PRODUCTION DEPARTMENT
M. R. ELLIOTT
Manager, Offshore Producing Operations

SUN OIL COMPANY DX DIVISION
P. O. BOX "AQ" • VENTURA, CALIFORNIA 93001

April 18, 1969

Mr. Don Solanas
Regional Supervisor
U. S. Geological Survey
300 North Los Angeles Street
Los Angeles, California 90012

Re: Tract OCS P-0240
Development Plan
Platform Hillhouse

Dear Mr. Solanas:

We are submitting herewith for your review and approval our plans for developing the westerly portion of Tract OCS P-0240. In connection with this development we are also furnishing some rather detailed evidence as to the manner in which we will comply with OCS Order No. 10. Much of this is supplemental to that previously furnished in our response to the Secretary's telegram of March 1, 1969. An itemized listing of the exhibits and reports is attached. The preparation of this material has been a joint effort involving Superior and Marathon and they have made many fine contributions. You may be assured that the very best thinking available in each company has been brought to bear on our planning.

We think you will find of particular interest the professional opinion prepared by Dames and Moore, Foundation Engineers. Theoretical aspects as well as actual experience are cited to show that pile driving required for the platform structure and conductors will not cause shattering or fractures that could result in escape of shallow producible hydrocarbons. Incidentally we have a 200% safety factor incorporated in our pile designs.

We are also furnishing a detailed report of our submarine inspection of the sea floor in the proposed platform area. The bottom has not changed in appearance since we first sent divers down in July 1968 on our well OCS P-0240 No. 2. There are no caverns, cavities, crevices or liquid hydrocarbons visible. A video-tape record was made of the inspection which we have offered to show.

File OCS-P 0240 Platform file

There are some special features of our plans which we think deserve emphasis. It is important to recognize that because the geologic structure dips in an easterly direction our structural position is at least 100 feet lower than that of Tract OCS P-0241. This provides us with an added safety factor in that the deeper occurrence of the first producible hydrocarbons will permit us to install more conductor casing as safely accomplished in the eight exploratory wells we have already drilled. The conductors will be cemented in straight, not deviated, holes. We will not perforate and produce both shallow and deep zone pays in the same well. Another matter of importance is our rather unusual plan to have pipe lines and equipment completed so that unexpected pressures can be relieved to shore.

We have made no mention of our pollution containment and removal equipment. These details will be furnished later with our application to drill rather than now to take advantage of the development work being done by our industry to make such equipment more effective in open waters.

Finally you will note we have scheduled the development to take place in phases beginning with the Lower Zone north, south and east of the platform and ending with the shallow zone west of the platform. We have previously reviewed this approach with you.

We hope these plans and procedures meet with your approval. They were very carefully prepared, generally exceed minimum requirements, and the people who will carry them out are the most capable in our organization.

Yours very truly,

SUN OIL COMPANY
DX DIVISION

M. R. Elliott

M. R. Elliott

MRE/nkr

Attachments

OCS P-0240
LIST OF EXHIBITS

1. Plan for the development and operation of the west side of OCS P-0240.

2. Report on a submarine inspection of the proposed installation site of Platform Hillhouse.

3. Dames and Moore report on "Fracturing Potential During Pile Driving - Platform Hillhouse."

4. The following schematic presentation exhibits:

   (a) North-South Typical Repetto Structure Section - West Side of OCS P-0240.

   (b) East-West Typical Repetto Structure Section - West Side of OCS P-0240.

   (c) Pile installation plan for Platform Hillhouse noting lithology from the mudline to the first possible producing sand.

   (d) Casing installation for eight (8) exploratory wells drilled on OCS P-0240 by the SSM Group after obtaining the lease.

   (e) Curve indicating the considerations given to BHP and fracture gradients as related to surface casing setting depths. This curve verifies the credibility of the casing setting depth requirements listed in OCS Order No. 10, Section 3, paragraph (ii).

   (f) Typical Lower Zone casing and completion program.

   (g) Typical Upper Zone casing program.

   (h) Casing design safety factor chart.

   (i) BOP installation until surface casing has been set.

   (j) BOP installation after surface casing has been set.

5. Dames and Moore statement of qualifications.

File Platform ~~Hillhouse~~ Conoco. to Hillhouse

PLAN OF DEVELOPMENT

AND

OPERATION

WEST SIDE OF OCS P-0240

Prepared for the U. S. Dept. of Interior,
Geological Survey

by

Sun Oil Company - DX Division, Operator

The Superior Oil Company

Marathon Oil Company

Sun Oil Company - Sunoco Division

August 15, 1969

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INTRODUCTION

This report was prepared in compliance with directives of the United States Department of Interior, Geological Survey. Its purpose is to present the approach of Sun Oil Company and its partners, The Superior Oil Company and Marathon Oil Company, to the development and operation of the west side of OCS P-0240, Santa Barbara Channel, California.

The exploitation of OCS P-0240 will adhere to the principle of developing the maximum quantity of reserves by the optimum method as determined by prudent operation. The development plan proposed herein incorporates the recommendations of the special DuBridge Commission Panel as approved by the Secretary of the Interior for the Union Lease in that the first seven wells (defined as Phase 1) will be shallow completions designed to reduce pressures in the upper sands at the western end of the lease.

