temperature

Equilibrium formation temperatures can be estimated using the following method (excerpt from a paper by Walter H. Fertl—Oil and Gas Journal, July 24, 1978, pages 54-61).

The data needed are (1) at least two measured bottom-hole temperatures; (2) circulating time, t , in hours for well conditioning, and (3) Δt , time in hours after circulation stopped when the BHT was recorded.

Using the ratio of $\Delta t / (t + \Delta t) = 1.0$, with the BHT recorded, yields a straight-line relationship on semilogarithmic paper of static BHT in $^{\circ}\text{F}$.

Example

1. Circulation time to condition hole	6 hrs.	
2. Elapsed time when 1st BHT taken	7 hrs.	220°F
3. Elapsed time when 2nd BHT taken	11.5 hrs.	225°F
4. Elapsed time when 3rd BHT taken	19.5 hrs.	228°F
5. Depth of hole--10,000 feet		

Solution $\Delta t / (t + \Delta t) = 1$ (t = time)

For 220°F	$7/6 + 7 = 0.538$
For 225°F	$11.5/6 + 11.5 = 0.657$
For 228°F	$19.5/6 + 19.5 = 0.765$

This data is then plotted on semilog paper as shown below, resulting in a static BHT of 235°F.

Logging calculations for formation water resistivity, etc., should be made using well temperatures rather than equilibrium formation temperatures.

RESEARCH NEEDS IN LOGGING GEOPRESSURED-GEOTHERMAL RESERVOIRS

1. Calculation of Formation Water Resistivity From Log Data

Recent data from the geopressured-geothermal test program shows that SP-derived formation water resistivity is typically too high, often by a factor of two (calculated water salinity too low) in these hot, high-pressure wells. Work carried out at the University of Texas Petroleum Engineering Department suggests that the difficulty probably lies in the use of an incorrect value of mud filtrate resistivity, R_{mf} , when lignosulfonate muds are used. Since most deep hot wells drilled since the early 1960s have used lignosulfonate muds, the problem is widespread. The filtration process at depth for these high-density muds is apparently enough different from the surface conditions when mud filtrate is obtained using a conventional filter press to account for the large errors. Laboratory and field experiments are needed to confirm and hopefully to explain the results of the University of Texas work, which is based on calculations made in about 20 wells where good log data and measured formation water resistivity data were available. Use of nitrate-labeled muds and samples from the repeat formation tester may allow recovery of mud filtrate fluids from the formation at depth to compare with surface samples of the mud filtrate using the mud filter press.

Literature data show that muds and mud filtrates do not always follow the same resistivity versus temperature variation as NaCl solutions (see References 1 and 2). Present procedures typically use the NaCl relation when correcting R_{mf} from surface to downhole temperature, and this can lead to errors of 10 to 20 percent in R_{mf} , and thus consequently in the formation water resistivity, R_w . Most of the data on variation of R_m and R_{mf} with temperature is old and does not include the lignosulfonate mud types currently in use. Lab data is needed on these muds so the correct temperature correction of R_{mf} can be made.

The literature (References 6 and 7) indicates that large, short-term variations in R_m and R_{mf} can occur in a drilling well even when the basic mud type remains constant. Since the mud filtrate in a given sand is controlled primarily by the mud in the well when the sand was drilled rather than when it was logged, this large variation would make an accurate calculation of formation water resistivity from the SP impossible if all we know is mud and filtrate properties at time of logging. Work is needed to get more data on the actual variation of mud resistivity in modern geopressured-geothermal wells. A continuous measurement of mud resistivity and temperature by sensors placed in the mud flow line would be desirable, supplemented by frequent comparisons of R_m and R_{mf} .

A new relation for calculation of R_{mf} from R_m has been proposed (Reference 3) which replaces the empirical relation of Overton (Reference 4) with an analytical expression. This expression is a function of only mud water content, or "porosity." The expression seems to fit experimental data even when extended to low water contents (porosities) typical of rocks. It may offer an improved relation between formation factor and porosity. If so, an improvement would result in formation water resistivity calculation from porosity tools and resistivity tools (R_{wa} calculation; ϕ versus R_t cross plots, for example). More work is needed to decide whether the new relation will actually improve the porosity versus formation factor calculations and if so, by how much.