Section 1 – Geology

Not for Public Release

Section 2 – Reservoir Analysis

Not for Public Release

3. DEVELOPMENT

3.1 Platform Location:

The west side of OCS P-0240 will be developed from the proposed 60 well Platform Hillhouse. Ultimately, 42 producers and possibly 11 water injection wells may be drilled from the platform. Slots are provided for 7 extra wells.

The proposed platform location is 1400' east and 3900' south of the northwest corner of OCS P-0240. This location was selected since it is near the volumetric center of the underlying productive sands.

3.2 Zone Separation:

For development purposes, the sands will be segregated into zones. The particular sands completed in each well will depend upon the following:

3.21 The proximity of other wells penetrating that sand.

3.22 The total number of wells to be completed in that sand.

3.23 The total reserves that can be attributed to that well. Each well must be economically justified.

3.3 Development Drilling:

Development of the west side of OCS P-0240 will be done by two drilling rigs operating simultaneously. To develop the shallow formations as completely as possible and to extend the horizontal development radius in sands in the deeper formations, one drilling rig will be capable of drilling 25 degree slanted holes. The advantages to be gained utilizing this approach are indicated diagrammatically in Figure 4.

3.4 Plan of Development:

The proposed plan of development for the west side of OCS P-0240 will consist of three phases. Phase 1 will include development of the Brown Zone (C & D) and the Yellow Zone (E series). This phase will also include at least one well which will penetrate all Repetto Zones for testing purposes. The first well with the conventional rig will core the sands from the ocean floor to the top of the Brown Zone. Subsequent phases will be as follows and will be contingent upon the safe and satisfactory completion of Phase 1 and each succeeding phase.

Phase 2: Complete primary development of all zones on the west side of OCS P-0240.

Phase 3: Supplemental recovery program.

Maps IV and V indicate the bottom hole locations of wells for each development phase.

The proposed plan will permit a comprehensive evaluation of the area to be developed from this platform. This plan of development will demonstrate that the new requirements pertaining to drilling and completions are adequate to safely develop the Rincon Trend.

3.5 Period of Development:

It has been estimated that 20 days will be the average time to drill and complete each well.

3.6 Drilling and Completion:

The procedure for setting the structural or initial casing string will be to drill 100' (TVD) below the ocean floor and cement 20" O.D. casing to the ocean floor. Gravity cementing operations will be conducted as conditions or requirements necessitate. Soil conditions at the site indicate that the casing will be anchored in firm dense sand. A typical casing program will be as follows:

Conductor:	16" O.D. set at 300' (TVD) below O.F. with cement circulated to the O.F.
Surface:	10-3/4" O.D. set at approximately 1150' (TVD) below O.F. with cement circulated to the O.F. (to conform to USGS regulations).
Production:	7" O.D. set at TD (may be used as a liner in some cases).

Recently approved procedures for OCS P-0241 will serve as guidelines for the drilling and completion of wells on OCS P-0240.

Platform drilling and exploitation in the Santa Barbara Channel should not be considered either risky or hazardous when adequate safety measures are taken. Listed below are drilling practices we will observe:

3.6.1 Drilling Mud System:

Special care will be exercised to keep mud weight low while drilling the shallow sands to avoid hydraulic fracturing. Adequate mud weight and volume shall none-the-less be maintained to prevent blowouts. Mud testing equipment will be kept on the platform at all times. Recording mud pit level indicators will be used to determine mud gain or loss.

These indicators will trigger an alarm when conditions warrant.

A degasser will be installed on the mud system to degas the drilling fluid if gaseous conditions occur.

In making a trip, the first 5 stands will be pulled without wipers to visually check the hole for swabbing conditions.

A mud volume measuring device will be used for accurately determining mud volume required to fill the hole on trips.

A flow-no-flow indicator will be installed on the mud return line to alarm in case of loss of mud returns or swabbing action while pulling drill pipe.

Adequate mud material will be maintained both on the platform and land to meet emergency situations.

3.6.2 Cementing:

Float collars will be run on conductor, surface and production strings to insure effective cement jobs. The shoe joint will be set in shale or other competent formations. In the case of structural conductor and surface strings, the volume of cement will be sufficient to circulate back to the ocean floor.

Open hole casing packers, centralizers, stage collars, and cement baskets will be used to insure a good cementing job on the casing strings.

Cement for production strings will be a lightweight slurry with 10-15% salt content for expansion qualities and to insure adequate bonding. Cement bond logs and/or temperature surveys will be run. Secondary cementing corrections will generally be accomplished by squeezing. Cement on production strings will conform to the applicable rules.

The minimum WOC time for cement will be 12 hours under pressure or 24 hours when not under pressure. In all cases, special consideration will be given that the cement has been given sufficient time to acquire adequate compression strength before resuming any drilling operation on the well.

A minimum pressure test on all casing strings shall be 0.2 psi per foot of total setting depth. The strings must be capable of sustaining this pressure with a loss of no more than 10% for a 30-minute period. If required, corrective action will be taken prior to resuming further operations on the well.

3.6.3 BOP Equipment:

A Hydril-type preventer will be installed on the structural casing prior to drilling out. Subsequent to setting surface casing, blowout preventers will be one set of pipe rams, one set of blind rams and a Hydril preventer. All BOP equipment will be pressure tested when installed, before drilling out each casing shoe and at least once each week.

The BOP equipment will be actuated at least once each day and noted on the driller's log. The purpose of these tests will be to insure operational efficiency.

In addition to an upper kelly cock, a lower kelly safety valve will be maintained on the bottom of the kelly at all times. This valve will be able to pass through the BOP equipment.

An inside BOP assembly will be kept on the rig floors at all times. Both the assembly and the wrench to actuate it will be kept in an easily accessible designated place on the platform. BOP drills will include use of these tools by all crew members.

Lubricators will be used during all logging operations. A full opening valve will be installed on drill pipe when running wire line directional surveys. Closing the valve will cut the line in case of emergency.

3.6.4 Safety Drills:

At least once each week drills for securing control equipment and evacuating the platform in case of emergency will be conducted. Blowout preventer drills will be conducted twice each week to insure that crews are trained to carry out necessary duties.

3.6.5 Storm Chokes:

A storm choke will be installed in the tubing of all completed flowing wells. Flowing wells will have the tubing-casing annulus sealed with a packer below the ocean floor.

3.6.6 Well Heads:

Safety valves will be installed on the well head on the platform. All lines will be equipped with check valves at their connections to the well head.

4. PLATFORM HILLHOUSE

Platform Hillhouse will be an 8 pile template type self-contained drilling and production structure to be installed in 190' of water. It will have two main decks, a drilling deck and a production deck, each 140' X 105' in size. The production deck will be approximately 37' above MLLW and the drilling deck approximately 61' above MLLW.

The boat landings for both personnel and heavy equipment were designed with both safety and all weather usage in mind. The main boat landing is a hanging fender type which will extend along the entire north side of the platform. This fender type landing is supported by adjustable heavy cables to permit safe operations in heavy seas and changing tides. This landing allows both personnel boats and service craft to tie off solidly to it in rough seas. An additional boat landing is located on the east side of the structure to handle small boat traffic in cross seas as well as when the hanging fender is in use.

There will be two cranes located on this platform. These cranes are located adjacent to the service boat and barge fender so they can safely handle heavy loads in moderate to rough seas with winds from any direction.

Platform Hillhouse will be painted a light blue to minimize visibility from shore. The structure and its appurtenances are to be coated with a paint system that will furnish the maximum in corrosion protection as well as lasting color retention and ease of cleaning of the outside surfaces.

The submerged portion of the structure will be protected by an impressed current cathodic protection system to prevent corrosion damage or metal loss which might weaken the structure.

Special emphasis will be put on utilizing producing equipment that will permit rigid control of operations during the producing life of the platform. In addition to safety, this equipment will stress pollution control. A summary of the proposed equipment is as follows:

4.1 Gas Detector:

A gas detector and alarm system will be installed on the platform with gas leak detectors located at strategic points.

4.2 Standby Equipment:

The platform power source will be a submarine electric cable from shore. In the event of a power failure, standby generators driven by diesel engines will automatically start and furnish power within 15 seconds. Sufficient power will be available to run one rig, fire-fighting system, shipping pump to shore, navigation aids, and electrical equipment associated with emergency shutdowns and anti-pollution mechanisms.

4.3 Fire-Fighting:

An automatic sprinkler system will be installed in all well bay areas. A closed loop fire-water system will be automatically operated by electric motor-driven turbine pumps. A standby diesel system pump will also be included in the event of power failure. There will be no fired vessels installed on the platform.

4.4 Control System:

High and low level and pressure shutdown devices and alarms will be installed on all vessels on the platform. Remote and local automatic platform shutdown devices will insure positive control in any emergency.

Recording pressure charts will be installed on pipelines to shore. These lines will be equipped with high and low pressure sensor devices to automatically close safety valves on all well heads. All shutdown systems will be of the manual reset type.

4.5 Sewage:

An adequate, approved sewage disposal system will be installed on the platform.

4.6 Deck Areas:

Curbs, gutters and drains in all deck areas will be installed to collect contaminants for pumping to shore, where they will be cleaned prior to disposal.

4.7 Boom and Skimmer:

An approved containment boom and skimming apparatus, along with chemical dispersants, will be maintained on the platform and regularly inspected to insure operational efficiency.

The platform will be designed to withstand 35' waves and 125 MPH winds. The basic design incorporates a 15 percent seismic design factor.

5. OPERATIONS

5.1 Onshore and Offshore Facilities:

As an anti-pollution measure, handling of fluid and gas on the platform will be minimized. Figure 5 diagrammatically indicates the general scheme of processing products.

Except for well testing, separation on the platform will generally be two phase. Oil and water will be discharged from separators into a surge tank and then pumped to shore through a 12" submarine line. The fluid will be treated on shore for extraction of the water which will be clarified before disposal through an approved outfall line.

Low pressure gas from the platform will be transported to shore by a 12" line. Onshore, the gas will be treated and compressed for sale. All lines will be equipped with pigging systems.

5.2 Future Operations:

The submarine line has been sized for the possible addition of a second platform which may be installed on the east side of the Tract. Initially, all operations except the automatic well test system will be manually operated on a 24-hour surveillance basis.

Ultimately, a complete supervisory control system is contemplated for a two-platform operation. An onshore computer station would automatically control and record the platform and onshore operation by periodically scanning all of the facets of the operation. The feasibility of this type operation will be studied when sufficient time has elapsed for the necessary accumulation of operational and production data.