The literature (Reference 5) shows that there is a temperature effect on the formation factor F which could change the value of F by 10 to 20 percent for geothermal temperatures (200-350°F). The effect depends on both porosity and permeability of the rock. Fair estimates of porosity can be obtained from the porosity logs, but permeability estimates for geopressured-geothermal reservoirs would have to come from regional porosity versus permeability correlations. These could be improved (probably) by using other log-derived data, such as estimates of formation shale content (from density versus neutron cross plots, gamma-spectral logs, etc.). Work is needed to get better estimates of porosity versus permeability relations, using all available log data for the geopressured-geothermal formations. These improved relations would be helpful in assessing reservoir quality as well as for improving the utility of the F versus T relation.

2. Comparison of Conventional With Long Spaced Sonic Log

More work is needed in this area, with emphasis on conditions expected in geopressured-geothermal wells (Reference 8). Work in the Pleasant Bayou test showed problems in automatic picking of arrivals and in high attenuation in the oil base mud used in one portion of this well. Reliable shear wave data is highly desirable to improve the elastic constants calculation. The mechanical properties log has been useful in predicting sand production in unconsolidated oil and gas reservoirs. It should also be useful in water-producing geopressured-geothermal reservoirs. Sand production is a severe problem in many geopressured-geothermal areas in Louisiana. In the absence of shear velocity data, the shear modulus must be estimated from an empirical correlation with shale content.

3. Research on Shale Properties in Geopressured-Geothermal Formation

Diagenesis of shale (montmorillonite-illite conversion, primarily) is widely thought to be intimately related to the development of geopressured zones. The gamma spectra log separates the observed gamma flux into potassium-derived, thorium-derived, and uranium-derived components. Since the various clay minerals contain different amounts of these elements, this log, together with other log-derived data such as density and hydrogen content of shale, may permit in situ estimates of geopressured-geothermal shale diagenesis.

4. Estimates of Free Gas Saturation Buildup in Geopressured-Geothermal Formations

Most geopressured-geothermal reservoir waters are thought to be gas saturated or nearly so. As production of this saturated water continues, pressure decline occurs which is greatest near the well bore, and gas comes out of solution. This gas is not movable until a few pore percent saturation is reached, and even then it should not move far before it is again trapped until the gas saturation cumulatively builds up to above 20 to 30 percent (the residual gas saturation of a water flood). At these high residual gas saturations, the permeability to water is significantly reduced, so that local blockage or damage around the well bore is expected to occur and the well productivity is expected to be reduced. Well damage can also occur due to other causes (blocked perforations, scale formation, etc.), and it is important to distinguish between them in analyzing the test well performance. A series of pulsed neutron logs run early and late during the well production history should be able to measure the development of 20 to 30 percent gas saturation near the well bore.

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APPENDIX B

GUIDELINES FOR CORE HANDLING PROCEDURES AND ROCK MECHANICS LABORATORY TESTING FOR GEOPRESSURED-GEOTHERMAL WELLS

INTRODUCTION

A rock mechanics testing program is essential for developing an understanding of the mechanics of geopressured aquifers, for evaluating such resources for long-term commercial production, and for assessing environmental issues such as subsidence. More specifically, a core testing program will be useful in:

- Identifying and anticipating problems associated with changes in porosity, permeability, rock chemistry, and strength that are related to reservoir production.
- Providing a correlation and understanding of reservoir properties as determined from well tests and logs.
- Providing a basis (by understanding of physical mechanisms) for long-term performance predictions that are made by computer analysis, where otherwise, only empirical predictions can be made.

In order to achieve the above objectives, some core is needed from each well from potential production and injection sand horizons, from shale zones near production horizons, and from overburden horizons. The following guidelines are intended to establish core recovery and testing standards for each well and for an overall program. The tests recommended range in type from almost routine to extremely specialized. The purposes of these guidelines are to provide general technical advice to DOE contractors, to establish uniformity in procedures among the field operators and the laboratories collecting core and conducting tests, and to suggest budget levels for laboratory work.

CORE SAMPLING AND HANDLING

Cores should be obtained from as much of the potential production sands, interbedded shales, bounding shales, injection sands, and overburden sediments as is practical. Priority should be as follows:

1. Production sands.
2. Bounding shales.
3. Interbedded shales.
4. Injection sands.
5. Other overburden lithologic sequences.

It is realized that the increased cost and the possible jeopardization of the successful drilling and completion of the well caused by the coring program will have to be carefully considered when determining the actual amount of core to be obtained. These considerations depend on drilling conditions at a specific site. At the very minimum, two coring runs are recommended, one across the upper shale/sand boundary of the production zone and one in the center of the most favorable production sand.

Final responsibility for choice of coring points and coring operations will lie with the prime contractor for the well. Once the core has been recovered, either the prime contractor or a single designated organization will have responsibility for handling and distribution. This is imperative in order that necessary decisions can be made quickly in the field. This does not preclude several organizations handling and receiving core; it only places final responsibility for decisions in the hands of a single organization.