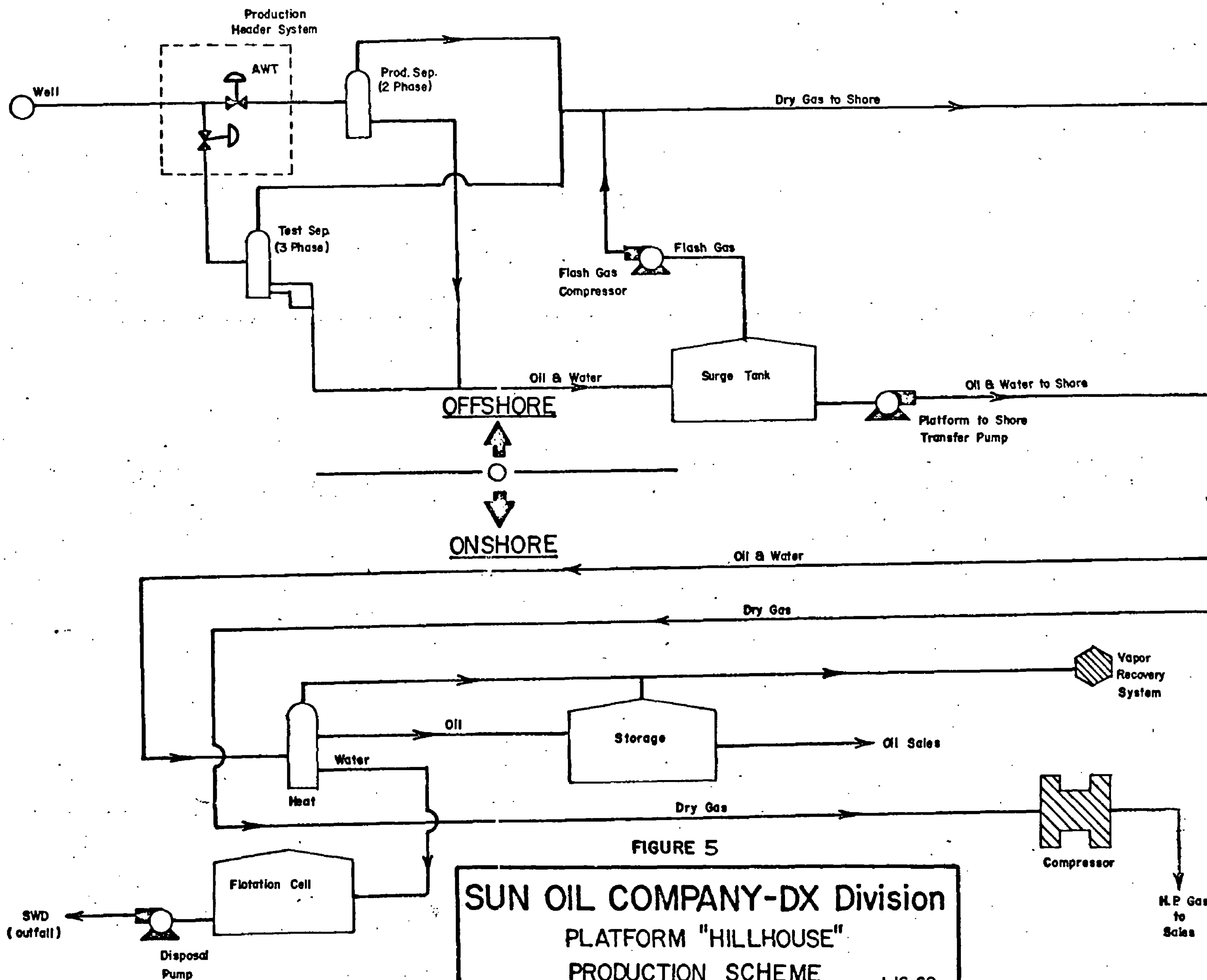

FIGURE 5

SUN OIL COMPANY-DX Division
PLATFORM "HILLHOUSE"
PRODUCTION SCHEME

1-16-69

Deep Stratigraphy Test and Bottomhole Locations

Pursuant to the Freedom of Information Act (5 U.S.C. 552) and its implementing regulations (43 CFR Part 2) and as provided in 30 CFR 550.199(b), the information contained in this section is deleted from the public information copy of this submission.

Map III – Bathymetric Maps

Not for Public Release

Maps IV & V – Bottom Hole Location Maps

Not for Public Release

SUBJECT: Submarine Inspection at Proposed Site of Platform Hillhouse

DATE: April 10, 1969

FROM: G. J. Welsh

TO: M. R. Elliott

CONCLUSION

The sea floor survey of the site of proposed Platform Hillhouse revealed a flat, clear bottom devoid of rock outcrop or geologic disruption which could pose hazards to tip-up of a platform. The exposed sediment is believed to be part of a 6'-7' thick loose mantle unconformably overlying more consolidated sediments of the upper Repetto (R-2) formation. As this overburden of Recent age obscures geology of the sub strata, one must seek other means for examining the nature of the underlying Repetto.

INTRODUCTION

On April 3, 1969, a submarine inspection was made of the ocean floor at the proposed location for Platform Hillhouse. The vehicle used was the two-man General Dynamics submarine Star II, piloted by Mr. Bill De Cort. Subsurface observer for the first portion of the survey was the undersigned whose report follows. Subsurface observer for the second portion of the survey was Mr. H. D. Palmer, Marine Geologist, of Dames and Moore, whose report will be incorporated in a larger report to be prepared by Dames and Moore. Surface survey of the submarine's position was accomplished by Mr. Ken Chapman of Lewis and Lewis Offshore, Inc. Surface observer was Mr. B. F. Brawley of Sun Oil Company-DX Division.

EXHIBITS

Included with this report is a bathymetric map of the vicinity of proposed Platform Hillhouse showing ocean floor leg penetration points of the eight-pile structure, position of Star II at various times during the survey and notes of several features seen. Survey positions are based on Lewis and Lewis autotape "Shot Record", a copy of which is enclosed. Also included is a Surface Log of Activities by Mr. Brawley and a Subsurface Log of Activities by the undersigned.

Also in Sun Oil Company's possession at its Ventura office is a video tape of the ocean floor over most of the survey. This tape was produced on and may be replayed on a Sony EV-200 Videocorder.

METHOD OF SURVEY

A reference marker buoy was placed at the position of the proposed platform's northeast leg. Star II was launched from its work boat, towed to position and submerged at the marker buoy.

Despite problems described in attached log, the sea bottom at the platform site was adequately inspected and videotaped to fulfill the planned mission. An average radius of investigation of 175' from the center of the proposed platform was surveyed by Star II. This was more than enough to investigate the area covered by the ocean floor leg penetration points of the platform (163'-4 1/2" X 133'-4 1/2").

OBSERVATIONS AND GEOLOGIC COMMENT

General Features

The general character of the ocean floor over the area surveyed was of a flat plain. The bathymetric map indicated a shallow southerly dip but this was not evident from the submarine. Upon the plain were impressed current ripple marks of some 2"-3" relief which trended in a northwest-southeast direction. The bottom appeared to consist of a mixture of unconsolidated gray silt and fine sand, firm enough to support the submarine sled for skid marks were no more than 4" deep, but loose enough to form a powdery dust cloud when stopping or turning the submarine. Common over much of the floor were finger sized holes or borings between which lay curled clumps of boring debris or casts, both features obviously related and made by marine worms. Occasional larger burrows or pits (up to 2" diameter) were noted. Most of these appeared no more than 3"-4" deep and may have been old burrows partially filled in. While no casts or debris were associated with these features, they gave the impression of having been created by marine life. Other physical evidence seen on bottom were rare, small (1/2"-1") sea shell valves (pelecypods), one piece of a land tree root system apparently carried to sea by storms, several kelp leaves, and two tin cans.

Several varieties of sea life were observed:

1) Common sea cucumbers, of at least two species, crawled on bottom.

2) Common small fish (cod?) 4"-9" long swam individually or in pairs above bottom or rested on bottom on their pectoral fins.

3) Occasional sea pens 1'-2' high rose above the bottom.

4) Several starfish and starfish impressions were observed.

5) One flat fish (halibut or ray) darted from its position on bottom leaving its impression in the floor. Several more of these impressions were seen.

6) One nudibranchiate was seen crawling on bottom.

Except for the special features discussed below, no significant geological features were seen. There were no outcrop or even loose rocks or pebbles. There were no disruptions of the ocean bottom, no slump areas, no linear markings. No evidence of hydrocarbon oil, free or residual, was seen. And except for the pelecypod shells and kelp leaves mentioned above, no dead marine life was observed.

Special Features

On the first northerly leg of the voyage (at approximately 10:40 a.m. near P3 of the enclosed Shot Record and Bathymetric Map) there was encountered the westerly edge of a depression created most probably by the placement of anchor #2 on well #2 by the Wodeco IV. With water visibility at six feet and a limited view from the porthole, the depression or pit might be described as a 6' long arc concave to the east and dropped down to the east. The initial drop of about one foot was abrupt, almost a scarp, then shallowed to a declivity some 1-1/2' deep. Upon the sloping portion of the depression lay three or four live sea cucumbers and upon one of these lay a large starfish. Star II was ordered to stop to enable us to track and film this feature but in the dust kicked up by stopping and turning we lost it. We should note that we did not witness: color change between floor of the depression and surrounding ocean floor, any evidence of oil seep or oil staining or any gas bubbles, no surrounding debris, no rocks or pebbles, no layered sub-stratum.

A second special feature encountered were bubbles emanating from finger size holes in the ocean floor. Clusters of these features appeared near P6 and P15 as shown on the bathymetric map. The P6 cluster was not filmed. The P15 cluster was filmed but the videotape does not record the bubbles. The impression gained from relatively rapid passage through these bubble clusters of limited areal extent was of pressure flattened clear bubbles intermittently rising from finger sized holes. Some holes percolated the bubbles while other similar holes in the vicinity did not. There appeared no evidence of oil or tar on the bubbles, in the water or surrounding the holes. Furthermore, there were living sea cucumbers among the holes. Subsequent discussion with professional divers in the Santa Barbara Channel reveal they too have witnessed this feature. In the absence of chemical analysis we would describe the bubbles as low pressure marsh gas.

SUMMARY OF GEOLOGY

The Star II survey of the Platform Hillhouse site revealed a homogeneous appearing flat bottom (agreeing with an earlier sonic reflection survey) remarkably clear of vegetation, rock outcrop or bottom disruption. Almost certainly this monotoned mono-textured bottom is a veneer of Recent age covering a sub-strata of Repettian age.