The following steps should be taken to obtain and distribute core:

1. The approximate number of cores to be taken and their general depths are selected by the prime contractor on the well, DOE, and other contractors or consultants.
2. Specific coring points are selected by the prime contractor based on correlation of drilling time and electric logs from nearby wells with drilling time and electric logs (if available) from current well. Modifications are made according to hole condition and drilling difficulties, if necessary.
3. Drill and recover core with as much recovery and as little breakage as possible. Recommended procedures are given on pages B-8 through B-15.
- *4. Wipe core to remove surface mud, observe, and catalog. (Do not rinse with fresh water.)

- *5. With on-site equipment and using appropriate brine for the cutting fluid, saw lengthwise a 1-inch slab or heel for permanent geological or archive set. Place in wax-interior boxes. Deliver to appropriate warehouse. This set will be used for:
- a. Interpretation of depositional environments based on vertical changes and sedimentary structures.
 - b. Clay mineralogy studies of shales.
 - c. Petrographic studies of sandstones.
 - d. Later identification of sections of sealed and waxed cores to be selected for rock mechanics studies.
 - e. Calibration of various geophysical logs.
- *6. With on-site equipment and appropriate brine as the circulating fluid, plug the sandstone portion of the larger side of core for standard core analyses of porosity and permeability.
- *7. Using procedures requested by USGS and detailed on page B-16, can shale samples of as large a size as possible based on the type of recovery obtained. However, first priority recipient of large, intact shale samples will be rock mechanics laboratory.
- *8. Wrap the entire large remaining portion of the core in plastic and foil, seal in beeswax, and place in wax-interior boxes.
- *9. Deliver material to warehouse, core analysis and/or rock mechanics laboratories, and USGS as appropriate.
- *10. Obtain water sample for cored interval where possible and deliver with sealed core.

*Steps 4 through 10 can be performed by prime contractor or designated sub or associate contractor; however, performance and results of all work should ultimately remain the responsibility of the prime contractor.

ROCK MECHANICS TESTING

Various types of testing will be needed for the rock mechanics program. Some tests will be needed on core from each well to assist in completion design; bench-condition testing for porosity and permeability are examples. In situ condition tests will also be needed on core from each well until sufficient data have been accumulated to develop rock behavior models. Long-term or creep tests will be needed on selected samples from each well, with comprehensive testing of one or more wells as indicated by results as the tests progress.

It should be understood that shale compaction studies, including shale dewatering, are implicit in the rock mechanics testing program (basic properties, short-term testing, and long-term testing). Measurement of shale permeabilities and compaction behavior will, of course, require more specialized equipment and more time to conduct, as compared to the higher permeability sandstones. For example, pressure pulsing techniques, rather than steady-state fluid flow techniques, may be required for permeability determination in some or all of the shale samples.

Basic Properties

Bench-condition testing for density, porosity, and permeability should be done at 1-foot intervals using conventional, core laboratory methods. Priority should follow that for core sampling, i.e., production sands, bounding shales, etc. Permeabilities parallel to and normal to bedding should be measured at selected intervals for layer-to-layer comparison, where this can be done without sacrificing samples for in situ condition testing. Pressure pulsing techniques will likely be required for measuring shale permeabilities.

Short-Term, In Situ Condition Testing

Since little is known about geopressured rock behavior, comprehensive testing of selected samples from each well should be conducted. Priority should be given to potential production horizons, bounding shales, and interbedded shales. These tests are needed for development of rock behavior and reservoir models for short-term reservoir response and interpretations of well log data. Overburden and confining stresses, temperature, pore fluid pressure, and pore fluid chemical composition should be representative of in situ values. Owing to hysteresis in rock parameters with load history, simultaneous or sequential measurements should be conducted wherever possible. The test conditions should encompass the range of conditions likely to be seen during the operational life of the geopressured-geothermal reservoir in question. Types of tests should include:

- Hydrostatic and triaxial pressurization.
- Pore pressure decrease from in situ value at constant confining pressure (with and without axial load).
- Pore pressure decrease from in situ value at constant lateral strain with constant axial load (uniaxial compaction).
- Strength tests (limited number).

Measurements and derived quantities should include:

- Axial and lateral strains.
- Compressibility, Young's modulus, Poisson's ratio.
- Compaction coefficients.
- Porosity from pore fluid volume change, from deformation measurements, and from ultrasonic velocities.
- Permeability to brine.
- Resistivity.
- Ultrasonic velocities.
- Triaxial failure envelopes.