Indicated on the bathymetric map are the two coreholes drilled for Platform Hillhouse foundation investigations. Corehole #1 penetrated 7' of overburden composed of dark green-gray loose silty fine sand containing shells and decayed vegetation with an H_2S odor. Corehole #2 penetrated 6' of this same overburden. The anomaly between the darker colored high vegetation content overburden of the coreholes and the light colored vegetation clear bottom observed from the submarine may be explained by the action of stronger winter currents sweeping the bottom clean. It is our opinion that the observed bottom sediments are but another layer of the overburden found in the coreholes. And with 6'-7' of overburden in the area there is little wonder that no outcrops were observed. Furthermore, the overburden's content of decayed vegetation could account for the bubble clusters seen.

Immediately below the overburden both coreholes penetrated sediments of the Repettian R-2 stage. These results agree with the R-2 stage designation for the area as mapped by the CUSS Group in their ocean bottom sampling and corehole program.

Gordon J. Welsh

Gordon J. Welsh
Project Exploitation Geologist

GJW/ph
Attached

Bathymetry Data

Pursuant to the Freedom of Information Act (5 U.S.C. 552) and its implementing regulations (43 CFR Part 2) and as provided in 30 CFR 550.199(b), the information contained in this section is deleted from the public information copy of this submission.

Proprietary

Not for Public Release

FRACTURING POTENTIAL DURING PILE DRIVING
PROPOSED OFFSHORE PLATFORM HILLHOUSE
SANTA BARBARA CHANNEL
SANTA BARBARA, CALIFORNIA

FOR SUN OIL COMPANY

DAMES & MOORE ACCOUNT NO. 0837-015-02

EARTH SCIENCES

DAMES & MOORE

CONSULTING ENGINEERS IN THE APPLIED EARTH SCIENCES

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CHIEF ENGINEER: HUNTER R. MOORE, JR.

April 11, 1969

Sun Oil Company
DX Division
Post Office Box AQ
Ventura, California 93001

Attention: Mr. B. F. Brawley
Project Engineering Manager

Gentlemen:

We herewith submit our report "Fracturing Potential During Pile Driving, Proposed Offshore Platform Hillhouse, Santa Barbara Channel, Santa Barbara, California, For Sun Oil Company." This report was prepared in response to your letter of April 7, 1969, authorizing a feasibility study of bottom or subsea conditions on your OCS P-0240, Parcel 401 relative to pile foundation work.

The purpose of our study was to consider the lithology of the area, the indications that could be obtained by rock mechanics analysis techniques, and other conditions which might bear on the installation of foundation piles for Platform Hillhouse in the Santa Barbara Channel.

Very truly yours,

DAMES & MOORE

Vernon A. Smoots

Vernon A. Smoots

VAS:HDP:bs

FRACTURING POTENTIAL DURING PILE DRIVING

PROPOSED OFFSHORE PLATFORM HILLHOUSE

SANTA BARBARA CHANNEL

SANTA BARBARA, CALIFORNIA

FOR SUN OIL COMPANY

INTRODUCTION AND SCOPE

This report presents our opinions regarding the behavior of sea floor materials during pile driving for Platform Hillhouse, Parcel 401, Santa Barbara Channel. Our opinions are based on:

1. A brief reconnaissance of the sea floor by our marine geologist.
2. The results of our foundation investigation of the proposed site. Our final report was dated November 4, 1968.
3. Analysis of the physical properties of the bedrock formations using rock mechanics techniques.
4. Analysis of the reaction of soils and rock to pile driving. This analysis was prepared by Dr. Ronald F. Scott, Professor of Civil Engineering, California Institute of Technology.

SEA FLOOR RECONNAISSANCE

On April 3, 1969, our marine geologist, Harold D. Palmer, participated in a reconnaissance of the sea floor at the proposed platform site. This study was conducted with the submersible STAR II under the direction of Sun Oil Company personnel. Mr. Buz Welsh, geologist for Sun Oil Company, surveyed the western half of the platform site; our marine geologist examined the northern portion of the eastern half.

The above geologists have compared their observations and found that they were similar. The following comments are based on these observations:

1. The fine sand and silt comprising the bottom surface materials at the site display ripple marks. The crests of these ripple marks trend 240 degrees magnetic, indicating a current or surge direction from 150 degrees or 330 degrees magnetic. Surface currents in the area are generally from west to east, suggesting that bottom currents are from the approximate heading of 330 degrees. Bottom currents were weak at the time of observation, but deflection of sea organisms attached to the bottom support this assumption.

2. The upper 70 feet of the water column was clouded by organic matter (leptopel). The lower boundary probably represents the thermocline at the time of the dive.

Oil was seen on the surface of the water at the site. No oil was seen rising through the water column during the two dives.

Horizontal visibility was as follows:

DEPTH IN FEET	VISIBILITY IN FEET
100	75
170	10
200	3

Turbidity at the bottom was caused by suspended sediment.

3. During the dives, streams and clouds of bubbles were noted within the water column. Observations at the sea floor indicated that these bubbles were rising from circular pits in the sediment. The average diameter of these pits was estimated at 1 inch, with maximum diameters of about 3 inches.

Mr. Welsh encountered a large pit of unknown dimensions during his dive. Restricted visibility precluded investigation of this feature. However, the indications are that this pit is fairly deep. It is our opinion that this pit was created by detonation of a heavy explosive charge. Such a charge was required to sever a "stuck" drill string during our foundation investigation. This charge was detonated at a depth of 10 feet below the mudline.