Emphasis during this work should be placed on measurements that can give reservoir compaction and permeability changes that are caused by pore pressure reduction.

Long-Term (Creep), In Situ Condition Testing

Because geopressured reservoir rock is likely to behave inelastically with long-term stress changes, some time-dependent deformation behavior should be evaluated on samples selected from each well at in situ conditions. Priority should be given to potential production horizons and bounding shales. A thorough study of this behavior should be done on at least one well. Overburden and confining stresses should be held constant while pore pressure is reduced to maximum drawdown. Alternatively, the long-term tests could be done in uniaxial compaction; however, this is more difficult from a procedural viewpoint and is of dubious advantage. In either case, sample dimensions, stresses, and pore volume change should be measured with time. Permeabilities should be measured at selected drawdown levels and fluid chemistry changes should be monitored.

Apparatus

Equipment used for simulated in situ testing at geopressured conditions should be capable of reliably achieving these conditions. Measurement techniques should be calibrated such that reliability can be demonstrated. The value of a "round robin" comparative testing program is questionable because of variation in rock properties from one sample to another. However, such a program has some use in establishing the overall variation in results.

Petrography and Fluid Chemistry

Studies before and after testing should be carried out to attempt to detect petrofabric and chemical changes associated with deformation. These should include examination by:

- Optical microscope (thin sections).
- Scanning electron microscope.
- Energy dispersive analyses by X rays (EDAX).
- X-ray identification of clay minerals.
- Analysis of pore fluid chemistry, including dissolved and suspended materials.

CORE BARRELS

Introduction

In order to achieve the best possible core recovery (quantity and quality) in Gulf Coast geothermal wells, the rubber sleeve core barrel and the conventional core barrel should be utilized.

Rubber Sleeve Core Barrel

The rubber sleeve core barrel is used to recover cores in soft or unconsolidated formations which have proved difficult to recover using the conventional core barrel. The core is encased inside a rubber sleeve at the time it is cut. The rubber sleeve will continuously support and prevent the core from being washed away or crumbled. The core is never exposed to the moving fluid (mud) since it is pumped between the intermediate and outer tubes then out through face discharge ports of the core bit. Mud contamination of the core is held to a minimum.

The rubber sleeve core barrel has the following limitations:

1. Only one size barrel available (i.e., 6 7/8 inches x 3 inches x 20 feet), which is limited to taking a 20-foot core.
2. The rubber sleeve itself becomes weak with a tendency to split as the temperature increases above 175°F.
3. The minimum drill string bore has to be 2 11/16 inches to permit passage of the stripper tube release plug.

Conventional Core Barrel

The conventional core barrel is for general purpose use. They are manufactured in various sizes to meet most needs in the petroleum industry. Core bit design and core catcher selection should meet the particular application requirements.

Coring practices and procedures using a conventional core barrel are discussed on pages B-14 and B-15.

DOWNHOLE CORING PRACTICES AND PROCEDURES

Operating Parameters

Hydraulics play an important part in a coring operation. This is mainly because drilling fluid is required to clean and cool the bit; but at the same time, this drilling fluid should not damage the core any more than can possibly be avoided.

Drilling fluids used in coring are:

1. Water.
2. Water-base muds.
3. Brine.
4. Oil-base muds.
5. Air and gas.
6. Combinations of the above.

The optimum coring mud should not damage the core, should help with good core recovery, maintain ideal hole conditions, and help give a longer bit life with better penetration rates. This means the mud should have a low sand content, low water loss, and a minimum of lost circulation material. Coring has been done with varying amounts of LCM in the mud, but it always presents problems such as the possibility of plugged inner barrels, plugged face discharge parts, excess pump pressure, etc.

The drilling fluid flow rate (GPM) while coring should always be consistent with good drilling practices. Generally, the flow rate increases as the bit size increases. However, the type of formation being cored can dictate the GPM required for good core recovery. See Figure 27 for recommended flow rates.

Sometimes air or gas is used as the drilling fluid during coring. As a general rule, the volume of air per minute recommended for air coring is 10 cubic feet per minute times the GPM required for the same size hole. In cases where gas is used as the drilling fluid while coring, the volume is usually slightly higher, say 1.5 to 2 million cubic feet per day of gas, than that of air coring.

Too little drilling fluid will not properly clean and cool the core bit; therefore, the core bit may be damaged and the penetration rate may be excessively slow. Then, on the other hand, too much fluid may cause core damage or outright loss.