4. Of the total number of pits observed by Mr. Palmer, it is estimated that less than 5 percent were actually releasing bubbles. In the active pits, bubble streams were seen to issue intermittently. Restricted visibility precluded an accurate assessment.

5. Benthonic fauna observed at the site included many sea pens, sea cucumbers and a few starfish. No polychaete worms or other burrowing organisms, usually associated with cylindrical pits, were seen.

6. The bubble streams rising from these pits are attributed to the escape of gas (hydrocarbons) from formations underlying the thin mantle of unconsolidated Recent sediments. Overburden thickness, as measured by sampling in conjunction with foundation studies, was 7 feet or less. The intermittent release of bubbles is attributed to discharge from numerous small subsurface voids serving as reservoirs. The upward velocity of bubbles issuing from the pits was commensurate with ambient hydrostatic pressure. In no case was a "jet" effect evident and there was no indication of subsurface pressure forcibly displacing the gas.

7. Biologic activity which will produce gas, and consequently bubbles, at the sea floor can only be attributed to the activity of bacteria. The gas is most commonly either ammonia or hydrogen sulphide. The samples of superficial Recent sediments obtained during foundation studies had a distinct odor of H_2S indicating that bacterial reduction of organic material with the associated generation of H_2S gas

was occurring. However, it is believed that the observed volume of bubbles cannot be solely ascribed to bacterial action within the sediment. Neither can it be attributed to metabolic processes (respiration) of larger organisms.

It is our opinion that the bubbles are primarily hydrocarbons from accumulations of light petroleum products. The chemical composition of the gas forming the bubbles may easily be determined by chemical analyses. If this factor is critical, a diver could collect samples of the gas at the sea floor at several different locations.

8. Historically, the natural release of solid and gaseous hydrocarbons from the sea floor is common in the Southern California area, especially in Santa Barbara Channel. Offshore gas leaks and tar seeps have been described in geologic literature for many years. Petroleum was found in foraminiferal tests and also was found in fractures in the upper samples recovered in our foundation investigation performed in November 1968.

9. Solid petroleum was seen only on the water surface. It was not observed in the water column or on the sea floor. Crude oil has been recovered within this general area in grab and core samples obtained

by the Allan Hancock Foundation, University of Southern California. However, digging with the submarine's claw did not reveal anything recognizable as crude oil at the Hillhouse site. Excavation to a depth of approximately 2 feet did not result in the release of bubbles.

PROPOSED CONSTRUCTION

We understand that 8 pipe piles of 39-inch outside diameter and 3/4-inch wall thickness will be driven to a depth of approximately 50 feet below the mudline or to refusal. A 28-inch-diameter hole will then be drilled to a depth of 195 feet within these piles and a 24-inch pile will be grouted in-place within this hole. In addition, an unspecified number of 20-inch-diameter conductor pipes will be driven to a depth of 25 to 35 feet below the mudline.

SITE CONDITIONS

The fine to medium sands labeled "Mid-Repetto" directly beneath the surficial Recent sediments were found to be from 14 to 20 feet thick. These dense sands are underlain by siltstone containing sand lenses or stringers and shell horizons. These materials were encountered to the maximum depth of sampling, or 146 feet below the mudline. These materials are also believed to be a part of the Mid-Repetto Formation. The fine to medium sand obtained from both the uppermost unit and the stringers within the siltstone are dense but are not cemented. The siltstone is relatively hard but contains lenses of clayey material as well as the sand stringers.

It is planned that the depth of piles will be 190 feet. However, our exploration borings were forced to stop at a depth of 146 feet, due to problems with the drill ship. Other data have been found which does confirm that the Mid-Repetto Formation continues well below the 195-foot depth.

Due to the nonhomogeneity of the formation, it is doubtful that a localized stress concentration could cause fracturing which would propagate vertically downward through the discontinuities that exist in this material.

PREVIOUS EXPERIENCE WITH PILE DRIVING

Experience in driving piles in similar foundation materials has indicated that open-end pipe piles can be driven to an average depth of approximately 20 feet. As the piles are driven, the blow count becomes very high. Finally, the pile cannot be advanced further. Evaluation of pile driving indicates that a significant amount of the hammer energy is transmitted to the tip of the pile, until the driving count reaches 35 to 40 blows per inch. Beyond this count, the efficiency of energy transmitted to the pile tip drops off very sharply.

Experience, and wave equation solutions, reveal that beyond a certain level of driving resistance little energy is transmitted to the tip of the pile. However, energy is needed at the tip in order for the pile to advance. Thus, most of the energy is dissipated within the pile itself, and the pile acts as a spring. Under these conditions, the pile tip remains at the "refusal" elevation and does not penetrate deeper. This is borne out by field experience where driving continues to high blow counts while the pile remains at a fixed level.

If the formation were to break or fracture during driving, one would expect that the driving resistance would drop and the pile would progress further into the formation. This situation has been observed in brittle materials (corals, volcanic sills, etc.) which shatter during pile driving. The physical properties of the formations at the platform site suggest that such shattering is highly unlikely. From foundation experience, piles driven to high blow counts will not be influenced by other induced stress conditions when other piles are to be driven at a distance of at least 4 diameters. The piles for the platform are spaced at a much greater distance than this.