Fluid damage of core can be kept to minimum by making certain that the spacing between the inner tube shoe and the bit is correct. An excessive gap, more

Recommended Flow Rates

Actual flow rate should be adjusted according to mud weight and consistent with good core recovery with regard to formation characteristics.

FIGURE 27

than 1/8 inch, between the lip of the inner tube shoe and the crown section of the bit will allow flushing of the core (also possibly actual washing away) as it enters the inner barrel.

But care should be taken not to allow the inner tube shoe to touch the bit, as this can cause the inner barrel to turn with the bit and cause the core to break up and possibly jam the core barrel.

Generally, the rotary speed (RPM) has a direct effect on the rate of penetration while coring. But in certain formations, this may not be the case. Therefore, the optimum RPM should be searched through trial and error, unless this is known through experience. Keep GPM and WOB constant while doing this. Usually, diamond coring rates or penetration are slower than those of diamond drilling bits. Note Figure 28.

Rotary speed may also affect core recovery, core blocking, etc. Therefore, the RPM must be adjusted to give the best core recovery in addition to the best penetration mentioned above.

Keep in mind the effect of drill string vibrations. Refer to APIRP7-G, "API Recommended Practice for Drill Stem Design and Operating Limits."

Finally, certain formations such as fractured or broken rocks are best cored with slow RPM and higher weights.

Weight on the bit is probably the most important of the three operating parameters affecting the performance of a core bit and core recovery. Figure 29 shows the WOB according to bit size.

The variables to consider in determining the proper WOB are:

1. Formation.
2. Bit size.
3. Diamond size.
4. Diamond quality.
5. Number of face stones in contact with the formation.

In fact, the most accurate method of determining WOB is to take the number of face stones times a weight factor in pounds (depending on the size and quality of the diamond).

The cutting action of the diamond bit is completely dependent upon each stone being held firmly in contact with the formation. This, of course, is the result of WOB. It is important that this WOB never exceeds the weight of the drill collars so that the drill pipe is always in tension. This condition is ideal and helps prevent drill string vibrations, core bit wobble, and other problems.

Recommended Rotating Speed for Core Bits

FIGURE 28

Recommended Weight on Core Bits

B-12

An alternative method to determine recommended weight on core bits takes into consideration the quality of diamonds used and the number of face stones.

$$\text{wt. on bit} = \text{Number of face stones} \times K$$

Diamond Quality	K Max.	K Min.
SP	30	10
P.Q.	25	10
Select	18	10
Standard	15	10

FIGURE 29

Core barrel and drill string stabilization is good drilling practice unless hole conditions are such that stabilizers are not recommended.

Stabilizers help increase penetration, improve core recovery, minimize core bit wear, and protect and prolong the life of the core barrels. Core barrels are usually dressed with one of the following types of outer barrel stabilizers:

1. Hard metal wear ribs (not a true stabilizer).
2. Straight or hard metal ribs (near or full gauge).
3. Spiral rib (Sc-1).

On standard core barrels, stabilizers are placed as follows:

1. Near bit stabilizer.
2. On outer tube substabilizer at the top of each outer tube.

Therefore, on a 60-foot core barrel, three stabilizers would be standard; on a 30-foot core barrel, two stabilizers would be standard; on a 90-foot core barrel, four stabilizers would be standard.

In most deviated holes above 10 degrees, it is recommended that the inner barrels be stabilized by brazing narrow brass strips at the center and at the top, just below the box, of each inner barrel. In addition, a bit bearing should be placed in the bit shank to stabilize the inner tube shoe.

It is important to maintain core barrel stabilizers in good condition and replace them when diameter wear exceeds 7/16 inch.

Summary of Operating Parameters

1. Flow rate must be sufficient to clean and cool the core bit, but not so excessive as to damage the core.
2. Optimum RPM must be determined by trial and error.
3. Proper bit weight must be applied evenly.
4. Too little weight slows penetration and may damage it.
5. Too much weight can crush diamonds in hard formations or clog the bit in soft formations and cause "burning."
6. The outer barrel should always be stabilized properly.
7. In deviated holes, the inner barrel should also be stabilized and a bit bearing used.

Conventional Core Barrel

When going in the hole with a core barrel, always advise the driller to run the barrel in carefully. Reaming with a core bit is not advised, but if it is absolutely necessary, do so with very little weight (1,000 to 2,000 pounds, up to a maximum of 5,000 pounds with an 8 1/2-inch bit), slow rotary, e.g., 40 to 60 RPM, and full pump.

If fill is encountered near bottom, wash down 10 feet at a time until hole is clean. Then try to tag bottom with pump on and no rotation if possible. If it is necessary to rotate, do so slowly and tag bottom with just enough weight to be certain bottom has been reached. Make certain that this point is the same as the calculated bottom depth.

Next pick up off bottom 1 to 2 feet and circulate with sufficient annular velocity to condition mud and clean the hole. This should be done with the ball out, in most cases, for 15 minutes to 1 hour, or longer if necessary.

After it has been determined that the hole is clean and the mud is conditioned, pick up and break off the Kelly and drop the steel ball or drop plug. Then replace the Kelly and pump the ball down at a slow pump speed. While the ball is falling, record the pump rate and standpipe pressure. As soon as the ball is seated, record the increase in standpipe pressure, return to bottom and start to rotate slowly (30 to 40 RPM) and start adding weight in increments of approximately 2,000 pounds. (Begin with about 20 percent of maximum desired WOB.) Gradually increase WOB and RPM and at the same time bring pickup rate to the desired GPM. Test various WOB, RPM, and GPM until optimum coring rates and conditions are found.

The following procedure should be followed when breaking off the core to make a connection or to come out of the hole:

1. Stop rotating.
2. Idle or shut off pump.
3. Slowly pull up until the core breaks.

In most cases, do not exceed the following strain over the weight of the drill string:

For a 2-inch core:	5,000 lbs.
3 5/8-inch core:	10,000 lbs.
3-inch core:	12,000 lbs.
3 1/2-inch core:	15,000 lbs.
4-inch core:	20,000 lbs.
5 1/4-inch core:	35,000 lbs.

If the core does not break with the maximum strain, then start the pump and hold the strain on the core until it breaks. The core should break within four or five minutes, but it could take longer. Do not rotate while breaking off the core, as the shoe could be pulled into seating in the bit so that the

rotation could cause the catcher to turn out or wear through the inner tube shoe.

It is a good idea to lock the rotary table while breaking off a core and making a connection. Then if the Kelley is backed out with chain tongs or the chain, the coring assembly can be placed back on bottom, after the connection, exactly as it was before the connection.

It is also a good idea to lower the core barrel back to bottom just after the core is broken off (be certain not to rotate or have the pump on), and add only about 50 percent of the coring WOB. This procedure is both a check to determine whether or not any broken core was left on bottom and whether the core is actually caught, by checking the weight indicator. Do this procedure at least two times.

When coring is to be resumed after making the connection, go back to bottom without rotating, but with the pump on, and apply approximately 30 percent more weight above the normal coring WOB to help release the core catcher so that the core can freely enter the inner barrel. Then pick up until WOB is the normal weight and start to rotate slowly and then gradually return to the normal coring conditions.

It is after a connection that sometimes junk damage occurs. Also, this is the time most inner barrel jamming occurs. Therefore, be alert to the rig floor indicators and develop a mental picture of what is happening at the bit and in the core barrel.

SHALE SAMPLING AND PRESERVATION PROCEDURES
FOR U.S. GEOLOGICAL SURVEY SAMPLES

The U.S. Geological Survey (USGS) desires shale samples from DOE-sponsored geopressured-geothermal design wells for its various investigations into the nature of geopressured sediments. The following instructions will ensure that the samples will retain as much value as possible for these studies.

After the core is recovered at the surface, it should be wiped of drilling mud and inspected visually. For USGS purposes, only sections of the core showing unfractured shale with no silt or sand laminae should be sampled. When a suitable section is located at full diameter, sample should be removed up to a maximum length of 10 cm.

With a clean hacksaw blade, cut the core longitudinally through the center, then once again at right angles to the first cut. This should result in four wedge-shaped pieces of core. Seal one piece immediately in an airtight container of the type used for storage of samples for organic geochemical analysis. It is permissible to break the sample in order to place it in the can. Label this can on the outside with an indelible marker:

"CLAYPOOL"

WELL:

DEPTH:

The remaining three pieces should be cleaned of any remaining drilling mud and wiped or blotted dry. They should then be individually wrapped tightly and completely, once with a plastic wrap (such as Saran Wrap), once with aluminum foil, and finally coated completely with beeswax. The three pieces should then be placed in individual lengths of PVC conduit of proper dimensions and with adequate packing to prevent damage during transportation. The ends of the conduit should be sealed with plastic caps or plugs. One each will be marked as follows using an indelible marker:

"KRAEMER"

WELL:

DEPTH:

"MANHEIM"

WELL:

DEPTH:

"THERMAL"

WELL:

DEPTH:

In the event core recovery is very good, samples from the top, middle, and bottom of the cored interval should be taken, if possible.