It may be possible to establish criteria to control driving energies so that uncontrolled, excessively high energies will not be induced into the pile, and then transmitted into the formation. One approach is to establish a minimum depth for the 39-inch pile. The pile might penetrate through the upper sand and penetrate into the siltstone to a depth of 10 to 20 feet. Driving would be continued until 2 consecutive feet of driving exceed 300 blows per foot.

The anticipated two-stage pile installation technique should provide relief for stress concentration at the tip of the 39-inch piles. Inasmuch as drilling will occur immediately following the driving, it is reasonable to assume that this stress would be relaxed following drilling.

The grouting operation in conjunction with the drilled-and-grouted pile should fill any voids that may develop. However, grouting pressures should be kept at a minimum commensurate with adequate foundation design.

ROCK MECHANICS EVALUATION

This analysis presents our consideration of the possible effects on the bedrock formation during driving piles and driving conductor pipes a short distance into the formation.

Not considered is the subsequent drilling through the short piles in order to set the deeper 24-inch piles.

This activity does not involve impact or the application of large amounts of energy within the bedrock. Therefore, this activity is passive and would not be expected to have an adverse effect.

Also not considered are:

1. The installation of deep oil well casing.
2. The effects on the bedrock formation of producing oil and gas, and of changes in gas pressures in various zones.

We understand that these activities are being considered separately.

During pile driving, stresses are induced in the soil and rock. In hard rock, fracturing will occur at the boundary of the pile and will extend radially to a point where the induced tensile stresses no longer exceed the tensile strength of the rock. The only tensile stresses which are induced by inserting the pile are tangential stresses. These are induced by pushing aside the surrounding rock as the pile penetrates into the ground.

The magnitude of the stresses developed depend on the elastic and plastic characteristics of the rock as well as the diameter, wall thickness, and shape of the pile, and the method of pile driving. Another major factor in predicting the induced stresses is the state of stress in the rock prior to pile driving. Assuming that the rock is in a "relaxed state" (uniform horizontal stresses in all directions), the tangential stresses induced by pile driving can be calculated. Such calculations indicate that the induced stresses at a distance of 1 diameter from the edge of the pile are about 10 percent of the induced stresses at the edge of the pile.

At this site, it is expected that there may be some residual tensile stress in the bedrock, which may modify the stress value of 10 percent at 1 diameter outside the pile.

The Mid-Repetto Formation bedrock is not brittle. It is not a crystalline rock. Small deformations of this material would not cause a "glass crack" effect. The material is capable of plastic remolding. In construction activities, where the material is exposed on land, we find that this bedrock material can be excavated with bulldozers and scrapers. When laid down as fill, it can be readily compacted by sheepsfoot rollers. The rollers cause the material to mash down and to remold into a fill which is homogenous, and bears little resemblance to the material originally classified as stratified sediments.

Under these circumstances, there is no reason to expect that fracturing of the rock would extend out into areas of small induced stresses. Therefore, fractures would not be expected to extend more than 2 to 3 diameters beyond the edge of the pile.

THEORETICAL ANALYSES OF FRACTURE POTENTIAL

In order to estimate the total volume of bedrock material which would be affected by inserting large-diameter piles, our laboratory data were examined by Dr. Ronald F. Scott, Professor of Civil Engineering, California Institute of Technology. Dr. Scott is a recognized authority in the field of soil mechanics.

To develop a conservative analysis, Dr. Scott assumed the worst conditions for each variable derived or calculated from our laboratory test data. These include the assumption that the materials are sufficiently brittle to fracture and that the following values apply:

Shear (or rigidity) Modulus = 0.4 X 10^4 pounds/inch^2

Cohesion = 3,300 pounds/foot^2

Buoyant Unit Weight = 33 pounds/foot^3

Sample Depth = 33 feet

Coefficient of Earth Pressure at Rest = 0.5

The analyses were conducted as follows:

1. Assume that a hole exists in the soil equal in diameter to the inside diameter of the pipe pile.
2. Assume that these soils are under existing overburden pressure stress state.
3. Expand the hole by an amount equal to the wall thickness of the pile (3/4 inch).

4. Calculate the stress in the surrounding soils by linear elastic theory.
5. Superimpose these stresses on the "at rest pressure conditions."

These analyses reveal that the maximum distance away from the center line of the pile that the bedrock will be affected by the driving of the pile is 8 to 10 feet. The bedrock materials more than 3 feet ahead of the advancing pile tip should not be affected by pile driving acitivity. These estimates should not change significantily with either an increase or decrease in hammer energy.

OPINIONS

On the basis of our observation of the sea floor on April 3, we believe there are no oil leaks in the sea floor at the proposed platform site. Gas of undetermined composition is issuing from the sea floor, but in small amounts and under very low pressure. We believe this gas to be a hydrocarbon leaking from the Mid-Repetto Formation underlying the thin surface sediments.

Driving of piles would be expected to cause fracturing of the rock immediately adjacent to the piles. However, the bedrock formation materials at the site are not brittle. They would not "shatter" under pile driving activities. Instead, they can deform plastically to accommodate small strains. Therefore, we see no reason to expect that localized fracturing of the rock adjacent to the piles would extend out into areas of small induced stresses. Therefore, fractures would not be expected to extend more than 10 feet beyond the edge of the pile.

The bedrock more than 3 feet ahead of the advancing pile tip should not be affected by pile driving activity. This distance should not change significantly with an increase or decrease in hammer energy.

Respectfully submitted,

DAMES & MOORE

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