APPENDIX C

OFFSET WELL DATA PHILLIPS PETROLEUM SWEETZ "A" NO. 1

DAILY REPORTS 10/29/73 through 12/11/73

- 10/29/73 Drilled to 12,960 ft. Penetration rate increased from 4-6 ft/hr to 12-14 ft/hr. Drilled to 13,000 ft; checked for flow; got 500 units of gas to the surface; chlorides increased from 1,000 ppm to 4,500 ppm. Built mud from 13 ppg to 13.5 ppg going in; mud coming out at 12.7 ppg; shale density 2.18 g/cc.
- 10/30/73 Circulated and conditioned mud to 13.8 ppg going in and 13.1 ppg coming out. Chlorides 7,500 ppm; large amount of heaving shale coming over the shaker. Gas in mud 260 units. Built mud to 14.1 ppg going in, 14.1 ppg coming out. Chlorides 7,500 ppm; gas 6-8 units; the shaker was clean.
- 10/31/73 Trip out of hole to remove bit. Went back in the hole with open-ended drill pipe. No fill encountered. Trip gas 150 units; mud cut to 13.5 ppg for 5 min; chlorides 9,500 ppm. Circulated and mixed 1/4 lb per barrel of Solfex for heaving shale. Made a short trip to the casing shoe; no drag, no fill, and no mud loss on short trip. Circulated, trip gas total 320 units, mud cut a total of 70 min from 14.1 ppg to 12.8 ppg. Circulated and built mud from 14.1 ppg to 14.3 ppg. Pulled out of the hole to log and to start running 10 3/4-in casing on 11/2/73.
- 11/3/73 Logged the well and then went in the hole to come out laying down drill pipe.
- 11/4/73 Finished laying down drill pipe and bottom-hole assembly. Rigged up to run 10 3/4-in casing and started running casing.
- 11/5/73 Ran 253 joints of 10 3/4-in csg. (10,347 ft). While slacking off with 350,000-lb hook load, the pipe parted. Pulled out of the hole and recovered 17 joints of 10 3/4-in casing. Total pipe left in the hole 9,669 ft. Recovered pin that jumped the box; no visible signs of damage. Lost returns when pipe parted. Hole took 370 bbls mud and 290 bbls water to fill.
- 11/6/73 thru 12/5/73 During this period, they were fishing, running pipe, and finally a casing patch. They experienced many lost circulation periods, many periods of well flowing, and other hole problems. They got the 10 3/4-inch in place and cemented on 12/5/73, and the shoe and casing tested to the equivalent 18.2 ppg mud.

12/6/73 Drilling 9 5/8-in hole from 13,000 to 13,130 ft. Mud weight 15.8 ppg. Vis. 48, water loss 4.0, chlorides 8,000 ppm, pump pressure 2,800 psi, pump volume 240 gpm, rotary revolutions per minute 100, weight on bit 30,000 lbs.

12/7/73 Drilled from 13,130 to 13,240 ft. No problems. Mud weight, 15.8 ppg.

12/8/73 Drilled from 13,240 to 13,500 ft. Drilling break from 13,282 to 13,290 ft; mud cut from 15.8 ppg to 14.2 ppg for 5 hrs. Circulated and built mud to 16.3 ppg.

12/9/73 Drilled from 13,500 to 13,514 ft using 16.3 ppg mud. Gas increased to 120 units; mud cut from 16.3 ppg to 15.8 ppg. Started raising mud weight to 16.7 ppg. Well started unloading. Shut in casing pressure 650 psi, drill pipe 100 psi. Killed well, circulated out gas and saltwater, cut mud with 11.2 ppg, and chlorides 33,000 ppm coming out. Raised the mud weight to 17.0 ppg and stabilized hole.

12/10/73 Drilled from 13,514 to 13,581 ft using 17.2 ppg mud, chlorides 12,000 ppm.

12/11/73 Drilled from 13,581 to 13,793 ft with 17.4 ppg mud weight, chlorides 7,500 ppm. Shale density 2.26 g/cc. No problems.

The projected total depth of the Dow-DOE Sweezy No. 1 is 13,600 ft.

Tstd. shoe w/1,500 psi,
equiv. to 14.8# mud.
Press. fell to 950# in
15 min. Sqz. w/200
sxs LS Neat. Found
RTTS set @ 3,935'. Set
RTTS @ 4,754' and re
sqz. w/200 sxs LS Neat.
Shoe test OK.

CASING SET 13 3/8" @ 5,008'; 10 JTS N80 72# 115 JTS. K-55 69#			
MUD WEIGHT & VIS.		9# 42V	9# 40V
BIT NO. & TYPE:		#1 17 1/2" hole	#4 12 1/4"
DAYS SINCE SPUD (10/5/73)		3/12	

Schlumberger

INDUCTION SPHERICALLY FOCUSED LOG

COMPANY: PHILLIPS PETROLEUM COMPANY OF LOUISIANA
 API #17-111-70455 RECEIVED
 WELL: SUEEZY "A" NO. 1
 FIELD: NORTH PARC PERDUE GEOLOGICAL SECTION
 COUNTY: VERMILION STATE: LOUISIANA
 LOCATION: 1800' FSL & 1650' FHL OF SEC 26
 Sec. 26 Twp. 11S Rge. 4E

Permanent Datum: BHT Elev. NA
 Log Measured From: RKB 21 Ft. Above Perm. Datum
 Drilling Measured From: SATL

Other Services:
 IDC-GR
 CNL-IDC-GR

Date	10-29-73	11-2-73	12-13-73	12-21-73
Run No.	ONE	TWO	THREE	FOUR
Depth-Driller	12863	12987	14131	15620
Depth-Logger	12853	12991	14149	15625
Bit Log Interval	12846	12984	14143	15619
Top Log Interval	5008	5008	12491	14143
Casing-Driller	11 3/8 5008	13 3/8 5008	10 3/4 12991	10 3/4 1291
Casing-Logger	5008	5008	12991	12991
Bit Size	12 1/4"	12 1/4"	9 7/8"	9 7/8"
Type Fluid in Hole	POLYMER	POLYMER	POLYMER	LIGNO-SUL

Dens. Visc. 12.9 45 14.4 45 12.3 52 12.9 50
 pH Fluid Loss 9.3 5.2 ml 10.0 4.2 ml 10.8 2.6 ml 10.2 1.2 ml
 Source of Sample CIRCULATED PIT FLOWLINE PIT
 R₁ @ Meas Temp 1.60 @ 90°F 0.49 @ 97°F 0.74 @ 70°F 0.78 @ 56°F
 R₂ @ Meas Temp 1.56 @ 70°F 0.42 @ 85°F 0.37 @ 72°F 0.34 @ 58°F
 R₃ @ Meas Temp 2.52 @ 90°F 0.74 @ 97°F 0.74 @ 72°F 1.17 @ 56°F
 Source Sal. R₁ H C H C H C H C
 R₄ @ BHT 0.87 @ 175°F 0.28 @ 172°F 0.24 @ 210°F 0.19 @ 226°F
 Time Since Circ. 7 HRS. 7 HRS. 6 HRS. 8 HRS.
 Max Rec Temp. 175°F 172°F 210°F 226°F
 Equip. Location 7631 NI 7634 NI 76871 OPCL 7633 NI
 Recorded By: PADON-WITCHER (L) BONE CRIBB-LANDR NELSON
 Witnessed By: 5335 THROWER THROWER HARRD-ALYAND TITTEBOAT AUX

No drilling problems.

CHLORIDES 2,300

CHLORIDES 2,500

9# MUD, 40 VIS., PUMP PR. 2,700#, VOL. 585 GPM, RRPM 200, WOB 40-45,000#

DRILLING WITH BIT NO. 5 TO 7,303'

RUN BIT NO. 6

12 DAYS

C-4

No drilling problems.

Broke rotary chain.
Down 14 hrs.

D to 11,754'. Attempted
to make conn. hole
tight. Cond. mud to
9.5#.

Built mud to 11.1#.

Lost total of 50 bbls.
mud on trip @ 12,177'.
Reduced MW to 10.8#.

9 5/8" HOLE

24	BIT #13	BIT #14	#15	#16	#17	#18	BIT # 19	#20	BIT #21	
25										
26										
27										
28										
29										
64										
65										
66										
67										
68										
69										
70										
71										
72										

SET 10 3/4" AT 12,987'

Lost 50 bbls. mud on trip @ 12,177'. Red. MW to 10.8.

Chl. 1,000 GIM BG 6-8, Trip 16, Conn. 8. Lost 100 bbls. mud on trip @ 12,564'.

Pore pressure increased @ 12,617'. C&CM to 11.9 12,818' PP incr. to 12.9.

12,818' increase in pore pressure 12.4 to 12.97 ppg.

Drilg. bk. 12,960'. Chl. 1,100 GIM, BG 8, Trip 12, Conn. 10.

At 13,000', chl. 3,800. Ck. for flow. 500u to surf.

C&CM to 13.5. Mud cut from 13.5 to 12.7. Chl. 4,500.

Proposed TD.